A DEDICATED TEAM

KLOHN LEONOFF CONSULTING ENGINEERS

1951—1991

Cyril E. Leonoff

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1951 - 1991

This volume documents the forty-year history of the consulting engineering firm Klohn Leonoff Ltd., and its predecessors, founded in British Columbia in 1951 by Charles F. Ripley. In its early years the company existed as a small group of adventurous young engineers specializing in the new science of "soil mechanics," which would in time evolve into the practice of what is now called geotechnical engineering. As it happened, in introducing soil mechanics to western Canada, the firm benefited from the encouragement and technical support of Dr. Karl Terzaghi, the founder and world's expert in this discipline.

In its second decade, spurred on by a burgeoning post-World War II economy, the company grew rapidly in size and diversity, expanding its services to include involvement in heavy civil engineering projects throughout Northwestern America. The story told herein traces the participation of the company in such megaprojects as the Kemano-Kitimat power and smelter development, immense pulp mill complexes, the development of Peace River hydroelectric power, the commencement of open-pit mining and tailings disposal sites so huge that they have literally changed the face of the earth, and in the accessing of Northern

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To Dorothy Annette Ripley and all the wives (and husbands) for their forbearance and support.

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My associates, behind the scenes, in the writing of this manuscript have been Jennifer and Ric Beairsto. Not only have they taken care of the technical details of the project, such as word processing and editing, but more importantly they have been responsible for making the story lucid to the general reader. Particularly they have kept the author from lapsing too far into technical jargon when attempting to explain complex engineering concepts. From the beginning, Jennifer and Ric's frank but always positive advice has been invaluable to the end product.

Cyril E. Leonoff
Vancouver, B.C.
January 1994

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Foreword

FOUR DECADES OF ACHIEVEMENT

The present consulting firm known as Klohn Leonoff Ltd. originated in May 1951 when Charles F. Ripley, Harvard-trained in the emerging discipline of soil mechanics, founded Ripley and Associates in Vancouver, Canada. The principal ownership of the firm expanded in 1952 when Earle J. Klohn and Cyril E. Leonoff joined the firm. Spurred on by an expanding post-war British Columbia economy, as well as the encouragement and technical support of Karl Terzaghi, the father of soil mechanics, Charles Ripley's new company grew rapidly in what eventually became known as the field of geotechnical engineering.

What started out as a small group of adventurous, young engineers has since grown into a multidisciplinary consulting practice with more than 225 engineers, scientists, other professionals, and support staff working out of five offices in western and northern Canada, as well as Washington State. The firm has, since 1951, provided engineering services to more than 7,000 projects in diverse geographical and cultural settings world-wide.

While its geotechnical expertise is still a mainstay of the firm's business, Klohn Leonoff Ltd. has, over time, extended the scope of its services to encompass civil engineering, transportation and municipal consultation, water resource management, tunnel and rock work, mining, as well as environmental and international community development. By broadening and diversifying its services, the company has increased its competitive position to the point where it now plays a management role in major, comprehensive engineering projects both domestically and internationally.

Today Klohn Leonoff, wholly owned by its employees, remains a British Columbia-based company, ranking in the top five engineering firms in the province. With projects completed in some fifty different countries from the northwest tip of Alaska to the South Island of New Zealand, the company's services have literally spanned the globe. Awards from professional engineering associations, and the high regard of its clients, attest to the reputation that the company has established for high standards of innovative, practical engineering, a reputation built by the many men and women who have worked for the company—each of whom can take some credit for its success. As a service industry whose basic resource is its people, the quality of the services Klohn Leonoff Ltd. provides to its clients can only be as good as the quality of its staff.

On this fortieth anniversary of the company's founding, I feel that it is timely to tell our story in these pages. And I take great pleasure in dedicating this volume to our staff members, past and present, who have made it all possible.

Earle J. Klohn
Chairman and Chief Executive Officer
September 25, 1991

FOUNDATION ENGINEERING BUILDING

Chapter One

SOIL MECHANICS: A NEW SCIENCE IS BORN AND COMES WEST

The diverse, unconsolidated materials comprising the earth's crust, broadly described as soil, constitute so large a portion of the earth's surface that few civil engineering projects can be carried out without dealing with some type of earthwork. As well, some of the largest man-made structures ever built—earth dams, dykes, canals, and highways—are composed largely of soil.

Prior to the turn of this century, any textbook on foundation and earthwork engineering divided soil into several categories—gravel, coarse and fine sand, silt, and soft or stiff clay. Various allowable bearing values, based on empirical equations or rules, were assigned to these different materials, but only one variable, the type of soil, was considered. Equally important mechanical properties of the soil, such as density and water content, were ignored.

In those early years, the foundation design of buildings placed upon soil, or of structures involving deep excavations and tunnelling, was based on primitive geological surveys of the materials located beneath the proposed construction site, often with highly disappointing results. The visible settling of monumental public buildings founded on materials other than bedrock was not at all an unusual sight; the famous tower in Pisa, Italy is perhaps the best-known example. When in doubt, pile foundations were the rule, and at the beginning of the nineteenth century, empirical pile formulas were developed, with the bearing capacity of each pile computed on the basis of the work performed by the hammer in driving the pile into the ground, the depth of the pile's penetration, and the resistance of the soil. While useful, these formulas did not, unfortunately, preclude the possibility of an entire group of piles settling. And if the pile tips were located above soft clay soil, excessive settling often took place as a result of the gradual, forced consolidation of the clay beneath the piles.

The only analytical tools at the disposal of civil engineers were the theories of earth pressure on retaining walls, and soil's natural angle of repose as enunciated by C. A. Coulomb in 1776 and W. J. M. Rankine in 1856. However, because of their simplified assumptions on the behaviour of soil, these theories had little practical usefulness outside the classroom.[1] The mechanism of landslides was not understood, and rational methods for evaluating the safety of slopes with respect to the possibility of their sliding were unknown.

Humankind had been constructing earth dams for many centuries prior to the nineteenth, for at least two thousand years in fact, usually for the purpose of creating water storage reservoirs. Yet the height of such construction was always restricted to about 100 feet. Any higher than that and the dam was liable to collapse. Such dam failures were widely reported in engineering magazines well into the nineteenth century when the mechanics of seepage, porewater pressure, and piping on cohesive soils were still undiscovered. Systematic methods for compacting the materials used to construct the dam remained completely undeveloped.

Early in the twentieth century, three major engineering failures precipitated the first modern soil studies. These were the great landslides in the deep cuts made to complete the Panama Canal, the catastrophic loss of life caused by slides on the Swedish state railways, and outward movements of the pile-supported quay walls used in the construction of the Kiel Canal between the North and Baltic Seas.[2]

During these years, Charles Karl Terzaghi (1883–1963) was becoming one of the world's most eminent and colourful engineers. An Austrian, he studied mechanical engineering and geology, receiving the degree Doctor of Technical Sciences from the Technical University in Graz, Austria in 1912. For the six years preceding World War I, Terzaghi worked as a construction engineer on a variety of engineering and contracting projects in the Alps, in Croatia, and in Russia, where he was able to absorb the practical side of civil engineering. Moreover, in such circumstances, he had ample opportunity to observe "the incompetence of the engineering profession in the field of earthwork engineering."

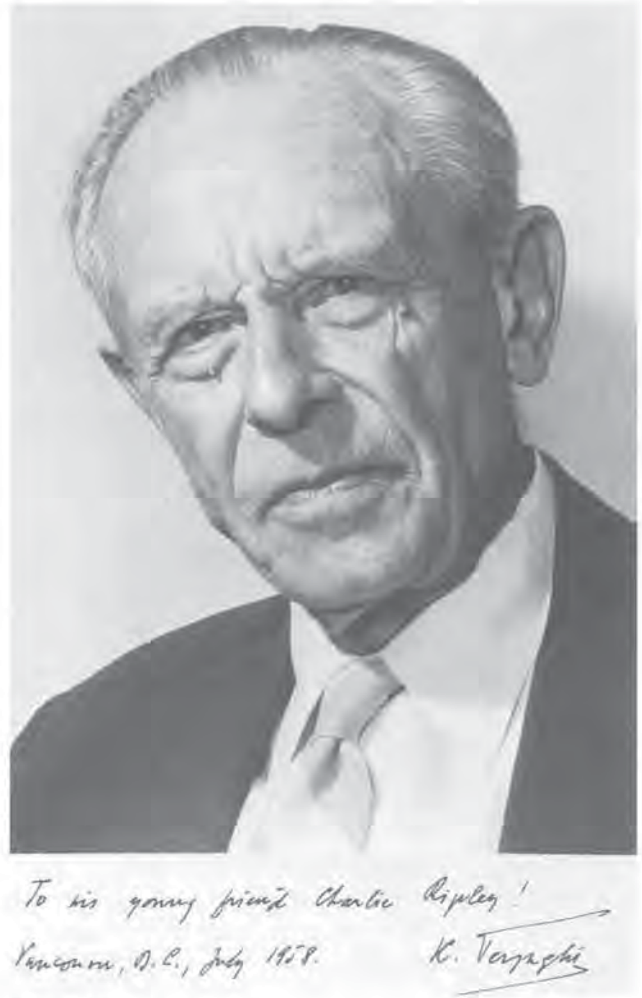
The empirical rules then in use by construction engineers were considered by Terzaghi to be "irrelevant," and the fact that no rational explanations existed for the settlement of foundations seemed to him unconscionable. In particular, problems which arose in constructing the foundations of a large building in St. Petersburg, Russia piqued his interest and set Terzaghi upon his life's mission.

Believing that the United States Reclamation Service, which was then engaged in a large number of dam and irrigation projects, was the principal pioneer in this field, Terzaghi spent "two years of hard labour" studying the geology of the Reclamation Service construction sites throughout the U.S.A. But, during this time, and to his great frustration, he failed to discover the "missing link"—the correlation between the performance of a foundation and the geological characteristics of its site. Returning home at the end of 1913, he was immediately "sucked up, like most able-bodied members of [his] generation by the maelstrom" of the First World War, landing in the air force of the Austrian Army.

In 1916, to his "great surprise," Terzaghi was ordered by the Austrian Ministry of Foreign Affairs to transfer to Constantinople, Turkey, there to lecture on construction and foundations at the Imperial School of Engineers (the present Technical University of Istanbul).[3] At that time, the Ottoman Empire had sided with the Central Powers, and Constantinople's institutions were under German influence. Terzaghi himself reports that he was regarded by his colleagues at the School as someone with "brains and originality," but nevertheless an "adventurer and spendthrift." Undeterred, Terzaghi set to work "with great enthusiasm" and began his first systematic investigations into the properties of construction soils. The nine years which followed (1916–25) were to be perhaps the most significant period in his professional life.

From 1916 to 1918, Terzaghi worked in Constantinople as an educational advisor within the protocol of the influential foreign ministry of the ruling Austro-Hungarian Empire, enjoying the commensurate income and social connections. Not surprisingly, he was later to recollect these years with considerable fondness:

"When I saw the city in its radiant beauty bordering one of the finest harbours of the world, I experienced its spell at once, as many people and many nations did before. . . . These were the two happy years of my life. Only the infrequent incidents of lifeless bodies in white shirts, hanging from tripods on my way to the university, the confusion of the Turkish soldiers in shred-rag clothes rushing in and out of the railway station to be transported to the battle grounds, and the few explosions of an air bombing by the British were the occasional noteworthy events."[4]



Karl Terzaghi

Earlier in the war, the Turks, under the leadership of their rising folk hero Kemal Atatürk, had defended themselves courageously against the British at Gallipoli and prevented the fall of Constantinople. However, in the fall of 1918, the collapse of the Central Front in Europe ended the First World War, and Constantinople came under the control of the Allied Powers. Terzaghi was dismissed from the Imperial School without notice, and overnight found himself, along with his wife and infant child, without any means of support. At this nethermost point in his career, Terzaghi felt humiliated, bitter about the war, and terribly pessimistic about the outcome for humanity. (Though the scion of a military family, Terzaghi abhorred war.)

Soon enough, however, Terzaghi was offered an appointment at Robert College in Constantinople (the present Bogaziçi University), an English-speaking school founded in 1863 by American missionaries. (In 1912 a full, four-year engineering course had been established at the college.) The salary would hardly cover the barest necessities, but Terzaghi had another reason to be less than enthusiastic about the proposed position. He felt "no urge whatsoever to teach," inasmuch as he was "too deeply preoccupied with [his] own ignorance." Nevertheless, as Terzaghi later told the story, he was sitting on an outcropping of rock overlooking the beautiful Bosphorus, contemplating the teaching offer, when suddenly inspiration struck—he visualized what was needed to obtain a rational approach to the problems involved in earthwork and foundation engineering. Progress depended entirely on the development of testing equipment and methods which could provide a quantitative measure of the mechanical properties of the soils involved. On two sheets of paper (still extant in the Terzaghi Library), he listed a number of possible ways to test soils, made sketches of the equipment needed, and suggested how the results could be interpreted. Terzaghi had finally made his fundamental discovery, one that today geotechnical engineers take for granted. He determined that, "Engineering geology cannot become a reliable tool in the hands of earthwork engineers unless and until we acquire the capacity to assign to each material of the earth numerical values."[5]

Within a few weeks of beginning work at Robert College, Terzaghi had set up a small hydraulics and civil engineering laboratory in a room of the Engineering Building. During the week the laboratory's lights were to be seen burning well into the night. Weekends were usually spent on expeditionary field trips along the Bosphorus and the Marmara Sea coast. Terzaghi had begun seven years of "strenuous experimentation" with soils using borrowed measuring devices and apparatus built with odds and ends scrounged from the college dump. His first earth-pressure apparatus was made from empty cigar boxes, and his loading devices consisted of empty oil cans filled with sand.[6] In 1925, with the publication of Terzaghi's first book, *Erdbaumechanik*,[7] the science of soil mechanics emerged from its academic womb.

Five decades later, in August 1973, the First Terzaghi Memorial Lectures on Soil Mechanics and Foundation Engineering were held on the campus of Bogaziçi (Bosphorus) University. Ruth D. Terzaghi, the professor's widowed wife, gave the introductory remarks, and invited papers were presented by a number of internationally renowned guest speakers. At that time, a "modest monument" was inaugurated by Mrs. Terzaghi commemorating the years of service that Professor Terzaghi had spent on the Bogaziçi campus, the place, in Terzaghi's words, "where I laid the foundations for soil mechanics."[8]

Graduate student Aysen Lav demonstrates Terzaghi's direct shear box of 1921, Technical University of Istanbul, Turkey, October 21, 1991.
Photo: Cyril Leonoff

On October 21, 1991, during the research for this volume, Cyril Leonoff and his wife visited both Bogaziçi and the Technical University in Istanbul, where they found the name and accomplishments of Karl Terzaghi to be legendary. Says Leonoff: "It seemed that in meeting the younger professors and students, a representative whose company had actually worked with Karl Terzaghi four decades earlier was himself something of a legend, and we were warmly welcomed." The Technical University possesses some Terzaghi memorabilia, including his roll-top desk and wooden direct shear box of 1921, and today the tree- and shrub-bordered Terzaghi monument occupies an appropriately quiet and reflective corner of Bogaziçi University, below the Engineering Building and presumably near the spot where Terzaghi first conceived of the elemental principles of soil mechanics.

Professor Erol Guler, left, and Cyril Leonoff at Terzaghi Corner, Bogaziçi University, Bebek, Istanbul, Turkey, October 21, 1991.
Photo: Faye Leonoff

From the fall of 1925 until October of 1929, Terzaghi spent his second period of time in the United States, this time at the Massachusetts Institute of Technology (MIT), where numerous new buildings were undergoing large and continuing settlements. While at MIT, he codified the equipment essential for soil testing and made the acquaintance of Dr. Arthur Casagrande (1902–1981), who was to become his principal associate throughout the second half of Terzaghi's career. Like Terzaghi, Casagrande was a native Austrian. He graduated from the Technical University in Vienna before coming to the United States in 1926 with little money and no genuine prospects for work. He gained an interview at MIT, met Terzaghi and immediately began work for him. In 1934 Casagrande moved on to Harvard University,[9] becoming Gordon McKay Professor of Soil Mechanics and Foundation Engineering.[10] In addition to Casagrande, Terzaghi trained several others who were to go on to eminence in soil mechanics, and Terzaghi's tenure at MIT can logically be considered the birth of soil mechanics in America.[11]

Terzaghi returned to Austria in 1930, as a professor at the Technical University of Vienna, and soon his department there became a renowned centre of soil mechanics, attracting students from many countries. And he continued to consult on important projects throughout Europe, North Africa, and the Soviet Union.

In 1936 Terzaghi assumed the role of visiting lecturer at the Harvard Graduate School of Engineering, at which place and time the first International Conference on Soil Mechanics and Foundation Engineering was held, convened by Arthur Casagrande, with Terzaghi elected as first president of the International Society. After Hitler occupied Austria in 1938, Terzaghi moved permanently to Harvard, becoming Professor of the Practice of Civil Engineering, where he taught courses on engineering geology and applied soil mechanics. During this time he also lectured at the Imperial College in London, at MIT, and at the University of Illinois. His books *Theoretical Soil Mechanics*[12] and *Soil Mechanics in Engineering Practice*,[13] the latter co-authored with Professor Ralph B. Peck of Illinois, became the seminal texts for all university courses in this field. Terzaghi also produced more than one hundred scientific papers during the course of his career.[14] Thus Terzaghi and his disciples trained the first and second generations of the world's practising soil mechanics engineers, among whom were the principals of a firm incorporated in Vancouver, British Columbia, a firm called Ripley and Associates, later Klohn Leonoff Ltd.

Terzaghi was never content to restrict his work to experimentation in the laboratory or theorizing at his desk. Early in his career, he realized that soil mechanics could only be successfully applied as a tool in engineering practice through a capacity for judgment gained by years of contact with actual field conditions. Whereas the designer of structures deals with steel and concrete, whose properties are constant when manufactured in accordance with standard specifications, the designer in the field of earthwork engineering has to apply the laws of mechanics and hydraulics to an infinite variety of heterogeneous materials and stratifications formed as a result of natural processes. Design assumptions had always to be verified or modified by observing, first hand, soil conditions as they are exposed and measured during construction. In his paper "Soil Mechanics in Action," Terzaghi succinctly outlined his approach: "Soil Mechanics will not consistently serve its purpose until practising engineers come to realize that it is a supplement to, and not a substitute for, common sense combined with knowledge acquired by experience."[15]

As Terzaghi's controversial theories began to circulate outside of university walls, they were at first met with scepticism among American civil engineers. But, as their validity was consistently demonstrated in civil engineering practice, his ideas soon began to gain widespread acceptance.

Terzaghi's first exposure to the soils of the Pacific Northwest came during his visit to the United States in 1912–13, when he had opportunity to observe the instability of clay slopes in Washington and Oregon. Years later, in 1929, as professor of Foundation Engineering at MIT, Terzaghi was engaged by V. D. Simons Inc., "Industrial Engineers" of Chicago,[16] the designer of the Grays Harbor Pulp and Paper Mill in Hoquiam, Washington. Terzaghi was asked by this firm to analyze the cause of settlement which was occurring beneath the mill's foundation piles at tidewater. In a landmark report, containing detailed computations, Terzaghi determined that the settling was not, as previously believed, the result of "the weight of fill forcing the piles into the ground." In fact, settlement occurred "as if the piles were non-existent." The settlement was due to the gradual consolidation of a soft clay layer, 30 to 50 feet thick, located at an average depth of 120 feet below the surface of the tidal flat, later described by Terzaghi as "drowned valley clay."[17]

Venning Dodge Simons,[18] who in 1914 had founded the firm which designed the Grays Harbor Mill, was, in 1929, still the active head of the design department. The field engineer on the Grays Harbor site was his son, Howard Allan Simons, a 1922 MIT graduate in mechanical engineering. Howard Simons later moved to Vancouver, B.C., where in 1944 he established the international engineering company which bears his name. This contact later brought Terzaghi to several consulting assignments in British Columbia, where geological conditions similar to those in Washington were encountered.

As Terzaghi's stature in the engineering profession became universally acclaimed, his expertise as a consultant was avidly sought in many parts of the globe. But he carefully husbanded his time, selecting only those assignments that were avant-garde, that advanced the science, and demanded artful, novel solutions. Because of its spectacular mountainous terrain and complex valley stratigraphy, Terzaghi in particular favoured British Columbia, and, during the last decade of his career (the 1950s), many of his major consulting assignments were conducted in Canada's western-most province. His principal clients in British Columbia were H. A. Simons Ltd., then building vast forest industry complexes on soft-soil tidewater sites, B.C. International Engineering Company and the B.C. Electric Company, which were constructing hydroelectric dams on formidable valley sites, and the Greater Vancouver Water District, which was building large water storage dams that had to offer assured safety to a surrounding populace.

Karl Terzaghi's greatest influence was no doubt indirect, through the universities. But in working so frequently in B.C. his greatest direct influence, as it happened, came to be upon the fledgling firm of Ripley and Associates during that company's first decade of consulting practice throughout British Columbia.

In Canada, a few pioneer Canadian engineers had practiced the methodology of foundation engineering long before the analytical tools invented by Karl Terzaghi had become available.

Sir Sandford Fleming (1827–1915), born in Scotland, was Canada's pre-eminent railway engineer of the nineteenth century.[19] He was chief engineer of the "Intercolonial Railway," built over a four-year period beginning in 1871. During the construction of this line, the piers of the Miramichi Bridge, in New Brunswick, were found to be settling, due to the fact that they were underlain by silt and clay. Fleming stopped the work, proceeded to enlarge the pier caissons in order to spread the load, and preloaded each pier until the settlement stopped.[20] This bridge has carried the mainline traffic of the Canadian National Railways between Montreal and Halifax until this day, without incident.

Later Fleming became engineer-in-chief of the Canadian Pacific Railway, superintending the surveys through the Rocky and Selkirk mountains. He was the pioneer of the standard time system, necessary for the scheduling of transcontinental train service. Fleming also designed the first Canadian postage stamp—the three-pence issue of 1851—symbolically depicting a beaver building its dam. This motif was later adapted as the logo of the Canadian Geotechnical Society.

Canadian-born Joseph Hobson was chief engineer for the

St. Clair River railway tunnel between Sarnia, Ontario and Port Huron, Michigan, built between 1889 and 1891.[21] In investigating the site, Hobson made detailed soil borings, taking 110 samples in line with the proposed route.[22] During construction of the tunnel, he employed what was then state-of-the-art technology, using a hydraulic shield to successfully bore through the soft clay beneath the riverbed. This tunnel would serve international train traffic for a century, after which time Klohn Leonoff Ltd. would work on a replacement tunnel (Chapter 14).

Quebec-born Samuel Fortier, an 1885 graduate in civil engineering of McGill University, presented a paper in 1896 to the Canadian Society of Civil Engineers (now the Engineering Institute of Canada) on the storage of water in earth reservoirs.[23] This paper, which earned for its author the Gzowski Medal (then as now the senior technical award of the society [institute]), recognized the significance of soil sampling, the mechanical analysis of particle sizes, the void ratio, and the importance of compaction of soils in earth dam construction—all employed in modern soil mechanics practice.[24] (Seven decades later, the same medal would be won by C. F. Ripley and D. B. Campbell of Ripley, Klohn & Leonoff Ltd. for their paper on Seymour Falls Dam in British Columbia [Chapter 4].)

Two classical cases of engineering soils observations have been noted in British Columbia. In 1897 Robert Brewster Stanton, M.A., M.Inst., C.E., read a paper before the British Institution of Civil Engineers on the great landslides that had occurred on the Thompson River near present-day Ashcroft, at the time of construction of the Canadian Pacific Railway in the 1880s.[25] Within a distance of some five miles there were seven large landslides, six crossing the railway line, as well as a number of smaller slips. Twenty miles farther down the river, at a point opposite Spences Bridge, there was a similar large slide. Three of the slides were of giant proportions. The largest, the 100-million-ton Great North Slide of October 1881, actually blocked the river for forty-four hours, causing a huge flood.

Stanton, after careful observations, attributed the slides to irrigation by farmers of the silt terraces above the river, which, when they became saturated, lost strength and collapsed into the river. (Later observation has indicated that the silt is finely layered with clay, and that the seat of shearing may have been in the clay.)[26] In his first assignment in British Columbia in 1951, Charles Ripley was to advise the railways on a later manifestation of slide action in the same region (Chapter 3).

Robert M. Hardy, presented to Charles Ripley, 1957.

Construction of the CPR Empress Hotel at James Bay, Victoria began in 1904 on a site reclaimed from the sea. Marine clay underlies the site to a thickness ranging from a few feet to more than 100 feet. The building was constructed on a foundation of 1,853 timber piles, each about 50 feet long. Settlement observations began in 1912, after settlements were first noticed, and have been continued ever since. By 1971 the differential settlement across the building from north to south amounted to some 30 inches.[27]

In later decades Canada generally lagged behind its more sophisticated neighbour, the United States, in discovering and employing soil mechanics, although there were a few early, isolated "bright lights" within the Canadian academic field.

I. F. "Ikey" Morrison, professor of applied mechanics in the Department of Civil Engineering at the University of Alberta (U of A), may rightfully be described as the father of soil mechanics in Canada. An engineering graduate of MIT, Morrison came to the University of Alberta in 1912. A perpetual student, he began reading Terzaghi's and other works in German, which he then translated into English, and thus Morrison started to include the subject of soil mechanics in his engineering courses.[28] With a keen mind and a gift for sharp dialogue, Ikey Morrison inspired generations of students throughout the thirties, forties, and fifties.[29]

In 1930 a bright young professor, Robert Macdonald Hardy (1905–1985),[30] who had graduated in structural engineering from Manitoba and McGill universities, joined Ikey Morrison in the University of Alberta's Department of Civil Engineering. Morrison encouraged "Bob" Hardy to attend Harvard, then the principal graduate school in soil mechanics, to take the courses offered by Terzaghi and Arthur Casagrande. Hardy did so, from 1939 to 1940, and as soon as he returned to the University of Alberta, he developed a state-of-the-art soil mechanics laboratory there, a facility which included classification, consolidation, and triaxial shear apparatus. In 1946 Hardy was appointed head of the Department of Civil Engineering and dean of the faculty.[31]

Thus, under the impetus of Morrison and Hardy, the University of Alberta became the first soil mechanics school in Canada and the primary training ground for Charles Ripley, Earle Klohn, and several other early staff members of Ripley and Associates, and its successor, Klohn Leonoff Ltd.

The true beginning of applied soil mechanics in Canada dates to the period of World War II, when both Morrison and Hardy initiated the application of soil mechanics to engineering projects in western and northern Canada. They were consultants to Calgary Power and the Montreal Engineering Company on the construction of several early power projects in Alberta. As well, from 1942 to the end of the war, Hardy carried out research studies on muskeg and permafrost for the U.S. Corps of Engineers, who were then hastily constructing the Alaska Highway—the first such tests of permafrost conducted in North America.[32] In 1951 he and Leroy "Chick" Thorssen established Materials Testing Laboratories in Edmonton to provide a commercial soil testing service. Indeed, for many years, until his death in

1985, Bob Hardy continued to develop an extensive consulting practice in soil mechanics and foundation engineering throughout the West.[33]

Concurrent with Morrison and Hardy's work, the other significant application of soil mechanics in Canada was initiated in the Prairie Provinces by the Prairie Farm Rehabilitation Administration (PFRA), a federal government agency that was building water conservation projects throughout Saskatchewan, Manitoba, and Alberta.[34] The catalyst for this work was Dean C. J. (Jack Chalmers) Mackenzie of the University of Saskatchewan, a structural engineer and designer of a number of large bridges in Saskatchewan who, as early as 1930, had recognized the need for the application of soil mechanics technology to foundation design.

One of Mackenzie's students at the University of Saskatchewan, David S. Kirkbride,[35] completed his master's degree in civil engineering in the summer of 1937. With this degree, Kirkbride was able to obtain employment with Monsarret and Pratley of Montreal, the leading bridge consulting company in Canada. But, soon after, as work wound down on design and construction supervision of the Lions' Gate suspension bridge in Vancouver, the firm experienced a business lull. Thus Kirkbride moved on to other employment with Canadian Industries Limited (CIL).

Through his contacts with Mackenzie and the bridge firm, Kirkbride had become aware of the developments taking place in soil mechanics and foundation engineering. Shortly after joining CIL, he applied to the Harvard engineering graduate school and received a Gordon McKay Scholarship worth $400, applicable against tuition. Kirkbride attended Harvard during the winter of 1938–39 and became the first-known Canadian to take the soil mechanics courses offered by Terzaghi and Casagrande.

Since its inception in 1935, the PFRA had been helping drought-stricken farmers to build small earth dams and reservoirs on their properties. In 1939, however, the agency was becoming involved in a few larger dams intended to provide reservoirs for entire communities, and the soil problems inherent in these structures were being encountered. Dr. Mackenzie was influential in recommending to PFRA that, in order to counter these problems, they should utilize the soil mechanics training that Kirkbride had obtained at Harvard. Kirkbride was hired as a junior engineer, but, as events transpired, he worked for PFRA only from his graduation in June to October 1939. During this short period, he set up the first elementary wash-bore drilling equipment to investigate sites and gave some soil mechanics advice on a few dam sites. War came in September 1939, and, feeling that the PFRA would be limited in its activities due to the war, Kirkbride returned to CIL to contribute to the war effort in the building of munitions and explosives plants. After the war, Kirkbride rose to senior management positions in CIL becoming vice-president responsible for engineering and production[36] and so did not make his mark in soil mechanics.

Robert Peterson

Dean Mackenzie was also responsible for persuading Robert "Bob" Peterson (1918–1969), a brilliant 1939 University of Saskatchewan graduate then on the staff of the PFRA, to take the Harvard course, which Peterson completed in 1941. Charles Ripley, who became Peterson's chief assistant in the late 1940s, has noted that civil engineers prior to the 1930s had not generally been expected to receive any specialized training. Because of this, the initial problem faced by most practitioners of soil mechanics was "to gain the confidence of people and persuade them that a foundation should be investigated and analyzed, and that you would have more economical and safer projects in so doing." According to Ripley, Bob Peterson possessed a marvellous ability in precisely that capacity: "He got along well with the different district engineers, and he made a great contribution in demonstrating that there was a place for soil mechanics in engineering for dams."

Though a graduate engineer with Harvard training and the head of a nascent soil mechanics department, in designing earth dams for the PFRA during the war years, Bob Peterson was hard-pressed to carry out the most elementary tasks. Ripley, who in 1941 was a summer student-employee, observed Peterson and his crew putting down drill holes at the St. Mary Dam site using primitive wash-bore equipment. Their tools consisted of some extra heavy 1-inch-diameter pipe for drilling, 2-inch pipe for the casing, and two or three pipe wrenches:

"Washboring is where you have a piece of pipe with a bit on the [bottom] end, a handle on the top [end], and a water supply line into the top of that pipe. . . . Peterson had a bucket brigade of men hauling water up the hill, and a hand diaphragm pump at the hole. . . . The water goes in, down the pipe to the bit, which has some jet points on it, you twist and wiggle the handle, and the water and the pressure of the man on the handle work the bit down into the soil. Every five feet, you pull that pipe out, put a sampling spoon on the bottom of the pipe, and drive it down to get a sample. The samples were driven in by weights that were lifted up by hand and dropped on the drive head at the top of the pipe."[37]

Despite such humble beginnings, Bob Peterson spent his entire career with the PFRA, becoming their chief soil mechanics and foundation engineer. He also worked for years as a specialist consultant, in the process becoming internationally recognized as an authority on earth dams.[38]

During and after World War II, soil mechanics was being practised by various provincial highway departments, but only in its most rudimentary form. For instance, in 1944 one of the earliest Canadian highway laboratories with soil mechanics equipment was set up by G. B. "Gerry" Williams, materials engineer with the Manitoba Department of Public Works, Highways Branch. In 1945 the science was also employed by the federal Department of Transport in the building of several airfields. A number of these projects employed young engineers who had taken training in highway engineering, chiefly at the University of Michigan. But the professor for the course in Michigan, William S. Housel, was reportedly vocal in his scepticism of the theory of consolidation,[39] and the shear strength apparatus that he was using and promoting was very crude.

In the thirties and early forties, there was no school in central and eastern Canada that was teaching soil mechanics courses of the calibre initiated by Morrison and Hardy at Alberta. Nor were soil mechanics principles being applied in engineering practice outside of the universities. In fact, in contemplating the Harvard course, "Dave" Kirkbride had approached the leading foundation company in Canada, located in Montreal, to sponsor his training, with the commitment that he would return to work with them. But they showed little interest. While nearing the end of his course at Harvard, he had also met with the dean of engineering at McGill University, with the idea of introducing soil mechanics into their teaching program. But the worthiness of the discipline was not recognized at the time, and therefore no place was made for it within the McGill curriculum.

Following his first teaching interval at MIT (1925–29), Karl Terzaghi had left behind a core of disciples, students, and professors who continued research and teaching in soil mechanics. Among these was Glennon Gilboy, who joined MIT's faculty in 1926, and Donald W. Taylor,[40] who joined in 1932. Both of these men died relatively young, but both had a lasting impact on soil mechanics. Taylor's book *Fundamentals of Soil Mechanics*[41] became a standard in university classrooms and was the textbook used at the University of Washington when Cyril Leonoff studied there in 1951–52.

R. Boucher, professor of hydraulics at École Polytechnique, had obtained the degree of M.A.Sc. at MIT in 1933. During his studies, he had taken a course in soil mechanics given by Professor Gilboy. A younger colleague, Jacques E. Hurtubise (1911–1987), had received his civil engineering degree at the École in 1934, then obtained a three-year teaching post at the school. After a stint with a consulting structural engineering firm, Hurtubise returned to the École in 1939 to take charge of the materials testing laboratory. That summer Professor Boucher encouraged him to take a six-week soil mechanics course at MIT given by Professor Taylor. Thus in 1939 Boucher and Hurtubise set up a small soils laboratory and instituted a course in soil mechanics,[42] making the École Polytechnique of Montreal the first central Canadian school to recognize soil mechanics. Hurtubise went on to become director of the Civil Engineering Department at the École, and he continued to teach geotechnical engineering there until his retirement in 1977. During his long career, Professor Hurtubise was involved as a soils consultant on such major projects as the Dorval Airport (1941–1944), the St. Lawrence Seaway (1953–1958), the construction of several hydroelectric dams, and the Montreal Metro.[43]

Robert F. Legget, O.C., obtained an honours degree in civil engineering from the University of Liverpool in 1925. Honours civil engineering students at Liverpool were required to take a minor in geology, which comprised both lecture and field work given by the eminent Professor P. G. H. Boswell. This course kindled Legget's lifelong interest in geology and the interaction of this science with civil engineering structures.

In the early spring of 1929, at the age of twenty-five, "Bob" Legget arrived in Montreal. In England he had worked on the investigation and construction of a powerhouse and tunnel, and his first job in Canada was on the construction of a hydroelectric plant, where he had the opportunity to observe the "fundamental importance of geology in civil engineering, and especially the geology of soils," subject matter which had been virtually neglected in technical literature. In January 1934 Legget read a paper on the relationship of geology and civil engineering before the Montreal Branch of the Engineering Institute of Canada (EIC).[44] With the encouragement of his mentor Boswell, this led to the publication in 1939 of Legget's classic first book, *Geology and Engineering*,[45] which included a chapter on "Soil and Soil Mechanics."[46]

In 1932 Legget obtained employment as a technical adviser with the Canadian office of a British steel sheet-piling company, which brought him into contact with foundation conditions from the Atlantic provinces to as far west as Winnipeg. Although not formally trained in soil mechanics, Legget had read Terzaghi's first American articles, published in *Engineering News-Record (ENR)*, 1925. In the spring of 1936, in a short item in *ENR*, Legget read about a forthcoming conference on soil mechanics to be held at Harvard University that June. Thus Legget became one of only eight Canadians, of some 200 engineers gathered from all over the world, to attend the first International Conference on Soil Mechanics and Foundation Engineering.[47]

After the conference, Legget obtained a lectureship in civil engineering at Queen's University, Kingston, where in one room he started a laboratory "equipped for the simple soil tests." But, early in 1938, he received an appointment from C. R. Young, head of the Department of Civil Engineering at the University of Toronto, (who had also attended the Harvard conference) as assistant (and later associate) professor responsible for a course in foundations. Legget spent nine years at this institution, during which time he established its soil mechanics laboratory and took on various consulting geotechnical assignments on dam, mining, northern transportation, industrial, and building projects.

During the war, Dr. C. J. Mackenzie had been co-opted from the University of Saskatchewan to become acting president of the National Research Council (NRC) in Ottawa. Legget has aptly described Mackenzie as "the real founder of organized soil mechanics in Canada." On April 20, 1945, Mackenzie formed the NRC Associate Committee on Soil and Snow Mechanics, which he asked Legget to chair. The name was something of a camouflage, because the committee's immediate "top-secret" job was to research a problem being encountered by the tracked vehicles of the Allied Forces—they were bogging down in the mud of northern France. Beyond the wartime need, however, in establishing the committee, the far-sighted Mackenzie saw that Canada would need a medium for the research and development of soil and snow mechanics for a great variety of peacetime problems.[48]

In October 1939, an early Canadian paper in the field of soil mechanics, authored by I. F. Morrison on the subject of pile foundations, appeared in the *Engineering Journal* of the EIC.[49] At the fifty-ninth Annual General Professional Meeting of the EIC, held at Winnipeg in 1945, for the first time a session was devoted to soil mechanics, co-chaired by Legget and A. E. Macdonald, professor of civil engineering at the University of Manitoba. The two papers presented were by Robert Peterson, soil mechanics engineer of the PFRA, on the investigation and design for the proposed St.

Mary Dam,[50] and by Gerry B. Williams, materials engineer of the Manitoba Highways Branch, on the design and maintenance of prairie highways.[51] These papers were reported to have "aroused much interest and good discussion." In fact, Peterson's was a landmark paper on embankment design in Canada.[52]

At the urging of Karl Terzaghi, president of the International Society of Soil Mechanics and Foundation Engineers (ISSMFE), in April 1947 the Associate Committee convened the first "Civilian Soil Mechanics Conference" in Ottawa, with the expressed purpose of forming a Canadian section of the society headed by Terzaghi. The conference was attended by forty "active Canadian workers in the field of soil mechanics." It was opened by Legget, while Dr. Mackenzie expressed the welcome of the NRC. Dr. L. F. Cooling, head of the Soil Mechanics Section of the British Building Research Station, was an honoured guest. Most of the delegates were from the universities and governmental agencies, as there were then few private practitioners in the field. The western representatives were Dean R. M. Hardy, G. B. Williams, and Charles F. Ripley, hydraulic engineer with the PFRA, representing Robert Peterson. During the technical sessions, Ripley reported on the current work at St. Mary Dam, where construction was about to begin. British Columbia, "alone amongst the provinces," went unrepresented.[53]

Since 1947 forty-four annual Canadian conferences have been held. The first sixteen were under the auspices of the Associate Committee. Then, in 1962, the EIC, which had formed a Geotechnical Engineering Division, assumed the organization of the conference. In 1972 the Canadian Geotechnical Society (CGS) was formed as a constituent society of the EIC, and since then has conducted the annual Geotechnical Conference.[54] As evidenced by the new nomenclature, by that time the words soil mechanics had fallen into general disuse, having been superseded by the more generic term geotechnical. The change was made in order to accommodate broadening of the discipline to include rock mechanics, soil and rock dynamics, and earthquake engineering.

Later in 1947, envisioning the great post-war building boom in Canada, President Mackenzie established the Division of Building Research (DBR) of the NRC, based on the earlier British model. On August 1, 1947, Legget became its first director, a post that he held until retirement in 1969. The objective of the DBR was and is to act as a catalyst for the universities, the design professions, and the construction industry in stimulating research in the building field.[55] Three principal areas of the division's research pertain to geotechnical concerns: foundations and soils; snow and ice; and building problems on muskeg and permafrost in the Canadian North. The DBR soil mechanics research laboratory was established in early 1948 under the first research officer and secretary of the Associate Committee, F. Lionel Peckover, a former student of Legget at Toronto who afterwards took the Harvard graduate course. Later "Peck" was to become the chief soils engineer for the construction of the St. Lawrence Seaway and in 1959 chief geotechnical engineer for Canadian National Railways.[56]

Earle J. Klohn receives Legget Award from Robert F. Legget, Quebec City, October 10, 1990.
Photo: Canadian Geotechnical Society

In September 1963, the first issue of the *Canadian Geotechnical Journal* was published under the sponsorship of the Associate Committee and the EIC. In 1970 it became one of the scientific journals published by the National Research Council and the principal publication medium for geotechnical papers in Canada.

A further milestone in Canadian geotechnical engineering took place in September 1965, when Montreal hosted the Sixth International Conference on Soil Mechanics and Foundation Engineering.[57] On that occasion, R. F. Legget was chairman of the Canadian Organizing Committee, and Cyril E. Leonoff was the British Columbia representative. Then in June 1983, the Seventh Panamerican Conference on Soil Mechanics and Foundation Engineering was convened in Vancouver, with the theme "Geotechnical Engineering in Resource Development." This marked the first time that a North American city has hosted this conference. Raymond P. Benson of Klohn Leonoff Ltd. was chairman of the Organizing Committee.[58]

Robert Legget has for many years, through his writings and in person, been an eloquent lobbyist and publicist for geotechnical engineering in Canada.[59] In 1970 the annual Legget Award, "for excellence in the geotechnical discipline," was instituted in his honour and has become the highest award of the Canadian Geotechnical Society. The early pre-eminence of the West in this field was recognized when Robert Peterson was given the first award posthumously, followed in 1971 by Robert M. Hardy. Later recipients have been Charles F. Ripley in 1987[60] and Earle J. Klohn in 1990.[61]

Chapter Two

THE FOUNDERS

In May 1951, when Charles F. Ripley came to British Columbia from the Prairies with the intention of incorporating a consulting engineering practice specializing in soil mechanics, the term was largely unheard of in the province. The company he founded was called Ripley and Associates, and it was originally a partnership between Charles and his older brother, Herbert A. Ripley. Herbert was the founder and president of Associated Engineering Services Ltd., a municipal engineering company located in Edmonton. By September 1951, with the addition of field engineer Mark T. Olsen, a recent University of British Columbia (UBC) graduate, and secretary Phyllis Middleton, the firm had three employees. By the summer of 1952, "Charlie" Ripley had already established a demand for the specialized services offered by the company, and so Earle J. Klohn, from the University of Alberta, Cyril E. Leonoff, who had completed graduate engineering training at the University of Washington, and Frank J. Pells from that year's UBC engineering class, were hired as additional employees. At the time of these hirings, most staff members were still in their twenties.

Charles Ripley, Earle Klohn, and Cyril Leonoff are considered the founders of the present company. They, like so many of the company's employees, are the descendants of families of European origin, families who left various countries to join the westward trek of immigrants across the Atlantic to North America in the eighteenth, nineteenth, and early twentieth centuries. In Canada, their grandparents and parents came to the West as pioneers, seeking land and new business opportunities. Often beginning with little education and capital, they built homes and communities through hard work and sacrifice, and their offspring were usually the greatest beneficiaries of these efforts.

A client has remarked that it is indeed extraordinary that three persons of such diverse personality and temperament as Ripley, Klohn, and Leonoff could build such a successful company. Nevertheless, each brought different talents that somehow coalesced to build, on the whole, an efficient and productive team, and each partner, in his own way, left his permanent stamp on the company.

Charles Ripley is said to have provided the initiative, energy, enthusiasm, and engineering excellence necessary to found a professional engineering company of the highest quality and integrity. As president through the company's first two decades, he set its course through its formative period, and his engineering work contributed significantly to the post-World War II development of British Columbia. Earle Klohn, the leader during the following two decades, combined unusual capacities as both a prominent engineer and a pragmatic businessman. The most ambitious, visionary, and entrepreneurial partner, he established and oversaw the broad policies for the international and multidisciplinary growth of the company. Cyril Leonoff, it may be said, was the most tenacious man in attending to the many, varied, and often arduous details of operating a consulting-engineering business. Perhaps more even-tempered, conciliatory, and patient than his partners, he enjoyed the human relations aspects of the business in dealing with accountants, bankers, bureaucrats, insurers, investment brokers, recalcitrant clients, staff, suppliers, and tax collectors.

Peter Lighthall, a twenty-one-year employee now in a senior management position with Klohn Leonoff (whose father was an engineering representative for the company's clients on a number of early jobs), has perhaps summarized the principal attributes of the founding partners in saying:

"The character of the company pretty well reflects the founders. Charlie gave the company its integrity—almost to the point of being difficult to do business with. Earle gave the company its vision in that he always wanted to take it somewhere. That integrity—instilled by Charlie and to some extent by Earle—is [reflected] in the principal consultants who still direct the technical abilities of the company. And Cyril gave the company its organization. It has good benefit programs; it's organized well."[1]

In compiling the present volume, a series of interviews was recorded with the principals and staff of the company, and that which follows is excerpted from those interviews.[2]

Charles Farrar Ripley

"On the paternal side, the Ripleys came from Yorkshire, England and settled in Nova Scotia in 1774. The British government had decided that it should encourage settlements in North America in order to provide an assured supply of masts for the British navy. Scandinavia was the usual source of masts, and Napoleon was trying to cut off that supply. So the government established what were called Yorkshire land grants, and a number of Yorkshiremen came over to Nova Scotia at that time.

"On the maternal side, my ancestor Lloyd was in the Battle of Waterloo. There was a subsequent soldier settlement plan, and he established himself as a tailor in Meaford, Ontario. Some of his descendants were inventors and developers of machinery. One of the more interesting was my grandfather's brother, Marshall B. Lloyd, who established, in the United States, the Lloyd Baby Carriage Company, which in my childhood was the baby carriage of North America. He became very wealthy.

"My mother, Edith Pearl Lloyd, was the second of twelve children. Her mother died when she was very young, so she had a very difficult childhood because of the terrible burden of tending all those children. Her aunts arranged for my mother to come out to Lethbridge around 1910 in order to learn to be a milliner—a person that makes ladies' hats. There she met and married my father.

"My grandfather Ripley moved, in the very early period of settlement, to the city of Lethbridge, Alberta. He came out on his own, temporarily leaving the family, his wife and five boys, on the farm in Nova Scotia. His move was related to the first development, by British capital, of coal mines on the eastern slope of the Rockies, needed by the CPR [Canadian Pacific Railway] for operating its trains. Most of the skilled people required for the mines—miners, blacksmiths, machinists—were enlisted from Nova Scotia, where those skills were well developed.

"My grandfather, as well as my father, William Herbert Ripley, worked for the coal company for a few years and then became interested in real estate and ranching. So they homesteaded some land a few miles outside Lethbridge. My father was in the transfer business throughout most of his career. He became involved with the Western Transfer Company, which delivered freight from the CPR yards throughout the city, using horse-drawn wagons. The family farm, in the irrigated district, supplied the feed and allowed for the handling of their own horses.

Charles F. Ripley
Photo: Commercial Illustrators

"I was born on April 7, 1922, the fourth of five children. I spent all of my life in Lethbridge, until I went away to university in Edmonton in the fall of 1940. I look back on those years with great fondness and happy memories, despite the fact that my father had serious problems financially during the Depression. Crops were poor, the transfer business was way down, and he had a family of five to raise. But he was a wonderful man to me, and one of the great things that he taught us was to take joy in our work—that hard work was normal and healthful and should be fun. We were a happy family, and it was a good home—no frills, but no wants. We were taught to respect integrity and honesty as the most important attributes.

"School was easy and interesting for me. First I was enrolled in a kindergarten. Then, at age six, I started in the public school system and I was put into grade two. As fortune would have it, we had an exceptional teacher, and she took our class through grades two and three in one year. So I was quickly two years younger than the average—the youngest and smallest person in the class of both boys and girls—and I always felt a little sensitive about that. I guess I was somewhat delicate, and because I was so much younger than the kids I played with, I was not particularly good at any of the normal games like soccer or softball or basketball. I was very good with marbles, and, as I grew older, I did a lot of skating. In those days we used to skate around the rink clockwise and counterclockwise, and I got to be a good skater from that point of view. But my stamina was never really strong enough that I could be any good at hockey. I didn't start dating girls until after I had finished high school and learned how to dance—it was such a contrast to the present era.

"My father put great emphasis on education and so did my mother. My father had finished his senior matriculation, [but] my mother's life had been so disrupted that she didn't get that far in school. As a result, I think she had an even greater interest in seeing that her children gained a good education. And they both felt the same for boys and for girls. So that the oldest one in the family, my sister Margaret, was sent to university as soon as she was finished high school, followed by my brother Herbert, who attended the University of Alberta. My next brother, Blair, wasn't that interested, and in 1940 he was of age for the first war-time call-up for compulsory military training. He was in the army for the extent of the war.

"So, as soon as 'Herb' was finished, I was sent [1940–44] to the University of Alberta, which was in Edmonton—seemingly a long way from home. But of course I had been prepared for that. It was always fascinating for me when my sister and brother would come home and tell little anecdotes about their life at university. It seemed a wonderful place to me. Also my parents were of the notion that we should be trained to be independent, and therefore that going away to university would be good for us. But I remember Herb cautioning me as to the fact that freshmen could often be hazed in residence. I was to just be sure and blend in: keep my mouth shut or somebody else would shut it for me. You have no idea how scared I was that first month.

"When my father asked me what I would like to take [at university], I said that I thought I would take engineering, because I had been strongest in sciences in high school. Since I was the most delicate one in the family, and because I think he felt that I was somewhat impractical, my father worried that engineering was not for me. He thought that perhaps law would be. So he asked his solicitor to come by our house to have a talk with me about law. Well, it so happened that this lawyer had not been an outstanding success, due chiefly to the hard times in the 1930s. And he was very frank—he wouldn't recommend law. My poor father's concept fell flat, so I went off to university and took engineering. And although I have respect for law and for lawyers, I have absolutely no regrets.

"I was always strongly influenced by my brother [eight years older]. Herb was not an outstanding student, but he had a tremendous thirst for knowledge. I remember as a young child that my father got him a subscription to *Mechanics Illustrated*, and Herb was always tinkering with things. He went through most of the course in electrical engineering, but I think it was disillusionment with one professor that caused him to switch to civil. And I think Herb gave me very good advice: 'I suggest that you register in civil engineering, and if the engineering courses appeal to you, continue in that but keep your eyes open, your mind open—change whenever you want. It is a heavy course and will be recognized if you want to branch out into any other field.'

"But I really had in mind to go into chemical. Of course, in the first two years, all engineers take essentially the same courses. And, while my best marks were in chemistry, the smell and confinement of the laboratory soon convinced me that this wasn't the life for me. I loved the outdoors and thought I would rather be in civil engineering, where I would be outside a great deal. So I was disabused of any previous thoughts about chemical engineering and followed through in civil, for which I have been very happy.

"In the Civil Engineering Department, there were two outstanding professors who had great influence on me—first I. F. Morrison, and then R. M. Hardy. Professors Morrison and Hardy were very interesting fellows, and they inspired all kinds of students. Morrison was one of the first in Canada to teach soil mechanics. He gave an introductory course in our third year and dealt with foundation design under a structural course. In the fourth year, Hardy gave a laboratory course in soil mechanics. I was intrigued by the lab testing—it was a new subject. Under Hardy's direction, a group of students would set up shear and consolidation tests—cut samples, insert them in the consolidometer, and run the test—for his consulting projects.

"I had worked on the Alaska Highway in the summer of 1942 and had some acquaintance with soil investigations for the highway. So my interest in soil mechanics was easily sparked.

"When I graduated in 1944, there were just two agencies in which I was interested. One was with the federal Parks Department—they were planning a big road program in Banff and Jasper. The other was the Prairie Farm Rehabilitation Administration—they were concerned with the development of large dams and irrigation projects in the Prairies. I was very interested in working with the PFRA—I had grown up in an area of irrigation around Lethbridge. And I had also met Bob Peterson, who was introducing soil mechanics to the PFRA, headquartered in Saskatoon. But the Parks job offered considerably more pay. So I went to Professor Morrison to ask him for advice. When I described these jobs to him, Morrison looked at me with great scorn and said, 'Ripley, why did you come to ask me? Obviously with one of them you will learn something. Go there.'

"So I went to work immediately for the PFRA, and that summer I was out on field investigations. And during the winter of 1944–45, I was engaged on an interesting program, under Dr. Neil Hutcheon,[3] testing rock samples from the St. Mary Dam site at the laboratory located in the engineering building of the University of Saskatchewan. Part way through the winter, Hutcheon said, 'Charlie, you should consider taking graduate work.' And my comment to him was, 'Neil, I'd like to. I don't have any money, that's my problem.' He replied, 'That's the poorest excuse in the world for not proceeding to further studies. For goodness sakes go out and borrow the money.'

"Thinking about where I should go, I went back to the University of Alberta to talk to Morrison and Hardy. I went to Morrison first. 'Ripley,' Morrison said, 'you come back here, and between Hardy and I, we'll give you enough special courses towards a master's degree.' So I was cheered up by that because the expense would be relatively nominal. Then I went to see Hardy and he said, 'Ripley, that's not the solution. Don't come here, go to Harvard. I will support your application and you'll go there. But there's one thing you can do for me—apply to come here, the sooner the better. I need the application in order to persuade the faculty council to set up a graduate program.' So I did this, and they started the graduate program in soil mechanics at Alberta in September 1945—at the same time that I was off to Harvard. That was typical of the adroit administrative moves that Bob Hardy would make. It was wonderful advice for me—not just the Harvard education, but also getting out and being exposed to another country.

"And then I talked it over with Bob Peterson. It was not customary in those days for an agency to finance education. After thinking it over, he said, 'Just raise the money and go to Harvard' [rather than a less expensive university]. You'll laugh today at what then seemed a phenomenal sum—the total cost for transportation, living, and fees was $2,000. But my salary with the PFRA, until I got back from Harvard, was only $150 a month. My father was not living then, and actually I borrowed the money from my mother. I was hesitant to do that. When I got down to Harvard, I asked the dean if there was any way that I could get some financial help. After Christmas they granted me the fees for the second term.

"I just loved Harvard. Arthur Casagrande was head of the graduate school program in soil mechanics and gave most of the lectures. In the war years he had devoted his energies toward courses for military officers, so that by the time I was there, he seemed tired and a little bit cranky. Dr. Casagrande was a hard taskmaster and made it plain from the start that he expected only the best. That's wonderful training for a student—although today's society tends to frown on it. But he was a marvellous lecturer—his eyes just shone when he got up in front of a class. We revered the ground he walked on.

"Terzaghi gave only one course at that time—Engineering Geology. He would say, 'These are your textbooks; [his *Theoretical Soil Mechanics*, which had recently been published, and another book on geology by Arthur Holmes] read such and such.' Then his lectures wouldn't include any of that material—they were on practical case studies. We took copious notes. When it came to examination time, we had no idea of what kind of questions he would ask, and all of us were in dread of the exam. He didn't shine in front of the class—just a venerable teacher, very positive about everything—and it was a fascinating experience. But you didn't have any feeling of closeness to him—his office was almost out of bounds. You see, Dr. Terzaghi was a very disciplined man. He realized that he had unusual gifts, and that he had to guard his time to devote to original research and preparation of his book *Soil Mechanics in Engineering Practice.*

"Dr. Terzaghi's wife Ruth, a geologist, was in the laboratory in a research position, and I enjoyed chatting with her. [In 1928, Ruth Doggett, who was studying for her doctorate in geology at Radcliffe College, called on Karl Terzaghi at MIT to obtain some information on scientific matters. His reaction to her personality was 'instantaneous and decisive.' They were married in 1930, after she had received her doctor's degree.][4] The other person that I treasured getting to know a little was Juul Hvorslev, who was doing research for his book on the art of soil sampling, funded jointly by Harvard University and the Corps of Engineers.

"In the first term, just after the end of the war with Japan, there were only two Americans in our class of about fifteen. Most of the students were from South America—Brazil, Chile, and Venezuela. One classmate was a professor at the main university in Chile. There was a Greek, and a Chinese-American from Hawaii. It was obvious that I and David C. Hall, a graduate of Princeton who had taken soil mechanics courses from Gregory P. Tschebotarioff, were just yards ahead of the others in preparation. And we found the laboratory program very easy, whereas the others were just stumbling. In the second term there was a big influx of American and other Canadian students.

"When I graduated in May 1946, the universities were preparing for a great influx of veterans. Again, few of them had any formal training in soil mechanics. Then, out of the blue, I got a letter from the dean of engineering at the State University of Iowa offering me a job on the faculty. He had never seen me, but I found that I had been referred to him by two Albertans—Jack Forster, one of my classmates, and Leroy Thorssen, an instructor—brilliant men. So I thought, my goodness, that man will be expecting me to be as bright as they are. I talked to a doctoral student I had worked with in the laboratory, and he said to me, 'You know Ripley, I suppose when you finish here, you will go to the university, and you'll teach exactly what they have taught you here!' That really shook me, because it brought to my attention that I needed some practical experience. So I turned down the university job, with regret.

"Just before leaving Harvard, Arthur Casagrande said, 'Ripley, I've got a job for you. I'd like you to go out to British Columbia on the Bridge River project—they need someone like yourself.' He was a consultant to Shawinigan Engineering on the diversion dam at Bridge River, and I had been doing some triaxial tests on the project for him. This bothered me, because if he suggested you should do something, then you did it. But I had already indicated to the PFRA that I would be coming back. Bob Peterson was counting on me, and I knew they had a big construction program coming up. So I had to refuse Arthur Casagrande, which wasn't an easy thing to do. However, he said he understood.

"At that time, the Canadian government was looking to immediately initiate projects that would employ veterans. The St. Mary/Milk River irrigation project in southern Alberta, which involved several dams, had been approved by parliament, and final engineering was proceeding at a rapid rate. So I was sent out by the PFRA on construction there from the summer of 1946 until January 1949. St. Mary Dam was precedent-setting in Canada. Designed by Bob Peterson, it was one of the largest dam projects undertaken until that time. It was the first design based on the application of soil mechanics principles—investigation of the foundations and the construction soils—and the first in which significant instrumentation was installed. The technical concern was for the strength of a 200-foot-high embankment, of which the principal component was clay.

"In the fall-winter of 1944–45, I had been out with a diamond drill getting cores and carrying out laboratory tests to determine the elastic properties of the bedrock foundation. When I returned from Harvard in 1946, we investigated the borrow pits and irrigated them to a reasonable moisture content before construction began. The first dam started was called Pothole, a few miles away—smaller in height but built of the same materials. At Pothole Dam we installed the first piezometers and settlement devices—types that had been used by the U.S. Bureau of Reclamation. Then St. Mary Dam proceeded.

"The problem that we faced was enforcement of the specifications with regard to quality control of the earth construction. There was a lot of airport and highway construction happening at the time, with similar specifications that were not being rigidly enforced. We insisted that Pothole Dam be built according to the specifications regarding water content and density control. As a result, the contractor got into financial difficulty and filed claims for extras, and was, rightly in my opinion, given some relief on compassionate grounds.

"Also the civil engineers in the Administrative Division had no comprehension of the seriousness of building a dam of such dimensions and felt that we were 'gilding the lily.' St. Mary was a precedent-setting dam in Canada, and because we were concerned about the long-term strength of the clay, I wanted very good records kept of every sample we took out of the dam—all the data, weather, everything. And I knew there could be disputes with the contractor over costs. I prepared rate sheets so that all these records would be kept. These were ridiculed by the project and resident engineers, who told me that the sheets should be in a simpler form. Nevertheless, it is a good dam and [forty years later] I really don't anticipate that there will be any difficulties.

"My wife Dorothy and I were married in October 1947. At that time I was in the field on the St. Mary project during the summer, and then back in Saskatoon headquarters in winter. Our office and laboratories were at the University of Saskatchewan. I had met Dorothy while she was a student there in household science. Her father, Ira Russell McKendry, was a well-known medical doctor and specialist in surgery at Melfort, Saskatchewan. He was also interested in farming and managed a substantial acreage close to town.

"Our first children were twins, born in October 1948 while we were living in the construction camp at St. Mary Dam. We were forty-five miles from the city of Lethbridge. It was a pretty busy time in our little house, and we were only able to get by with the help of my mother-in-law. The children were rather delicate and had feeding troubles, so we prepared their bottles using boiled water and condensed milk. Then we had a small washing machine for all the diapers. With all the moisture in this little house—it was only eighteen by twenty-four feet—the walls just dripped. At the time I made $225 a month. I think engineers were then paid perhaps a little more than school teachers, but not much. You could buy a lot more for a dollar in 1948, but we still had to be very, very frugal in our expenditures.

"In January 1949, I was transferred back to Saskatoon. The federal government had voted $2 million to intensive studies for the South Saskatchewan River project. Up to this time, preliminary investigations had been carried out at a series of sites from the Alberta border to just south of Saskatoon, but now the intensity of studies was being greatly increased. I took over the direction of the geotechnical studies for the project, which included the site of the present [James G. Gardiner] dam, and also for a secondary dam in the Qu'Appelle Valley, near the town of Elbow [Qu'Appelle Valley Dam]. The studies involved detailed subsurface investigations for the dam sites, as well as investigations into suitable sources of concrete aggregates and earth materials to be used in construction. Two years later, at the end of 1950, it became apparent that the government was not going to proceed with the project in the near future. So I gave thought to other work.

"Actually I was very happy with the PFRA. I was Bob Peterson's senior assistant. My salary had risen to $425 a month. We had a total staff, including field drilling crews, laboratory technicians, and engineers, of nearly a hundred. The work was challenging; it was interesting. But I felt that the longer I stayed with government, the less likely I would be to change. And with the apparent drop off in the government's interest in the South Saskatchewan project, I began to wonder whether, in being a government employee, I was missing out of something in life by not being in business."

Earle Jardine Klohn

"Klohn is a unique name. Anyone who has the name spelt that way is a relative. I believe it originated in Alsace-Lorraine. The sons emigrated off to different countries, and they kind of got lost. The problem in those days was keeping track of people. The families were large, and the oldest would be producing offspring while the youngest might not even have been born yet. So you get generations all mixed up, and it's very difficult to sort them all out. I have bumped into Klohns in South America and in Switzerland who are cousins several times removed. My grandfather Klohn and grandmother came from Europe to Winnipeg sometime in the 1880s. I believe that he worked for the railway. My father was born in Winnipeg—the youngest in the family. So I only remember my grandfather as a very old man, and don't know much about him.

Earle J. Klohn
Photo: David Roberts

"On my mother's side, the McLeods were some of the original Scottish settlers in Ontario—going back at least 200 years. They came out by oxcart and homesteaded in the Interlake Region of Manitoba. My mother, Florence, was born in Stonewall. I had aunts and uncles who, up until a decade or two ago, had farms around Gypsumville on Lake Manitoba—in fact their farms bordered on the old lake-boat harbour.

"My grandfather McLeod sold the farm and moved into Winnipeg. He had a team of horses and became a freighter—hauled things and ploughed with the horses. But he caught pneumonia, for which there was no cure at that time, and died relatively young.

"My mother was a chief operator for the telephone company for many years. She was quite an athlete—the big superstar on the ladies' hockey team around World War I. She had scrapbooks, cut from the newspapers with headlines, 'McLeod Scores Again'—quite exciting for me as a kid.

"I was born in Winnipeg in 1927. My father, Frank, was a machinist there for Simmons [bedding company]. Then the family moved to Edmonton when I was ten years old, where my father worked for Canadian Bedding for many years. I remember Winnipeg—I was old enough for it to make an impression. But my formative years were really in Edmonton. I went to Eastwood High School, which had grades one to twelve. I entered in grade four and went right through high school there. I was athletic—played hockey, football, soccer, and basketball.

"In the early 1920s, Edmonton had been the victim of tremendous land speculation, and the city was spread out over a very large area. On the outskirts there would be only one or two houses to the block—the rest would be open bush, trees, and creeks. Berries—saskatoons and choke cherries—grew rampant in these places, and we had only to cross the street to pick them. And the river valley was all undeveloped—all trees, top to bottom on both slopes—and it was a great place for kids—ravines, animals, everything.

"I am the oldest of four siblings and the only one to go to university. Engineering sounded like an interesting thing to do. Several other fellows, a year or two older, from our high school were taking engineering. Actually, I thought mining engineering would be the exciting stuff, and that's what I registered in. Ironically, mining's an industry for which I ended up doing a lot of work in the last two decades. The courses for civil and mining were very similar for the first two years, then you had to decide what option to take. By then I knew that mining engineers spent all of their time out in the bush, and I was a little more interested in the civil side of things, so I switched to civil.

"My first two years of university life were hectic. Classes were filled, the school was overloaded, with very few places to eat a proper lunch, or to do anything else for that matter. This was the beginning of the post-war veterans' influx, and classes were the largest that had yet gone through the university. In our graduating class there were close to one hundred civil engineers.

"Professor Morrison, quite a learned gentleman, was the father of soil mechanics at the University of Alberta. He had introduced these courses many years before I was a student there. But by my time he was in very frail health and didn't have anything to do with the graduate students. R. M. Hardy was the leader of the Soil Mechanics Club at the U of A, and all the graduate students were under his leadership.

"When I graduated in 1950, in all of western Canada there were no private consultants, certainly that I knew of, in the field of soil mechanics. Hardy set up his practice later that year, and Charlie Ripley started his in 1951. I had subscribed to the American Society of Civil Engineering [ASCE] magazine, *Civil Engineering*, and through their advertisements wrote to three or four American companies that looked interesting. Eventually I did get an offer, which I accepted, from O. J. Porter and Company of California. Porter was a former employee of the California State Highway Department who had gained fame as the inventor of the fifty-ton super-compactor, which had proved its versatility in providing high densities in thick lifts of subgrade fill. Porter and Company were also the big sand-drain people in building freeways through the eastern part of the United States."

[By coincidence Klohn had followed another ex-Albertan to California to work for the company that the latter had founded and made internationally famous. O. J. Porter was born and raised in a small town on the Canadian side of the border south of Cardston, Alberta. Though unknown and uncelebrated in his own country, he made a sizable contribution to the United States war effort. Untrained, Porter worked his way to California where he found a job as a technician—virtually a labourer—in the laboratory of the State Highway Department. Prior to that time, construction equipment used to compact highway bases, which carried relatively light car and truck loads, consisted of small "wobble-wheel," rubber-tired rollers and steel-drum "sheepsfoot" rollers. During World War II, there was great need for improved airport runways to carry airplanes which were constantly increasing in weight. An innovative and creative man, Porter pioneered the concept of larger and heavier construction equipment, particularly the use of very heavy pneumatic rubber-tired rollers. These were used to compact thick layers of runway base soils to high density, which were thereby capable of supporting aircraft wheel loads without failure.]

"So I arrived at their Sacramento office, which had fifteen to twenty people in it. Bill Jervis managed the office. He had been a well-known civil engineer with the Corps of Engineers, and had joined Porter to be his chief dam designer. The chief engineer in the office, the man who had hired me, was Reinhard Brandley, a master's graduate of the University of Alberta [and a contemporary of Charles Ripley]. Brandley had gone to Harvard to obtain his Ph.D., but he got into a dispute with Casagrande—refusing to change something in his thesis—and never received his degree.

"I was in the Sacramento office for only a few months when they opened an office in Los Angeles, and I moved there to set up a small soil mechanics laboratory. I got the equipment together and did some work in the lab, but I was working mostly in the field, on all kinds of jobs. A well-known one was at the Willington Oil Fields in Los Angeles, where we were drilling and sampling. The ground was subsiding, and they were raising the dykes to gain more freeboard. And they were using bentonite slurry trenches to cut off the underseepage—another thing in which Porter was a leader.

"I came back to Canada because of rather unfortunate circumstances. The Korean War broke out in 1950, and all reciprocity deals between the Canadian and U.S. governments on citizenship went down the tube. If I was drafted, they told me that corporal was the highest rank I could attain in the army, and I couldn't be involved with anything secret. There was also some question as to what effect this would have on our citizenship. (I was married by that time.) My employer, Bill Jervis, was very good about this. He checked with the recruiting people and advised me that it was a waste of my time to stay down there.

"So I came back to work at the University of Alberta laboratory for Bob Hardy. Then I spent January to April 1951 in the Yukon, running drilling and exploration crews for the new bridge across the Teslin River. This was my second job in the Yukon. The first, as a student, had been in 1949 as survey party chief on Mayo Lake Dam for the Montreal Engineering Company.

"As fate would have it, I almost got killed in 1949, flying in a DC-3, and would never have become an engineer. We were caught in a white-out—one of those squall storms that come up—between Whitehorse and Mayo Landing, heading for just a mud strip on the Stewart River. We were flying low, at 1,500 feet, down a narrow valley. So there were mountains on both sides. You could see only the tree tops and a tiny creek below. The stewardess came back and gave everybody their overshoes and parkas, and said, 'Put on your clothes and boots because we have a little emergency.' I had half an hour to contemplate eternity. Then the pilot just came over the trees and dropped onto the mud strip. Had he missed, we were all goners. The people waiting for us to land never even heard the airplane—it just suddenly appeared, and bang it was on the runway—pretty exciting stuff. Years later, I was talking to one of the CP [Canadian Pacific] Air pilots about this incident. He said, 'Oh yeah, the guy that flew that run knew every tree on the route.'

"When I came home [to Edmonton] in the spring, I was sent to Kitimat—the first engineer on the ground there—and stayed for five months. This was the initial drilling program for the aluminum smelter site and the wharves. The whole area was treed, the loggers were just moving in, and it hadn't been cleared yet. There were no roads. It was very interesting. Being a prairie person, I hadn't been exposed to the problems of tides and tidal currents. We were drilling on the tidal flats and moved the drill between holes by dragging it onto a floating scow by means of a tow rope. Normally we had enough freeboard, but one time there was a twenty-five-foot neap tide. It was dark, the middle of the night, about one o'clock in the morning. The scow upset because it was partly on ground, partly in the channel, and the drill fell into the water. All the oil and gas drums floated away. We were up to our armpits in water, standing out in the middle of that delta. One could easily have drowned out there if you weren't too careful. We all managed to climb into the boat, abandoning everything, and went home for the night. It took weeks to gather up all the oil drums.

"I had been accepted into graduate school at the University of Alberta for September 1951, on a fellowship to study the effect of calcium chloride on maintaining densities of road base courses. But it wasn't until November that a gentleman named Hans Dutz came up to replace me. The university people weren't too happy about this, but since it was the dean who had delayed me, I entered without too many problems. By the next spring, I had finished my course work, and unbeknown to me, was about to be launched on a consulting engineering career that would consume the next forty years of my life."

Cyril Edel Leonoff

"The Leonoff family originated in the southern Ukraine, in a city called Nikolayev, which is situated at the junction of the Bug and Ingul Rivers, just upstream from their entry into the Black Sea. Nikolayev was a substantial city, larger than Winnipeg[5] was when my grandfather arrived there in 1903.

"Because it now forms part of the company name, I'd like to think the origin of the Leonoff name is of interest. At the end of the eighteenth century, during the reign of Catherine the Great, the Russians drove the Turks out of the Black Sea North-Shore Region and captured the fortress of Ochakov, not far from Nikolayev, building a naval base there. An ancestor of mine of Jewish-Russian descent established the first overland transportation and mail service between that base and Kiev, the capital of the Ukraine. He was honoured by the Czar and given the name Léonov—son of the lion. In America, the name was anglicized to Leonoff, a rare name on this continent.

"My grandfather was the only one of several brothers to emigrate to Canada. A branch of the family also went to China, but most stayed in Russia, and my own knowledge of them is very limited. A number of prominent people in Russia bear the name, but we have no idea of the relationship. The cosmonaut Aleksei Léonov,[6] for instance, the first man to walk in space, bears the family name.

"The Leonoffs were small-scale merchants in Russia, and my grandfather Joseph continued as a storekeeper in Winnipeg. My father, William, was just ten when he arrived in Canada. Following the family vocation, he rose to senior management positions in major dry-goods and clothing warehouses, which were prevalent in Winnipeg when that city was the main trading centre for the West. Residing there throughout the remainder of his life, for nearly seventy years, he always described Winnipeg as the greatest place in the world to live.

"My maternal grandfather, Joseph Edel Brotman, came with his family to Montreal in 1886 from a small town near the city of Lvov [Lemberg], in Galicia, which was then a province of the Austro-Hungarian Empire. He was an educated man, and it's said that he was fluent in seven languages. In Montreal, my grandparents planned to start a bakery, which no doubt was a family trade. (The name in German is pronounced Broitman—'bread man.') But the oldest son, Charles, who was nineteen at that time, had heard of the free lands available in the West and persuaded the family to homestead, which they did in 1889, north of Wapella, Saskatchewan. My grandfather and his three eldest sons all took out homesteads and farmed a section of land [640 acres]. Because of his fluency in languages, grandfather was also appointed immigration agent for the district, which was being settled by a multinational, multilingual European population.

Cyril E. Leonoff
Photo: Commercial Illustrators

"My oldest uncle, Charles Brotman, had ten children and moved to Brandon, Manitoba, where he felt they could receive a better education. The farm he purchased near Brandon was on very fertile land, and it remained in the family until the mid-1930s when it became a part of the Dominion Experimental Station. "Charlie" was also one of those colourful characters indigenous to the West. Off-season he was a fur trapper and trader, roaming across the Prairies and the North. I recall, as a child, being fascinated by the wondrous tales of his adventures in 'Eskimo-land.'

"My mother, Rose, one of the younger of ten siblings, was raised on the farm. Because the settlers around Wapella did not build a one-room country schoolhouse until 1898, she received only four years of schooling. Furthermore, although she was a lefty, in the country school they made her write with her right hand; consequently she felt self-conscious about her poor penmanship. However, while living in Winnipeg, she worked her way up to a clerical position with the brokerage firm of Osler, Hammond and Nanton. Because her older siblings had large families and suffered extreme hardship in the early years, my mother resolved to have a small family—just myself and my older sister. Both my parents wanted us to have a good education, and my sister started university, but dropped out after a year or so and soon got married. My father always expected me to have a professional career—didn't care what field it was in—as long as it was professional.

"My mother's youngest brother, Ernest Brotman, was idolized by the family because he was the only one in the family to gain a university education, and he became a prominent Winnipeg lawyer, alderman, and police commissioner. My father, although he always worked full-time during the day, educated himself through night school.

"I was born in 1925 and brought up in Winnipeg's teeming North End, populated by various working-class ethnic groups such as Ukrainians, Poles, Czechoslovakians, and Jews. But, because our family was middle-class, we lived in the newer, northern part of the district, near the boundary of the historic Scottish settlement of Kildonan—so there was also a considerable British element. At Luxton School, when I attended, the teachers were almost always women—the daughters and granddaughters of the original British settlers. They were very strict. We were endlessly drilled in arithmetic, reading, writing, spelling, and grammar—any skills I have in these subjects originated from this formative period. The teachers—to us they seemed awfully old—had usually taught our older siblings.

"Miss Sybil Inkster, of a mixed-blood pioneer family, taught grade nine, which was the highest grade. She had a remarkable memory for the names of every person whom she had ever taught. The first day in class she went around the room and asked, 'Are you so and so's brother, or so and so's sister?' When she got around to my classmate Gerry Mensforth [who later became an engineering colleague], she said, 'Oh Gerry, is ______ your brother?' 'No!' he replied, 'He's my father!' She really blushed at that. 'Old-lady' Inkster was a fixture in the district, living on the family estate until well into her nineties.

"St. John's Technical High School, grades ten to twelve, was located in the heart of Winnipeg's ethnic ghetto. 'Tech' must have been the most multiracial school in the world, and it produced a potent mix—academically, culturally, athletically, and politically. High achievement and stiff competition were the rule, engendered I think by the families' desire for their children's upward economic and social mobility. This only reflected the realities of life at that time for those people, but it may account for the high success rate of the school's students in later life—in business, the professions, government, and the arts. As well, the school was presided over by an outstanding principal, Mr. C. J. Reeve, who believed in and practised democracy in the school system—an idea well ahead of its time.

"You learn from today's historians just how economically depressed that region was, especially in the 1930s. Yet most North-End Winnipegers will tell you what a wonderful place it was to grow up in. As kids we enjoyed every minute of it. In winter there was tobogganing, snowshoeing, and skiing, as well as outdoor rinks for skating and hockey. In summer there were open fields for baseball and football, bicycle routes, and nearby river and lake beaches. Who had time for vandalism? Culture flourished—symphony, ballet, theatre, and visiting celebrities. Politics was a hectic concern. The labouring classes generally favoured the C.C.F. or the Communists, but, since many of the immigrants had been encouraged to come over during the progressive Laurier regime, and were influenced by J. W. Dafoe and his *Winnipeg Free Press* (one of the outstanding newspapers in the country), there was also strong support for the Liberal Party—especially by the business element.

"I started at the University of Manitoba in 1942. I was seventeen, and for the first two years was in the general Arts and Science Faculty. I was somewhat directionless—had no idea what career I wanted to embark upon. I worked in my father's warehouse one summer and in my uncle's law office another, but neither of these piqued my interest. [Later, a room in the law office premises, the Confederation Building, would house the first Ripley, Klohn & Leonoff Ltd. office in Winnipeg.] I loved the outdoors, and a course that I took in geology fascinated me.

"In the summer of 1944, I was fortunate to be employed on a Geological Survey of Canada field party in the foothills near Jasper, Alberta—the first time I had ever seen a mountain. War in Europe was raging, so that fall I enlisted in the army. I asked to join the engineers. Instead I was assigned to the Royal Canadian Signal Corps and sent to their headquarters in Kingston, Ontario to take a year's training as an electrician and instrument mechanic, servicing field telephones and tank radios. After this I was posted to the Signals Research and Development Establishment, located at the NRC in Ottawa. By then the war was over, and I was demobilized in the late fall of 1945, having decided on a career in engineering, which I thought to be more practical than science.

"In January 1946, I enrolled in the first veterans' engineering class at the University of Manitoba. This was under a good arrangement for service people—many of whom before the war could not afford to go to university. The government paid our tuition and gave us a living allowance. While I was only owed for two years' service, because I was near the top of the class they continued payment for the entire four years. And since I was living and boarding at home, at no charge by my parents, I had ample spending money and savings, which I later used for graduate training. Because many of the veterans had been in the services throughout the war and were now married and raising families, this was a mature, serious, no-nonsense class. Several of the sixty members of this class of '49 went on to significant careers in civil engineering.

"The immediate post-war civil engineering faculty at Manitoba was strong in two disciplines—structural and surveying. Professors A. E. Macdonald, W. F. Riddell, and Jack Hoogstraten were all experienced engineers and good teachers, and we spent a lot of time designing steel bridges, plate girders, and reinforced-concrete buildings. We were also taught classroom and field courses by two venerable, old-school railway-survey professors. Thus, on the verge of Canada's great airport, highway, and dam building era, budding engineers were learning to lay out archaic boundary surveys, and railway curves and frogs, none of which had any great relevance to their future careers. There were no soil mechanics theory or lab courses. Only one younger professor, Oscar Marantz, taught an elementary highway course that included rudimentary reference to soil mechanics.

"Yet soil mechanics problems were recognized in Manitoba as early as 1913, following the classic failure of a large, concrete grain elevator in Transcona that year. Macdonald cited this case in his structural course. The building was founded on a raft foundation over soft saturated clay. Within a period of twenty-four hours after being first filled, shear failure caused the building to tip spectacularly—on one side a full twenty-nine feet below the original grade. On the other side it rose five feet. It was righted and underpinned by installing concrete piers between the elevator and bedrock.[7]

"Charlie Ripley has noted that Dean Macdonald, of the University of Manitoba, was a forward-looking man. He recognized the need, but at that time, there were just very few people trained in soil mechanics. For four or five years after Charlie graduated, he received letters from Macdonald, pleading with him to join the staff of the University of Manitoba. With the exception of Alberta, which fortunately had Hardy, most of the other universities right across the country were devoid of soil mechanics people.

"This situation was to change after I graduated. The Sixth Canadian Soil Mechanics Conference was held in Winnipeg in December 1952, chaired by Dean Macdonald, and attended by 110 persons. By this time, the university had a full-time professor of soil mechanics on its staff.[8]

"I had always wanted to come out to the West Coast, where four of my mother's siblings had settled in the 1920s. By coincidence, in 1948, between third and fourth years, I had applied for student employment with Public Works of Canada, and, out of the blue, I was assigned to their New Westminster office. Apparently they were impressed enough with my work that Ken Morton, the district engineer, invited me, upon graduation, to join his permanent staff.

"I had already met my future wife, Faye Matlin, when she was taking Arts at the University of Manitoba. Faye's father and grandfather were both tailors, coat and dress designers in the needle-trade industry, first in Liverpool, England and then in Winnipeg. We graduated concurrently in May 1949, married, and jumped at the opportunity offered us by Ken Morton to come to the West Coast.

"In my early years here, 1948 to 1951, British Columbia was in a state of deep economic depression. The old coalition government was reactionary; the resource industries were stagnant. Jobs were scarce and pay was low. I started out as a graduate engineer at a salary of $215 per month. And Faye, who worked as a doctor's assistant, made $100 a month. Morton, the district engineer for all of British Columbia and the Yukon, who had been with the department for forty years and managed a staff of 100 persons, earned a meagre $6,000 per annum.

"The federal Public Works office was located in New Westminster since, from historic times, the Fraser River had been the main route of commerce into British Columbia. The department was responsible for the river engineering—dredging the channel, clearing snags, placing marker buoys, and training of the river. Our office also did the engineering design and maintenance of the hundreds of harbours and government wharves upcoast, serving the steamships, fishing and logging industries, as well as pleasure craft. At the time I arrived, the office was archaic[9]—staffed mainly by older engineers, many of whom had not gone to university, but had received their engineering training by apprenticing on the job. They had a great deal of practical experience, but were not up to date in modern technology. Our design drawings were meticulously drafted by pen and ink on linen. Certainly soil mechanics was unknown in the office.

"I worked under Major A. E. 'Archie' Paget[10]—a venerable engineer from a distinguished engineering family. Several of his brothers and nephews were engineers. Paget had received his engineering training by apprenticing with the CPR and, over a long career, had constructed railways, highways, bridges, and concrete dams in the army during World War I, in northern Alberta, the Okanagan, Central and South America, and as a consultant in Vancouver. He had entered government service in World War II as resident engineer on construction of army and air force bases, and when I arrived on the scene, he was six or seven years beyond normal retirement age. We were responsible for construction and maintenance of some 100 ports and wharves on northern Vancouver Island and adjacent islands. Archie Paget was the first 'real' engineer I had worked with, and I gained a great deal of know-how from him. For the remainder of his long life, we were close family friends, and indeed he was of some assistance to us at the beginning of our consulting practice.

"I worked with Public Works for two years, and I gained a great deal of experience in design, specification writing, and construction. Many of my peers were satisfied with a rather relaxed, unworried, but uneventful career in the public civil service. However, I was more ambitious and felt that, if the department was to adequately face the modern era, the younger engineers needed academic training in the problems that we encountered, such as wave forces on bulkheads and breakwaters, foundations, approach fills, and roads. So I approached Ken Morton and told him that I wanted to get more training and that I thought it would help the department. 'You know,' he said, 'I've never had a request like this in my whole career—somebody wanting to go and take post-graduate work. I want you to stay on with the department. We like you.' He supported the request, and wrote to Ottawa recommending leave with half-pay. But, at that time, headquarters was not receptive to the idea, and responded by saying that they would be happy to keep Leonoff on staff while he was away—but with no pay. So I had to go out on my own. I took the position then that, okay, I'll take this leave of absence, but I'm under no obligation to return. This incident 'broke the ice' for successive government employees, who routinely were allowed leave, with pay, for further studies.

"The University of Washington, in Seattle, provided a ready opportunity for me. It was one of the few universities that gave port and harbor engineering courses, had a good soil mechanics faculty, and gave state-of-the-art classes and laboratory training in highway engineering and asphalt paving technology—all useful to the work on which I was engaged. Commencing in January 1951, I received free tuition and a fellowship, under Professor Robert G. Hennes, to do research on wave forces on breakwaters. The fellowship paid $200 a month, and Faye, in her line of work, received a sixty percent increase—the then differential between the cost of living in New Westminster and Seattle—so we managed.

"Washington was a revelation compared to Manitoba. In our Manitoba class there were no international students. In my Seattle courses we had classmates from India, Turkey, and Japan, as well as Americans. I was the only Canadian. Classes were on the quarterly semester system. The professors had broad practical experience and taught by the case-history method. My soil mechanics professor was Richard Meese, a Harvard classmate of Bob Peterson, who also did consulting for Shannon and Wilson, the principal soil mechanics firm in the area. There was even a lady professor on staff—the first time I had ever encountered a female engineer.

"Working straight through to the summer of 1952, I completed my research thesis and received a master's degree in civil engineering. The research was of some significance and was in fact later published. I also did some consulting work for 'Bob' Hennes on a railway crossing of the Great Salt Lake. Upon graduation, there were opportunities for me in the United States—in consulting, and in the doctoral program at the University of California, Berkeley. As well, a number of government agencies, such as the Bureau of Reclamation, had expressed an interest in hiring me. But our first child was just three months old, we were flat broke, weary of the deprivations of school life, and anxious to return home to Canada."

Chapter Three

BRITISH COLUMBIA: FIRST CONTACTS

Charlie Ripley has said that it was discussions with his older brother Herb that were the "triggering mechanism" which caused him to look outward from his government position. Herbert Angus Ripley, born in 1914, was the oldest son of the family. At home he was considerate of his parents, helpful with household duties, and set a good example for his brothers and sisters, thereby enjoying their respect. Following two years of work, Herb attended the University of Alberta from 1934 to 1940, graduating as a civil engineer. While not a brilliant student, he was hard working and achieved good to excellent marks in the subjects he liked. He was also popular and well regarded at university.

After his father's death, Herb assumed the position, and was accepted, as head of the family. He apparently lived up to his adopted stature quite well, often helping his siblings with both advice and money.

According to Charlie, one of Herb Ripley's strongest traits, displayed at home, in school, and in working life, was his independence of spirit—Herb liked to do what he chose to do on his own terms and at his own speed. An example of this characteristic was his naval career. After enlisting in the engineering section of the Canadian navy during World War II, Herb found himself in Halifax doing very little, awaiting further action by officialdom. Finally he issued his own fiat of sorts—he didn't intend to waste his life in Halifax. Instead he would occupy himself with a consulting firm in the city which was doing strategic work.[1] The navy wasn't used to being told what to do by a junior officer, but Herb did it anyway, and they obliged by releasing him for this work.[2]

At the end of the war, in 1945, Herb Ripley started in private practice in Alberta. He established his own firm, Ripley and Associates, and later Associated Engineering Services Ltd., which became a major municipal consulting firm in Alberta and British Columbia, with headquarters in Edmonton.

As Charlie Ripley has explained, during the time that he was working in Saskatchewan, there was no one practising as a consultant in the field of soil mechanics anywhere in the Prairie provinces. But Charlie had an affection for Saskatoon and Saskatchewan, and, while working for the PFRA, he spoke to a number of senior engineers there asking them if he could expect to make a living as an independent consultant. The responses he got were "mostly negative." It was felt that it would simply be too difficult to persuade the general engineers and contractors at work in the field in Saskatchewan that there was a need and use for soil mechanics.

While at work on the St. Mary Dam in 1948, Charlie had met Paul Cook, a 1940 graduate in civil engineering of the University of British Columbia. Cook, under the aegis of the British Columbia Research Council (formed at the end of World War II), had been employed as a research engineer with the B.C. Department of Public Works. That department was responsible for highways and bridges, but, under the terms of his employment, Cook was also permitted to work for other government agencies, and for a time he was engaged by the provincial Water Rights Branch working on earth dams. During this period, Cook had been tutored by Dr. Alex Hrennikoff, structural professor at UBC, who, during graduate studies at MIT, had taken some soil mechanics courses. UBC offered a course in highway engineering, so that a basic laboratory had been set up which included some simple soil tests—grain-size analysis, compaction, Atterberg limits, and permeability. Thus Cook had become interested in soil mechanics, and wrote to the PFRA asking if he could "come out to gain experience on dam construction."[3] The request was happily accommodated, and in the fall of 1948 Cook worked for two months as a field inspector on the St. Mary Dam. During this time Charlie Ripley and Cook became well aquainted, and, because Cook was very interested in establishing a laboratory in British Columbia, they often spent evenings perusing various drawings of apparatus, such as consolidation and triaxial equipment, that were being developed and used in Saskatoon.

After returning to Vancouver, in 1949 Paul Cook established a small consulting practice and drilling business in the soil mechanics field. And, at this time, he approached Charlie with a proposal—that Charlie join him in business. Charlie gave the offer serious consideration. Then, with the intention of joining Cook, in the winter of 1951 Ripley made the decision to leave the PFRA, gave the agency a few months' notice, and put his house up for sale. He travelled to Vancouver in March 1951—his first trip to Vancouver—intending to talk with Cook about the business arrangements they could make together. However, on this visit, Ripley became apprehensive about joining Cook directly:

"At that time, Cook was doing some work for the B.C. Electric Company and a few engineering and architectural firms. He had an operating laboratory—consolidation equipment, a shear box, perhaps an elementary triaxial machine—but the limited amount of work couldn't justify employment of a full-time technician. As well, most of the work was drilling investigation. And I felt that the drilling was, to some extent, a conflict of interest with an engineering practice."

So, in May of 1951, Charlie moved to Vancouver to establish an office of his own, working as a pure consultant—that is he wished to avoid being involved with a laboratory or with the business of a drilling company:

"I told Cook that I would be happy to use his facilities and, in that way, help him expand the amount of work in these areas. Paul was not very happy about this—I think he felt that I should join him. And, in the early consulting work I obtained, I found it difficult in getting any kind of schedule from Paul's lab because of his limited staff. It wasn't a good fit. So, in effect, we just drifted apart—he went his way and I went my way."

Ripley had in fact been in British Columbia on an earlier assignment, while still with the PFRA. The agency had received a request through the government to send a representative along with J. L. Charles, chief engineer for the western region of the Canadian National Railways (CNR), to visit a recent landslide that had disrupted the CNR line in the Thompson River valley. As Ripley relates the story:

"Bob Peterson was busy and said he couldn't go—would I go? Perhaps he did this out of kindness to me, knowing that I was moving out to British Columbia. So Charles and I travelled by private railway car to the site, which was just opposite Shaw Springs in the Thompson Valley. This was a relatively small slide compared with the historic, massive slides farther north at Basque and Spences Bridge, which had occurred at the turn of the century following construction of the railway, cultivation, and irrigation of the high silt benches. The present concern was related to a stretch just above the river's high water level—where there had been chronic subsidence of the tracks. This was during the Korean War period, and the government was very concerned about the risk to trans-Canada communication because in this location both railways were on the same side of the river. So I commented in particular on this area and also gave my thoughts about the larger landslides."

With this one exception Charlie had no experience whatsoever in British Columbia and very little concept of the variety of terrain and subsurface conditions. When he had told Bob Peterson of his intent to move to British Columbia, Peterson's droll comment was, "Well Rip, all you'll need out there is a set of sieves, because all they've got are sands and gravels."

Ripley would soon learn that the soil conditions in British Columbia are much more

CN Rail slide, Thompson River, B.C., Charles Ripley's first job in British Columbia, May 3–5, 1951.
Photo: Charles Ripley

complex than Peterson had appreciated.[4] The province's mountainous terrain gives rise to the perennial hazard of avalanches and landslides, the classic instance being the Thompson River valley slides mentioned above by Ripley. That same rugged terrain also necessitates construction on very deep, soft deposits of silt and clay which lie at tidewater in many of B.C.'s coastal fjords—a problem best illustrated by Ripley's later work at Kitimat. Perhaps most critically, British Columbia lies within an active earthquake zone, and so there arise problems of safety for water storage dams and the potential for river valley sand and silt building sites to liquefy under ground motion conditions.

However, as yet unencumbered by any detailed knowledge of these complex problems, Charlie Ripley began his Vancouver practice as a one-man operation.

The first office was established at 1156 West Pender Street in an old clapboard building which, recalls Ripley, housed the small office of the Association of Professional Engineers of British Columbia and the building's owner:

"N. C. Sherman was a mechanical engineer who was a [sales] agent for water and sewer pipe as well as a number of British companies—BSA guns, a motorcycle firm, etcetera. I had a room in his building and was able to use his secretary for typing letters and that kind of thing.[5] In those early months, I was all by myself doing contact work. I really didn't know anyone, and of course B.C. people were completely unaware of the PFRA organization that I had come from. My initial task was to get out and meet people and try to indicate the services that I could provide. So the first month or two I spent contacting people and writing letters of introduction to architects and engineers. Luck probably was the greatest factor in my favour."

C. F. RIPLEY, B.Sc., S.M.
M.E.I.C.
P. ENG. (CIVIL)

File: B 3
PHONE
CE. 4444

RIPLEY AND ASSOCIATES
CIVIL ENGINEERS
CONSULTING AND INSPECTION SERVICE
EARTH DAMS - EMBANKMENTS - FOUNDATIONS
VANCOUVER

1608 West 5th Avenue
~~1156 WEST PENDER STREET~~
VANCOUVER, 9, B.C.
November 26, 1951

The company's first letterhead, as shown, described the services offered. It is interesting to note that soil mechanics was not mentioned, perhaps because it was a term then unfamiliar in the region.

Charlie Ripley had indeed chosen an opportune time to begin his practice. In the early 1950s, coincident with the founding of Ripley and Associates in Vancouver, British Columbia was on the threshold of an unprecedented economic, population, and construction boom. The previous two decades of depression and war, and their aftermath, had left the province's cities in decay, its buildings shabby, and its industrial plants archaic. And even in 1950, buildings, bridges, and industrial plants in British Columbia remained relatively small. They were required to bear comparatively light loads, and were often built of flexible construction materials, such as wood posts and beams, corrugated iron cladding, and timber piles, that allowed these structures to bear considerable settlement with little consequent damage.

Moreover, prior to the fifties, building sites of high bearing capacity (on rock and glacial-till soil) were readily available, forestalling the need for construction on the soft and compressible silt, clay, and loose sand deposits of the river valleys and deltas. Since they were serving small populations, hydroelectric and water supply dams were small. City freeways were undreamed of. The provincial highway system, through seemingly insurmountable mountain ranges, could perhaps best be described as preliminary. Airfields were few and rudimentary. All this was to change over the next two decades, coinciding with the progressive, sometimes flamboyant administration of Premier W.A.C. Bennett (1952–1971),[6] a government which had replaced the moribund Liberal-Conservative coalition of previous years.

With post-war improvements in the technology of transportation, particularly as regards the commercial jet airliner and the improved mobility of populations, people were coming to British Columbia in large numbers from many nations of the world. They brought with them money, ideas, entrepreneurship, and optimism. Yet the bulk of British Columbia's new population resulted from a westward migration of Canadians—some were from central and eastern Canada, but more often they were the second- and third-generation sons and daughters of Prairie families. This grassland migration was caused in large part by the continuing mechanization of farming, and the steady improvement of farm-to-market routes, with the resultant decline of small-town railway service centres and of rural populations. Young people were graduating in large numbers from the Prairie universities, and as professionals they were seeking new opportunities, opportunities which could often be found in resource-rich British Columbia. Fuelled by a voracious post-World War II demand for consumer products, development of British Columbia's forestry and mining industries was accelerating quickly, and this, combined with the development of water power and an improved transportation infrastructure, precipitated an unprecedented period of expansion.[7]

Charlie Ripley recalls the harbinger of this period:

"In March of 1951, the Aluminum Company of Canada (Alcan) announced that they were going to proceed with the construction of a very large aluminum smelter upcoast at Kitimat. Their plans involved the damming of the Nechako River and its subsidiaries in order to create a power source. This project was a tremendous shot in the arm for British Columbia, which in effect had been in the doldrums industrially and economically since the war—the result of the cessation of armament production and shipbuilding. As a matter of fact, the whole country was rather quiet. About the same time, with the Korean War on [and the Cold War], the Department of National Defence had announced a very large program of expanding old, and constructing new facilities right across the country—armed forces depots, airports, and, in the North, radar stations. So these factors created the beginning of a lot of construction activity and many opportunities for soil mechanics to be applied in Canada."

Sometime in July 1951, Charlie began to get "a little work." Some came from John Read, a structural engineer doing work for various architects, and some from the B.C. International Engineering Company [IECO] on B.C. Electric's Wahleach hydroelectric project. Later, more work came from Alcan. Charlie was also engaged to investigate and report on certain military sites and buildings.

A few months earlier, in May of 1951, Arthur Casagrande, Terzaghi's close associate, had made a visit to Vancouver in connection with the Bridge River hydroelectric project. Charles Ripley had in fact done work on this project while still at Harvard—triaxial tests on very soft clays—and at that time Casagrande had wanted him to go out on site inspection (Chapter 2). So it was to be expected that Casagrande, upon his visit to B.C., would contact Ripley. And so too did Charlie know what to expect: "He contacted me, and he was upset—he always tended to overwork himself, and with the troubles at Bridge River his nerves were pretty taut. He said, 'I have a few days here and I would enjoy spending some time with you.' So he did that—he had meals at our house, I drove him around, and we picnicked on the beach, which was very good for him."

Arthur Casagrande examining clay samples at the field laboratory, Mission Dam, July 5, 1960.
Photo: Mark Olsen

During the visit, Ripley told Casagrande of the massive landslides that had occurred on the transcontinental railways in the Thompson Valley of British Columbia.[8] Casagrande was interested and mentioned that Dr. Terzaghi had just written a paper on landslides[9] and would also no doubt be curious. Both Casagrande and Terzaghi were scheduled to return to B.C. in July of that year, in connection with the Bridge River project, and so Casagrande suggested that Charlie arrange a trip with the railway, such that the two professors could view the landslides. Casagrande was not reticent in adding that contact with the railway would do Charlie "no harm."

So, consistent with Casagrande's request and prior to the professor's return to Vancouver, Ripley contacted St. John Munroe,[10] the CNR district engineer in Vancouver (a man who, after retirement, for a short time would become a consultant to Ripley and Associates). Munroe was enthusiastic about the proposed trip and arranged with the B.C. area manager, Bernard Allen, to use the latter's private car to view the massive slides. The visit was made in early July by Doctors Terzaghi and Casagrande, Charles Ripley, and Munroe, who also invited along his counterpart with the CPR, a man named Tommy Price. The suggestion had also been made to invite the geologist, Victor Dolmage, who was then giving the railways advice on their problems. So Ripley had phoned Dr. Dolmage and was told that, although he was very interested, Dolmage couldn't join the excursion, due to a conflict of scheduling.

It seems that it was in fact Dr. Dolmage who had suggested that B.C. Electric obtain the opinion of Terzaghi on the Bridge River problems. Dolmage attended these meetings, visited the site, and this was the beginning of a strong friendship between Doctors Terzaghi and Dolmage. That fall, when Ripley became involved in the Wahleach project, he met Dr. Dolmage in person, as he was by then consulting for B.C. Electric on the power tunnel at that site. Charlie was immediately impressed, and it was not an impression which diminished with time. Charlie came to respect Dolmage "very greatly," and the two became good friends.

Born in Manitoba, Victor Dolmage (1887–1980) obtained his B.A. in geology from the University of Manitoba in 1912, and a Ph.D., with majors in geology and mining engineering, from the Massachusetts Institute of Technology in 1917. He worked with the Geological Survey of Canada in British Columbia from 1912 to 1929, becoming chief of the B.C. Division in 1922. Assisting in the mapping of large areas of Vancouver Island and the Queen Charlotte Islands—this while living with his wife on a boat—Dolmage began a lifelong study of the wide variety of soil, rock, and mineral deposits that occur in British Columbia.[11] During his tenure at the head of the Geological Survey, in the Chilcotin region of British Columbia Dr. Dolmage was to discover and measure the height of an "unknown mountain," later named Mount Waddington, which at 13,177 feet is the highest peak in the Coast Mountains of British Columbia.[12]

Years later, Ripley's field inspector Frank Pells would run into people who had worked for Dolmage on these surveys of the British Columbia Interior: "One couple, he'd run the pack train and his wife had been the cook. They held [Dolmage] in great regard and had kept in touch with him. They said Dolmage was very good to work for and hard working himself, a very sensible person, with a nice sense of humour."

In 1929 Victor Dolmage began practice as a consulting geologist based in Vancouver, specializing in mining geology, and later in engineering geology related to the major hydroelectric, dam, tunnel, and industrial developments in British Columbia. Perhaps Dolmage's greatest fame came in July 1958, when he planned and executed the blasting of Ripple Rock, a serious navigational hazard in Seymour Narrows between the mainland and Vancouver Island.[13] As Charlie Ripley recalls of Dr. Dolmage:

"He was the eminent engineering geologist on civil projects, certainly in western Canada. He was very deliberate of mind and thought, had a warm and likeable personality, and was very highly principled. His knowledge of the province was vast in connection with both civil and mining projects—he knew the province almost like his backyard. I became involved with him in so many projects subsequently—almost any project in which our company needed geologic advice, we just automatically utilized Dr. Dolmage [until his retirement in 1974]."

At the beginning of his practice in British Columbia, Charles Ripley was to establish contacts with numerous clients and colleagues that would irrevocably set the long-term course for his company and contribute markedly to its future success. His relationships with Dr. Karl Terzaghi, the founder and world's expert in the practice of soil mechanics, and Dr. Victor Dolmage, the pre-eminent engineering geologist of British Columbia, were no doubt key in both respects. Over the next decade, Ripley and Associates was


Victor Dolmage, presented to Klohn Leonoff, 1975.

to work with Dr. Terzaghi on more than a dozen major engineering projects. And Dr. Dolmage would have a close working relationship, as a consulting geologist, on a good many of these same projects.

By chance, Ripley was soon to simultaneously meet two other people of great importance to his company's future—one was to be his first employee and the other an important client. Charlie recalls that he met the former, Mark Olsen, "during an Engineering Institute of Canada field trip to the Clayburn brick plant at Abbotsford." Some time earlier, Charlie had contacted Stuart Lefeaux, secretary of the local branch of the EIC, to express his interest in this trip, and, as Charlie was unfamiliar with the route, Lefeaux had suggested that he join two other people who would be driving to the plant that day. Charlie happily agreed, and the driver of the car Charlie travelled in was Frank Bunnell, a young engineer with the Greater Vancouver Water, Sewerage and Drainage Districts who was later to rise to the position of commissioner. The other passenger was Mark Olsen, who had just finished his engineering degree at UBC.

Mark had joined the EIC while still an engineering student, and attended their meetings frequently. He was one of only a very few students to do so; the rest of those attending were mainly professors at the university and a few engineers from private business.

On the trip to Abbotsford, when Charlie asked Mark how he was occupying his time, Mark replied that he was "busy graduating." He didn't plan to look for a job until such time as he had fulfilled a family obligation to carry out a number of repairs on his parents' home, repairs that he hadn't had time to do while attending university. With that labour completed, Mark intended to begin looking for engineering work.

Mark Theodore Olsen was born on September 18, 1926 in Calgary. His father, Harold Olsen, who was a steam engineer, had emigrated from Denmark to Canada around 1908, working first on a farm, then in a machine shop. During World War I, Harold joined the Canadian army, and while overseas he met and married an Englishwoman named Dorothy Parker. Upon demobilization, the senior Olsen took out a veterans' land grant in Alberta, but did not remain long on the farm. In the mid-1920s, he worked on construction of the Imperial Oil refinery at Calgary, then joined the staff at the Imperial Oil powerhouse, working there until his retirement.

Mark's maternal grandmother was living in Vancouver so, in the early 1930s, the family began to make visits to British Columbia. There was no Trans-Canada Highway in those years, and Mark recalls just how rugged the trip to the coast was:

"It was quite an adventure—must have taken four or five days. We were driving all the time, but you'd have to stop and wait for the ferries [across Kootenay, Arrow, and Okanagan lakes]. We took the American route, intending to cross back into Canada at Kingsgate [southeast of Creston, B.C.], but we encountered a strange situation with the American border authorities. My mother was born British but when she married my father, she also became a Danish citizen. My father was by then naturalized as a Canadian citizen, and the immigration agents let him through the American border. My mother, however, was still considered Danish, and she had to get a visa. She became extremely upset over that.

"There was a hotel near Creston, a place with cottages—it was all pretty rustic, and my father couldn't get over the fact of all these orchards—it was sort of semi-tropical compared to the rigorous climate in Calgary. I recollect travelling on the paddle steamer across Kootenay Lake over to Nelson. I remember the streetcars at Nelson. Travelling north through the Dukhobor area, my father pointed out a chimney standing among burnt ruins—probably of a school, because the Dukhobors had burned the schools. Then we took the ferry across Arrow Lake at Fauquier and stayed at a two-storey lodge with many rooms and piles of furs—it would be nice and smelly out in the hallway. Then we went over a very rugged road to Vernon, and down to Kelowna where we took the ferry across Lake Okanagan. At Princeton, we had to get the front bumper welded back onto the Chev. From Merritt we drove over to the Thompson River, then down the Fraser Canyon to Vancouver where the old Cariboo Road, in places, was a one-way trestle hanging over the sides of the cliffs. Those are my first recollections of the West."

The Olsen family moved permanently to Vancouver at the end of World War II, after Mark had finished high school. Mark's father had talked about having a chicken ranch when he retired. According to Mark, "a lot of Prairie people talked along these lines." So the Olsens bought a semi-rural property in South Burnaby and Mark, who remained a bachelor, lived with his parents. Mark's father had his chicken ranch, and all the people in the neighbourhood came around to buy eggs from him.

But the ranch was more of a hobby than a business, and Harold didn't make much money. Inflation nibbled away at a retirement fund that had looked "pretty good in '49," and the family would have been in a difficult situation if Mark hadn't been living at home. As his parents became elderly Mark assumed greater control of the management of the property: "I gradually started paying the expenses and taxes. And every once in a while something would come up—like you'd have to put a new roof on the house, so you put a new roof on the house. It didn't pose a problem to me."

Mark Olsen had an early interest in engineering, in part it seems because of his father's work. In particular his father's workplace in Calgary had made a big impression on Mark, who remembers it vividly as "a smelly place" with numerous steam engines and boilers. After the family's move to Vancouver, Mark's father encouraged him to attend UBC, and Mark did so. His progress through university was the most general that he could find—electrical and mechanical engineering, even mining and geology were too specific. He wanted to have "latitude." However, at UBC, after two years, an engineering student had to make a decision:

"If you went one way, you took a summer school of surveying, and if you went the other way, you took a summer school of drafting. So I took the surveying and civil. The professor who impressed me most at UBC was Sam Lipson, in structural. The fellows who gave me the toughest times were Alex Hrennikoff and Archie Peebles, who presented the subjects closest to soil mechanics, but just in passing. Peebles [who was later to work for Ripley and Associates in the summers] gave a highway course where you did Proctor compaction tests and a few things like that in the lab. And the main professor, Hrennikoff, gave a difficult course on all the graphical solutions for earth pressures on retaining walls—such as the Coulomb Theory—that people think very little of these days."

Later, when Olsen learned from Charlie Ripley about the University of Alberta courses, he could only conclude that UBC was "primitive" in terms of soil mechanics.

Mark's graduation from UBC in 1951 coincided with the first significant job that Charles Ripley procured as a consultant:

"I received a call from W. G. 'Bill' Huber, general manager of the B.C. International Engineering Company.[14] The Vancouver office had been established primarily to carry out the engineering feasibility studies for the power phase of the Alcan Kitimat-Kemano project. In addition, they were doing some engineering for the B.C. Electric Company and had designed the Wahleach high-head power project on the Trans-Canada Highway between Chilliwack and Hope. A small earth dam was to be constructed there. They were a very busy office and didn't have anyone able to look after inspection of the earthfill. So Bill Huber asked me to give him a proposal on being responsible for inspection of the dam. I'm not sure how he became aware of my background, but of course I was very interested. My proposal was to place an engineer on the site full time, and that I would visit the project once a week to guide him and to check that things were going satisfactorily. And my proposal was accepted."

Charlie immediately thought of Mark Olsen as the needed on-site inspector because he had liked "Mark's forthrightness and the fact that he was a big fellow, which is in anyone's favour out on inspection of earth construction." The summer of 1951 was hot and dry, resulting in a forest closure over the whole southern part of the coastal area, so the work couldn't proceed until the rains began again in the fall. Fortuitously, this delay would allow Mark time to complete the repairs of his parents' home.

Upon going in for an interview, Mark recalls Charlie Ripley's immediate circumstances—"a rabbit-warren kind of office on Pender Street in the worst building you could imagine." But Mark found Charlie himself to be an impressive figure with a pleasant, likeable personality that was quite different from anything Mark had encountered before. What's more, Mark was impressed with Charlie's attitude: "He outlined the job in a general way, and he seemed particularly anxious that anybody who worked for him should take a practical, realistic approach. Charlie cited an example of not using your head that stuck with me for years: An engineer had designed a retaining wall for him and placed the rebars so close together that they couldn't get the aggregate through. I took the job and was Charlie's very first employee."

Mark reported for work on his twenty-fifth birthday, September 18, 1951. An early job was to move the office, on Thanksgiving Day. Charlie attached a trailer to his car, and he, his friend Jack Forster, and Mark Olsen loaded all the furniture into the trailer and moved it to a building at the corner of Vancouver's Fir and Fifth streets. As Charlie describes it, this office was slightly larger than his original space, but hardly palatial: "I shared [it] with Fred McMeans, a mechanical engineer who acted as an agent for different mechanical equipment suppliers.[15] And we shared a stenographer, Phyllis Middleton, a very nice girl. We had three small rooms, one for the secretary, and then Fred and I each had our own room."

The new letterhead of Ripley and Associates, issued from this office, was more explicit than the first, with soil mechanics emphasized in bold letters:

C. F. RIPLEY, B.SC., S.M.
M.E.I.C.
P. ENG. (CIVIL)

OUR FILE: B 3
YOUR FILE:

RIPLEY AND ASSOCIATES
CONSULTING ENGINEERS
SOIL MECHANICS
FIELD INVESTIGATION - LABORATORY TESTING - INSPECTION OF CONSTRUCTION
EARTH DAMS - EMBANKMENTS - FOUNDATIONS

PHONES
OFFICE: CEDAR 4444
RESIDENCE: KERR. 3095-R

1608 WEST FIFTH AVENUE
VANCOUVER 9, B. C.
February 13, 1952

Just three weeks after Mark started with the company, the renowned Dr. Terzaghi arrived in Vancouver, and Charlie organized a luncheon at the Hotel Vancouver. Said Charlie to Mark, portending the importance of the event, "I want you to wear a suit." All of the other men invited to the luncheon were professors from the university, and Mark recalls clearly his feelings as the luncheon commenced: "There was a big, long table seating all these professors—and up at the top was Dr. Terzaghi, and down at the end—Mark Olsen. I guess they were all looking at me and wondering what I was doing there." (Ironically, Mark would later become Terzaghi's principal field assistant in British Columbia.) During the course of the luncheon, Terzaghi asked about the courses at UBC in soil mechanics, and was dumbfounded to hear that half of the course work in the final year for civil engineering was comprised of structural lectures and laboratory work, with a full twenty hours per week devoted to bridge design. In typically laconic manner, he asked of Professor Hrennikoff, "How many bridges could you possibly need in B.C?" Hrennikoff's reply, lame though it was, was that he taught a few classes where he talked about "bulking of soils."

The objective of this meeting, instigated by Charles Ripley, was to persuade the UBC civil engineering faculty to establish a soil mechanics laboratory, which would be available for instruction, but which could also be used for commercial testing, as no such facility was then available in the province. Terzaghi had agreed to help Ripley promote this proposal and spoke at the luncheon of the great need for the facility and of the opportunity presenting itself to the university. However, and to Charlie's great frustration, the UBC professors were not receptive, stating that the purpose of the university was to teach "fundamentals" not "technology."

There would soon be a change in attitude. In 1953, Bob Spence, trained at the Universities of Alberta and Harvard, came to UBC to initiate the first undergraduate soil mechanics program. Spence recalls that, at the time of his arrival, "Dr. Hrennikoff had given a sort of graduate course once or twice—he gave Paul Cook a course in soil mechanics. They had a direct shear machine that Hrennikoff was busy trying to make work, but it was a piece that they should have kept for a museum."[16]

Despite such an inauspicious beginning, today UBC's Geotechnical Department ranks with the best in the country.

Soon after the luncheon with Terzaghi, Mark Olsen travelled to the Wahleach Dam site and, with limited training and no experience, began a career as an inspector of earth dam construction. A job that was supposed to last three months spanned the remainder of the decade. Three construction seasons at the Wahleach Dam were followed by five years as Dr. Terzaghi's personal field representative on B.C. Electric's Cheakamus Dam at Garibaldi, B.C., and at the Mission Dam at Bridge River.

Charles Ripley has observed that Ripley and Associates was the first firm in his area to sell clients on the need for site inspectors during the construction period, and Mark Olsen's inspection efforts at Wahleach Dam were probably the first such services ever undertaken in British Columbia. His instructions from Charlie were to know the B.C. International Engineering specifications "backward." The experience of the people constructing the dam was with the U.S. Bureau of Reclamation, and Mark's contact on site was W. G. Huber, the manager, someone Mark has described as "a rather difficult gentleman." According to Mark, Huber's attitude was that "when a design was finished, you just sent the drawings out the door, and someone else built it." Any problems in the design that might arise were to be resolved "in the field." Mark experienced "some real eventful times."

Mark was not only doing field density and laboratory tests, but also construction inspection—checking to see that work was done correctly—and writing weekly reports. The B.C. Electric people had a rudimentary Construction Division that looked after surveying, but these men were unfamiliar with dam construction. Mark discovered that the borrow material they planned to use was "a bunch of boulders mixed with organic material," and such inferior material would likely have gone into the dam, except for Mark's presence. He directed the contractor to pits that contained more suitable material. The contractor also had trouble obtaining supplies of riprap. So Mark had the contractor establish a large rock quarry and, with one enormous blast, bring down the supplies. As well, he was asked to supervise the precast-concrete spillway construction. Finally, the dam was being constructed in an active logging area, and raising the water level could flood the roads—so that, too, had to be carefully overseen.

The contractor, Northern Construction Company, hadn't encountered anyone like Mark Olsen before and tried to take "every advantage that they could." But Mark was undaunted: "I just stuck to my guns—closed them down twice." Both the contractor and the surveyor were outraged on these occasions and told Mark, "You won't have a job tomorrow—because you don't do this kind of thing." Both times when Mark halted operations, a delegation arrived the next day representing the client, the engineer, and the contractor—"all kinds of people, hopping mad." But, according to Mark, the contractor "looked at [him] a little differently" after having to walk a shovel up onto the site and dig out "all the things that I was complaining about—he had to start over again and do it right."

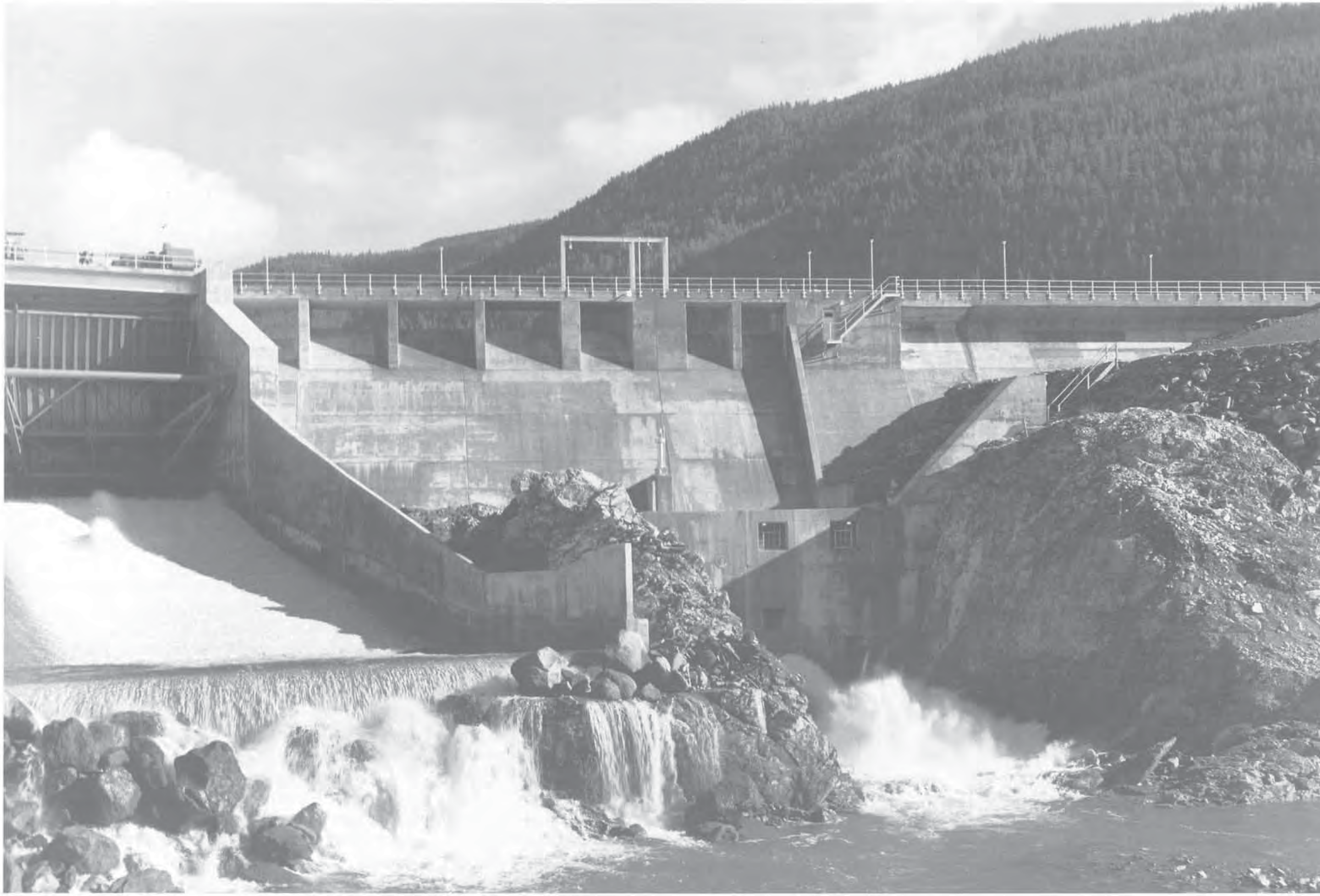
F. A. Lazenby was chief civil engineer for B.C. Electric—responsible for the civil end of the hydro-generating works and for dealing with the design people and contracts. According to Charlie Ripley, Lazenby was a sometimes-disguised blessing for his young company:

"We worked with 'Eric' Lazenby over a long period of time. He was a very interesting man, quite bright, but very caustic and vitriolic in some of his comments—chiefly related to people and any of their work that was substandard. Not that I wasn't occasionally the butt of some of his comments. You never were too sure where you stood with him, but I am sure we had his confidence. I had a lot of respect for him because he really was interested in the welfare of the company for which he worked. He was extremely loyal and only wanted good quality work done."

Mark Olsen didn't know it at the time, but it was Lazenby who had backed him up at the Wahleach project. When Mark later started work at Garibaldi, he came with Charlie Ripley to see Lazenby, and Lazenby's first remark was, "Well, have the scars healed over from Wahleach?" Still later, at the Mission Dam site, Lazenby would sometimes drop in at Mark's office to chat. On one such occasion, Mark asked Lazenby if he would be a reference for his professional registration, and Lazenby was happy to oblige. When Mark received his professional standing, he thanked Lazenby profusely, but Lazenby's only reply was, "I guess they let you in regardless of what I said."

Lazenby's wit was matched by the wisdom of Karl Terzaghi, whom Mark Olsen was by then representing in the field. Lazenby, too, had a deep reverence for Terzaghi and later addressed him in a letter by what he considered the most respectful title, "Professor." Terzaghi retorted:

". . . I was deeply flattered that you addressed me in your letter of April 17, for the first time as 'Professor.' When Conant of Harvard served his term as ambassador to Germany[17] they always called him 'Professor C.', because compared to a professor an ambassador is 'second rate.' If you are a university professor in Germany or Austria, you are a member of an exalted class, like a Brahmin, and not an ordinary professional man (the poor thing merely practices



Cheakamus Dam, Garibaldi, B.C., ca. 1957.
Photo: B.C. Electric

what the great, omniscient professors have taught him). Once you have been adopted by this fraternity (exceptionally on the strength of your achievements, but much more commonly on account of persistence combined with political maneuvering and intrigues) you are generously taken care of for the rest of your life. If you stop producing five years after your efforts were crowned with success, and concentrate all your further efforts on agitation in empty space, such as participation in numerous committees and raising your voice in interminable faculty meetings, you are ever a privileged member of the fraternity, which operates on strictly democratic principals, because you sacrifice your personal desires and ambitions to the 'common cause' and don't disturb the peace of mind of your colleagues by rising above the democratic image.

"I never attended more than a few faculty meetings at any one of the universities at which I served, because I got bored stiff (at Harvard I established the record of two meetings in sixteen years) and discouraged being appointed to serve on academic committees by simply ignoring the appointments. Therefore I always felt that I really do not 'belong' and I did not wish to produce misleading impressions by decorating my name with the title 'Professor'. . . ."[18]

The Wahleach project was completed in 1953, and so Mark moved on, in January 1954, to a major field assignment at the Cheakamus (Daisy Lake) Dam, near Garibaldi, B.C. Charles Ripley has recounted the selection of Mark Olsen for this job:

"When Terzaghi became involved in this project, he said, 'Ripley, I need a young engineer as my representative at Cheakamus Dam. Line up some of your men for me.' And I did—two or three fellows whom I'd had out on dam inspections. So he interviewed them and he said, 'Mark Olsen is my man.' And [with] the training that followed, Olsen has a stamp on him that is peculiarly Terzaghi."[19]

So too is that stamp on Charlie Ripley and on the first generation of the company that he founded.

Mark Olsen's arrival at the site was an indication of some of the many trials and tribulations he would endure as an engineer on these isolated construction projects:

"I went up there during the end of January for three months. There was five feet of snow at Garibaldi—it was a terrible place.[20] Today, a little farther on, it's a skiing paradise. But at the place where we were working, nobody is allowed to live now because it's all part of the slide area and is potentially dangerous."

At the Garibaldi site, upon Mark's arrival, three drills were running, a bulldozer was digging test pits, and a test shaft was being sunk. Someone was needed for drilling inspection and classification of the subsoils, and Mark Olsen, although he had never attended to "anything like that" before, was to be that man. He first lived at a lodge, but eventually a "typical drillers' camp, with tents" was built on site. His contact man was Alan G. Fletcher, an up-and-coming engineer with B.C. Electric who came up every two or three weeks to guide Mark. Later Fletcher completed his Ph.D. and became Dean of Engineering at an American University. Dr. Terzaghi was then consulting on the stabilization of the powerhouse at Shalalth, and Tom Ingledow, chief engineer for B.C. Electric, prevailed on him to stop at Garibaldi and "give them a few clues."

At Cheakamus Dam site, from left: Mark Olsen, Charles Ripley, Alan Fletcher, Victor Dolmage.

Reminiscent of his attitude toward the academic world, Terzaghi had little interest in establishing any sort of business organization of his own. He dreaded the draw upon his energies that establishing and operating a company would entail. Instead he preferred to act as an individual consultant on major engineering projects, even though this might mean a reduced personal income. In such a role Terzaghi nevertheless did require the services of a soil mechanics organization, resident in the local area, in order to conduct the field and laboratory tests, to inspect and guide the construction—to be his "eyes and ears" during his absences from the site. For these purposes, Terzaghi usually chose former students, whom he knew were well trained in the necessary methodology, and whom he could trust. In British Columbia, Charles Ripley and his associates fitted this role.

Construction of the Cheakamus Dam proceeded in the spring of 1955[21] and was completed two years later, in October 1957. During this period, Terzaghi visited the site sixteen times, and Olsen acted as his resident representative throughout. Olsen recalls their first meeting:

"I met Terzaghi when he first came up to the site. His background didn't mean anything to me then—I couldn't recollect if I'd ever heard his name mentioned at UBC. His usual procedure was to come in and put his bags where he was going to bunk, then, [within] twenty minutes we'd take a look around the site and then go talk about the work. He said, 'What I want you to do is just keep an eye on what they are doing, and see that they are doing it in the sense that I have indicated in my memorandum. Then each week I want you to send me a report where you describe everything that went on.' "

Cheakamus Dam is representative of precisely the type of project that aroused Terzaghi's interest. The challenge was to build a dam on a vast landslide deposit known as

Mark Olsen demonstrating size of shovel bucket, Mission Dam, November 19, 1957.

Rubble Creek wash using the only construction materials available—the fairly well-graded volcanic material of the slide itself, river-laid sand and gravel, and quarried rock.

Terzaghi's report, following his first visit to the site at the beginning of April 1954, outlined the problem:

"Prior to his departure for Vancouver, the writer was given an opportunity to digest the contents of the reports which have been prepared during the last year by Dr. Dolmage concerning the geology of the site, and by Mr. Ripley concerning the subsoil characteristics. At the site, he received valuable supplementary information concerning the significant features of the locality, and of the four dam sites which have so far been explored.

"On the basis of all this information the writer arrived at the conclusion that a dam could safely be built on any one of the four sites which have been proposed. However, the construction of a dam at any one of these sites would require elaborate and costly provisions for eliminating the danger of piping, and it would also call for extensive grouting operations, the cost of which represents an uncertain item. . . ."[22]

Terzaghi was soon able to suggest a better alignment for the dam, one that eliminated the costly grouting operations. He proposed that the dam alignment be turned a full 60 degrees, and the immediate result was that Mark, Fletcher, and Charlie Ripley were "out there surveying in five feet of snow." Before Terzaghi left, it was also decided that a test pit, about 700 feet long, was needed to confirm the new alignment. Eight days later, on his return to Vancouver, Terzaghi issued a report, later published, that was a model of brevity, objectivity, and clarity of message. Mark Olsen perhaps puts it in its best perspective: "It was kind of a famous report, and that was pretty well the way the dam was built." The dam was completed and the reservoir filled in October of 1957.

Arthur Casagrande has noted that, with Dr. Terzaghi, "there was a curious difference between the almost complete freedom which he allowed his staff and students in their research efforts and the tight control he exercised on his consulting projects. . . ." On these project sites, Terzaghi prescribed in great detail, in writing, the exploratory, testing, or observational programs that were to be undertaken. His representative on a job was usually required to mail him weekly reports. In addition, Terzaghi made frequent visits to the site to examine personally all new evidence and to maintain close contact with all developments.[23]

Before taking on a consulting assignment, Terzaghi insisted on two requirements from his clients: that his field representative should be an engineer of his own choosing and that Terzaghi be authorized to visit the site and to modify the design whenever he considered it necessary. In turn, Terzaghi assumed full responsibility for the stability and safety of the completed structure.

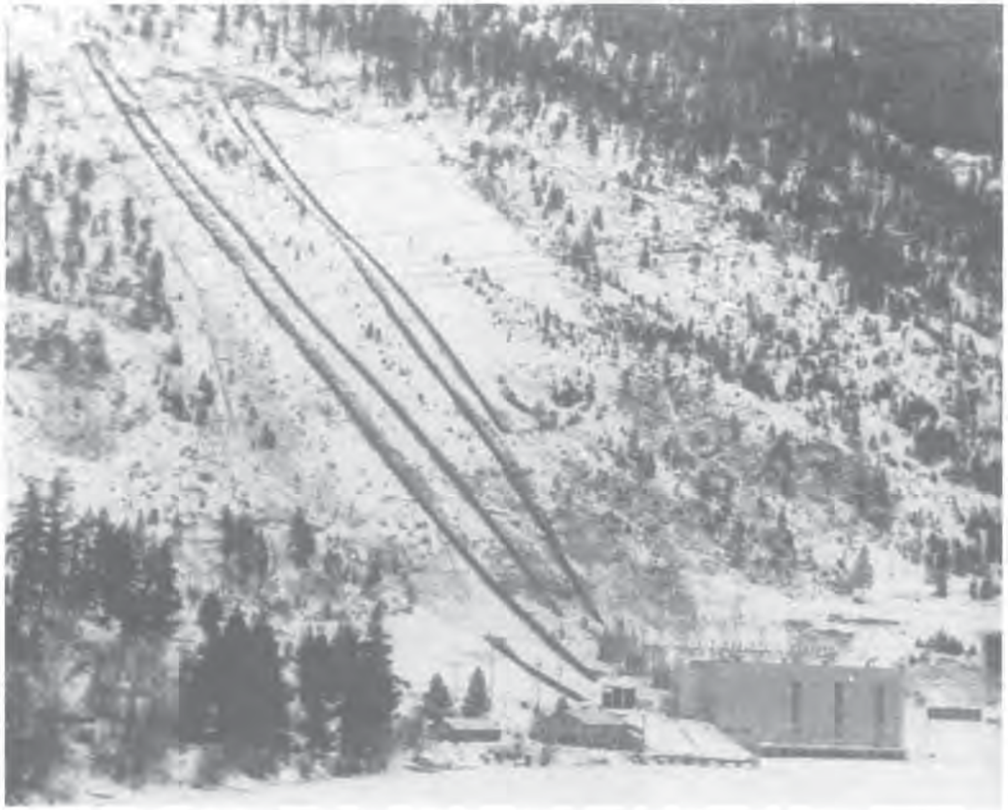
The following story is illustrative of both Terzaghi's *modus operandi* and Mark's role on the Cheakamus site:

"Early on in the job, he had a chat with me where he brought out my reports and went over them word by word: 'What do you mean by this, and what about that?' For instance, there were many rocks in the river, and he mentioned in particular the blowing of this one big rock. The contractor blew it . . . but only half the charges went off. I went over to it and all these wires were hanging out, and I said, 'Put a fence around it.' Later they figured out what they were going to do and blew it properly." When Terzaghi received Mark's weekly reports, he immediately wondered why two rocks had been blown. Six weeks later, upon Terzaghi's return to the site, Mark was quickly compelled to explain that this was the same rock, blown twice.

Whenever Terzaghi arrived, Mark took the attitude that "offence was the best defence." He would prepare a long list of items to discuss—"There was no shortage of questions to which answers were required." At the Mission site and to a certain extent at Cheakamus there was a lot of experimenting done. Sometimes, however, Terzaghi would not answer all of Mark's questions. Instead he would ruminate for a time, then call a meeting, or rather what Mark has described as a brainstorming session: "Everybody gathered around would talk. We'd get some of the craziest notions, but he never criticized them. We just talked until we got something that would work."

About six months prior to visiting the Garibaldi site, Terzaghi had suffered a heart attack, so, in the afternoons, he found it necessary to rest. In the evening, Terzaghi always had a "refreshment period" followed by dinner. After dinner he usually went off to work. But during the refreshment period and dinner, there was always plenty of time for talk:

"There were a lot of stories and bringing us up to date on what he was doing since we last saw him. He talked about the early days when he was a consultant in Russia—how he would stop in St. Petersburg and have a big party—because he wasn't going to live or eat very well for the rest of his trip. And he had these duelling scars, believe it or not. He was still lecturing at Harvard and Illinois in between travelling to different projects—his schedule was organized for weeks ahead. But he always told me where I could get in touch with him. I seemed to have his confidence—he



Powerhouse and penstocks, Bridge River development, Shalalth, B.C., February 22, 1956.
Photo: Mark Olsen

obviously trusted what I did. In turn, I just put myself out for him."

On one occasion, after Terzaghi had left the site, Olsen was confident that he clearly understood what Terzaghi was recommending. But, when Terzaghi's memorandum reached him, Olsen discovered that there were "a few items that were quite different from [their] understanding." Terzaghi called the misunderstanding "a real embarrassment." In future, Olsen was to travel into town before Terzaghi left, carefully read his memorandum, and see that he understood it clearly. Olsen was happy to do so, later calling these sessions "a great experience—to sit in his hotel room, read through his memorandum, and ask him questions about it." As Mark has noted, Terzaghi was a keen observer, with a remarkable memory; his mind was organized, and he wrote very well.

Karl Terzaghi's first consulting assignment for the B.C. Electric Company had begun in July 1951 when he was asked to aid in stabilization of the Bridge River powerhouse. The project, initiated in 1946–47, comprised a relatively small 60-foot-high diversion dam across the Bridge River,[24] a tunnel through Mission Mountain, and a powerhouse at Shalalth on the shore of Seton Lake, 1,200 feet below at the base of the mountain. The powerhouse sits on lacustrine silt and clay soils, just at the edge of the lake, and a short distance from the rock wall of the valley. Steel penstocks carry water from the tunnel down the rock wall to four turbines in the powerhouse.

By 1951 two problems had arisen. A sinkhole had developed at the crest of the dam, and, at the powerhouse, tilting movements had affected its connection with the fixed penstocks. Deep drill holes placed beneath the powerhouse revealed pervious layers lying between the lake deposits and bedrock. Cause of the movements was found to be the seasonal fluctuations of groundwater pressures, which varied from high in the spring with the snow melt to low in the fall. These problems were of great concern to B.C. Electric since the project was their major source of power for the province.

While the danger of failure was great (In 1952 high water pressures from tunnel seepage caused landslides which destroyed the $5.8 million powerhouse at Whatshan, B.C.),[25] Terzaghi's solution was simple and miraculous. He recommended the immediate placement of a small fill in front of the tailrace on the lake side of the powerhouse using spoil available from the excavation of the power tunnel. Such a placement would work to counterbalance the tilting and eliminate the problem. Further, subsequent stabilizing measures were also carried out to bleed off the high water pressures.

Terzaghi then continued work for B.C. Electric as principal consultant on the design and construction of Cheakamus Dam. And then, for the same client, he was to face his greatest challenge.

In 1955, in order to meet increasing power demands, the B.C. Electric Company decided to proceed with construction of a much larger dam across the Bridge River valley. "Mission Dam" would be constructed atop an earlier diversion dam which would be incorporated into the toe of the new dam. Mission Dam would rise to a height of 200 feet, store 820,000 acre-feet of water, and require the construction of a second power tunnel and powerhouse on Seton Lake. Although seventy-two years of age at the time, Terzaghi accepted the company's invitation to serve as consultant on this project with little hesitation. The reason was simple—owing to its complex subsoils of pervious sands and gravels along with compressible silt and clay deposits, the site had one of the worst dam foundations Terzaghi had ever encountered.

After extensive investigations, Terzaghi nevertheless assured the owners that a dam could be safely constructed on the site. Although comparatively small by present-day standards, Mission Dam was the "crowning achievement" of Terzaghi's career, according to Ripley, "because it's doubtful if anyone, then or even now, would have the ability to construct a safe dam at that site."

The site is underlain by two pervious aquifers separated by a thick layer of highly compressible clay. In order to control seepage through the foundation, Terzaghi's design called for a sheet pile cut-off through the upper aquifer and a deep grout cut-off through the lower, extending to a maximum depth of 520 feet. A zone type of embankment was designed to accommodate the available construction materials and the large differential settlements that were expected—up to 15 feet.

At the peak of construction, there was an inspection staff

Mission Dam, B.C., under construction, September 17, 1959.
Photo: Malcolm Parry, B.C. Electric

of forty persons at the Mission site. Yves Lacroix, a young French student studying in the United States on a Fullbright Scholarship, was resident on the job covering the theoretical elements, and Mark Olsen was overseeing the practical construction aspects. The dam was the subject of Lacroix's Ph.D. thesis at the University of Illinois, and Terzaghi co-published a paper with Lacroix on this project.[26] In the foreword to this paper, Arthur Casagrande has confirmed that "the design and construction of Mission Dam was the most difficult and most daring engineering project of Terzaghi's entire career."[27]

Mark Olsen's objectives at the earlier Cheakamus Dam were to "make it as simple as possible." He had devised a weekly blueprinted sheet containing an outline plan of the dam that made the required tasks much easier to illustrate than did written words. But the Mission Dam was more complex. Olsen has noted that, "Nobody ever took me aside and said, you're doing a lousy job and better smarten up." He did however, receive a complaint from Harold Taylor, the client's representative, asking him why he wrote so much and informing him that an entire filing cabinet was needed to hold his writings. In fact, the construction company found it necessary to provide Olsen with a secretary who did nothing other than type his reports, and Olsen is certain that Lacroix used many of them in writing his thesis.

Despite his expectations, Olsen found that with each succeeding job the challenges seemed to mount, to become evermore overwhelming:

"My whole life seemed to be one insurmountable problem after the other. I was always a little bit jealous of the other people who were working in the office or at Seymour Dam [near Vancouver] and at the Port Alberni pulp mill, who were closer to civilization. It wasn't a happy time; it was just hard, hard work. And with all the politics and the infighting that went on, it was far from pleasant. I was always hopeful that somewhere in the future I wouldn't be so isolated, and that there would be other variety. But I can honestly say that at no time, through all that agony, did I think of quitting or taking some other course in life. In the end, I guess I thought that I was doing pretty well where I was."

By the fall of 1960, the construction of Mission Dam was completed. Mark Olsen, freed from his field responsibilities, was taking long-postponed post-graduate studies in soil mechanics under Ralph Peck at the University of Illinois.

Terzaghi's principal university colleagues had recently compiled the book *From Theory to Practice in Soil Mechanics: Selections from the Writings of Karl Terzaghi*, summarizing his productive life and achievements. At Illinois, Olsen received from Terzaghi a personally autographed copy of the book, containing a rare tribute to his "faithful and invaluable services" rendered during the construction of the Cheakamus and Mission Dams.

In his later years in British Columbia, though still keen of mind, Karl Terzaghi was becoming increasingly frail. Frank Pells was one staff member to witness Terzaghi's attitude to the aging process:

"He came up to Seymour Dam a couple of times when he was [using] a walking stick, but still getting around and not giving in at all. . . . One time I picked him up at the Sylvia Hotel and drove him over to the office. And we were talking about Alaska, which had just become a state [1959]. He was surprised that it had happened so quickly. I remember we were going up the [steep] back steps of 1930 West Broadway [from the parking lot. The engineering offices were on the second floor]. He stopped halfway up to 'admire the view.' He wasn't ever going to admit that he was getting old."

Finally however, in 1960, Terzaghi was forced to suspend his field trips to British Columbia. Then, in 1963, symbolically, the end of an era came for Ripley, Klohn & Leonoff Ltd. when Charlie Ripley received a copy of a letter, dated October 25, 1963, written by Arthur Casagrande and addressed to Ralph Peck, Professor at the University of Illinois. On the letter was a handwritten notation: "Charlie, I send you this message with a heavy heart—Arthur." The letter, which Casagrande was circulating to a few of Terzaghi's closest colleagues, read in part:


To Mark J. Olsen

gratefully remembering the faithful a. invaluable services you rendered to me during the construction of Cheakamus Dam a. Mission Dam.

Winchester, Mass, November 1960.

K. Terzaghi

Terzaghi's tribute to Mark Olsen.

Terzaghi Dam: Unveiling of the commemorative plaque by Ruth Terzaghi and Harold Taylor, Montreal, Quebec, September 8, 1965.
Photo: Business & Industrial Photographers Ltd.

"I saw Karl for the last time on Monday, October 21. . . . He was much more tired. . . . The pains in his lower back were severe. Nevertheless, he asked many questions about mutual friends I had seen on my trip . . . and [about] the South Saskatchewan River dam. . . . Then we talked about his Mission Dam paper. . . .

"Yesterday afternoon I telephoned Ruth [Terzaghi] informing her that I would like to call on Karl and give him my completed comments on his Mission Dam paper. . . . When I arrived Karl was asleep under sedation. His doctor had seen him earlier.

"This morning Ruth told me the sad news over the telephone. She said that during the night he complained of chest pains, and his doctor called again. Ruth said that about seven in the morning he wanted to change to a sitting position, and while she helped him, he stopped breathing.

"And so this great man has left us, after completing his task well indeed. . . ."[28]

In 1965 the Organizing Committee for the Sixth International Conference on Soil Mechanics and Foundation Engineering, held in Montreal, "counted it a privilege and an honour" to arrange the opening session "as a memorial to this great man." Dr. Ruth Terzaghi was invited to take part in a ceremony unveiling a plaque renaming Mission Dam "Terzaghi Dam." This plaque now rests above the dam, attached to a block of granite, amid the mountains of British Columbia which Karl Terzaghi loved so dearly.[29]

In June 1983, during the Seventh Panamerican Conference on Soil Mechanics and Foundation Engineering, held in Vancouver, a memorial luncheon commemorated the centenary of the birth of Terzaghi, and Ruth Terzaghi was a guest of honour. Speaking at the luncheon, Charles Ripley paid a final personal tribute to Karl Terzaghi, saying, in part:

"His place in the history of civil engineering will be assigned by history. My opinion is that he will stand as one of the all-time greats for his contribution to civil engineering practice. Two characteristics were very evident in his strong personality—self-discipline and directness. . . .

"In his lifestyle he realized the importance of simplicity and mental tranquillity in order to conserve and concentrate

Terzaghi Dam: Cairn at dam site, from left: Mark Olsen, Robert Legget, Harold Taylor, Carl Crawford, summer 1966.

his energies on technical matters as objectively as possible. When in Vancouver, he avoided the large and busy luxury hotels. He arranged to stay at a small, quiet hotel where he could know the small staff and they could know his needs. . . . In spite of repeated requests from his clients and associates, he steadfastly refused evening social engagements, so that he could concentrate. His relaxations were relished, but planned. They were directed to enjoyment of contact with nature, the forests, the mountains, the seashore and the natural parks in which he loved to hike and stroll.

"His studied self-discipline in his work was apparent in his careful limitation of the number of engagements that he would accept at any one time, and in his careful selection of the engagements. . . . From the many requests for his services, he carefully selected projects . . . on which there was need to expand the boundaries of knowledge. Even with favoured clients he would refuse to participate in projects for which there were established solutions, and he would refer the client to former students and colleagues of suitable but lesser ability. I was a fortunate recipient of such referrals.

"He realized that objectivity and clarity of message require forthright and direct statement. Beating about the bush, obfuscation and fuzzy thinking . . . were foreign to him. My first message from Professor Terzaghi, when I came to British Columbia in 1951, was by receipt . . . of a copy of his letter to a Vancouver client: 'I have examined the report from you and find the data meaningless and not worth the paper written on. A copy of this letter to Ripley will indicate the standard of work that I require.' This letter, out of the blue, on work by others on a project of which I had no knowledge or involvement frightened me at first, until I understood the merit of such a message. It made my small staff and me realize that we had to prove ourselves, and that we would always be on trial with him. It made us strive to meet his standards. A relationship based on merit and professional honesty was essential and gave no credence to friendship as a measure of that standard."[30]

After the conference, Charles Ripley and Mark Olsen accompanied Mrs. Terzaghi on her first visit to Terzaghi Dam.

In a retrospective of the company's development, written in 1972, Earle Klohn summarized his own view of the Terzaghi period:

"Our [decade] of extensive exposure to Dr. Terzaghi affected, in many ways, both the company's outlook and it's image. It exposed us to the leading soil mechanics engineer in the world, and gave us considerable insight as to how he went about assessing a problem and ultimately reaching his answers. In addition, as all our work was reviewed by Terzaghi, it taught us great self-discipline and the need to check our work thoroughly. In a nut-shell, we took [ten] years of post-graduate training from Dr. Terzaghi.

"Terzaghi was well known all over the world, and it was also known that he would only work with competent and dedicated firms. The fact that Ripley, Klohn & Leonoff [RKL] was the firm he worked with in B.C. gave [us] an excellent image in the soil mechanics field."[31]

Karl Terzaghi at Salmon Glacier near Stewart, B.C., taken on a trip with his son Eric, Juul Hvorslev, Charles Ripley, and Herbert Ripley, summer 1956.

Chapter Four

PIONEERING JOBS

In the fall of 1951, Charles Ripley began his involvement in the Nechako-Kemano-Kitimat power and smelter project of the Aluminum Company of Canada Limited—the major construction project in the province during the decade and the largest construction job in British Columbia since the coming of the Canadian Pacific Railway.[1] The site was on the northwest coast of British Columbia, and the huge power requirements necessary to smelt alumina ore were to be generated by damming the Nechako River and its tributaries as they flowed eastward from the Coast Range, this by construction of Kenney Dam, a rockfill dam with an impervious core. The stored water was then to be diverted westward through a high-head (2,600-foot) power tunnel to a powerhouse located on tidewater at Kemano, on the banks of one of the many inlet channels typical of the British Columbia coastline. In these fjords, the mountain slopes rise steeply from the ocean shoreline providing practically no space for habitation, with the exception of the low-lying delta lands of the rivers as they empty from the mountain canyons and valleys into the sea. The key requirement for the smelter site was that it be close enough to ocean dockage to allow for direct water transportation of the alumina ore into the plant and shipments of the aluminum ingots out. Alcan's problem was to find an area large enough to accommodate not only a 44-acre plant but also an entire town.[2]

Ripley's first contact with the Alcan project, in the fall of 1951, came about as the result of a request from Bill Huber of B.C. International Engineering Company, the designers of the power project. Huber asked whether it would be necessary to explore for the material required for the core zone of Kenney Dam[3] and how long this exploration might take. The project schedule was very tight, requiring the embankment portion of the dam to be built within the 1952 construction season. At the smaller Wahleach Dam, Ripley had not recommended a drilling investigation to prove up the glacial-till material to be used in the impervious zone of the dam, because large exposures of the till were apparent on the cliff faces. This made this material easily available for testing in the field laboratory just prior to placement in the dam. Because of this experience with Wahleach, Huber hoped that, by employing a similar procedure, investigation of the materials for Kenney Dam could be delayed to the spring of 1952.

Ripley visited the site accompanied by the resident engineer, Joe Black, his assistant Jim Hayes (two very experienced dam construction engineers), and Harry Jomini, the Alcan resident engineer. Jomini had advised Ripley that Bob Hardy was their consultant and would be responsible for setting up the field laboratory and material inspection staff during construction the following year. As a result of this field review, the consensus was that for this major dam, at the time the largest sloping, rock-filled clay-core dam in the world,[4] Hardy be requested to start the drilling investigation and set up a field laboratory in the fall of 1951 and staff it over the winter so that the quantities and properties of the materials would be known well ahead of construction. On his return to Vancouver, Ripley reported these recommendations to Huber, who was "not at all pleased." Consequently, Ripley and Huber met with the IECO president, Charles Dunn. Dunn, after quizzing Ripley closely, accepted his recommendation.

Prior to this time, Ripley, in seeking work on this vast project, had made several contacts with Jack Kendrick, the British Columbia engineer serving as liaison man for Alcan. But Ripley's efforts had met with no success. However, later in the fall of 1951, probably at the recommendation of Bill Huber, Ripley was contacted by Cameron Jenkinson, who had just moved to Vancouver as Alcan's engineer in charge of the Kitimat phase of the project—that is the smelter site and adjacent town site, located in another fjord. Jenkinson explained to Charlie that a very large wharf was going to be built at Kitimat, consisting of three major concrete elements that would be built in a graving dock, then floated out and set in place on the wharf site.[5] The designers of the wharf were Frederic R. Harris Inc. of New York who insisted that a very detailed foundation investigation be carried out at the dock site, in accordance with an excellent set of specifications prepared by Stephen Olko, a young engineer who had Harvard soil mechanics training.

The Alcan head office in Montreal had generally, in the past, used Bob Hardy as their foundation consultant. But Jenkinson advised that, as the Kitimat work had to be carried out expeditiously, there were problems with Hardy because of his university commitment in Edmonton. Jenkinson asked Ripley to supervise the investigation work. Ripley spoke frankly—he was just starting out in practice, had laboratory and manpower limitations, but he understood the work and could certainly take responsibility for the project. However, he would need to call on the Edmonton testing facility and some of Hardy's staff in order to do the job promptly.

The work proceeded under the following arrangements: Ripley did the consolidation tests in Vancouver while the shear tests were done in Edmonton. Hardy provided his senior man in the field, Hans Dutz, who was in charge of a number of inspectors, and Dutz in turn reported to Ripley. The field work went on around the clock. Part of the drilling was carried out from heavy platforms that could be dragged about within the intertidal area and part of it from barges on the water. This was the first significant job carried out by Ripley and Associates for Alcan on the Kitimat project.

Upon its completion, Jenkinson was pleased with this work and seemed anxious that Ripley have a greater involvement with the plant site construction that would commence at the beginning of the following summer. Bob Hardy, too, was worried about the scope of the commitment he would have undertaken, come the summer, at both the Kenney Dam and Kitimat. So Hardy suggested that the foundation consulting and inspection staffing at Kitimat from that time onward be undertaken jointly by Hardy and Ripley. And this arrangement was acceptable to Alcan.

Bob Hardy, one of the patriarchs of soil mechanics in Canada, was clever, spoke convincingly, and invariably made a strong impression with clients. And certainly in client-consultant meetings, Hardy could be very aggressive in his opinion, leaving no doubt as to the correctness of his own view. If later, on the basis of new facts, he changed his stance, he was typically just as adamant. Murray Harris, an associate of Hardy's, has described an incident that is illustrative of both Hardy's character and the patriarchal hierarchy that existed in soil mechanics in the early years. Hardy incessantly smoked a cigar. Harris recounts that the single time he ever saw Bob Hardy cease smoking was when he was riding in a car with Arthur Casagrande. Casagrande had the temerity to ask Hardy to put out his cigar, and Hardy did so.

In an interview for a story on the life of Bob Hardy, near the end of Hardy's brilliant career, Charles Ripley made plain his admiration for his mentor and colleague:

"Of course Bob has a wonderful personality. He's an optimist. He's a highly competitive person. He's tremendously interested in his subject—he loves the soil and the soil . . . loves him. He has had a keen interest in anything new. He shares his thoughts and information generously. One of the reasons that people have liked [Hardy] is because he doesn't get excited. He remains quite calm—unflappable. So that he looks at things in an . . . objective fashion. And these characteristics have made it possible for Bob to do things other people have not been able to do to the same degree."[6]

Hardy's former librarian and biographer has concluded that, through his technical papers, "substantial salesmanship," and teaching activities, "Robert Macdonald Hardy is a geotechnical engineer who has made a greater impact on his profession and the people in it than has any other person of his era in western Canada."[7]

Hans Dutz, Hardy's senior man at the Kitimat site, was an Austrian whose native tongue was German, and, in 1951, there remained in Canada a good deal of anti-German feeling, a carry-over from the war. But Dutz surmounted this problem, mostly through a great ability to inspire the confidence of both the client's and the contractor's people. He had studied agricultural engineering rather than soil mechanics, but he was exceedingly well organized and kept excellent records. Dutz continued to effectively represent Hardy and Ripley throughout the major construction period of the smelter site.

The Kitimat smelter site covered a large area, 1,200 feet by 1,600 feet. The ground was overlaid with an organic mantle of varying thickness and underlain by a complex range of sedimentary deposits including sand, gravel, silt, and marine clay, tested to a maximum depth of 380 feet. Alcan, with the advice of Hardy, had decided that they would develop the smelter site by placing a well-compacted sand and gravel fill, varying in depth to a maximum of 30 feet, over the entire site. The buildings would then be

Hans Dutz, third from right, and his inspection staff, Kitimat, B.C., 1953.

supported on spread footings placed within this fill. The major foundation treatment involved stripping of the organic mantle, followed by placement and compaction of the fill material, which was available from a huge moraine nearby. This work would require a large inspection staff working over the extent of the summer of 1952.

This immense fill, weighing over 3 million tons, would exert tremendous pressure on the foundation subsoils. A grid of relatively shallow test holes had been drilled across the site, without encountering clay. And Hardy's preliminary analysis indicated that the total, eventual settlement would be relatively small, in the order of 18 inches maximum. Furthermore, he believed this settlement would occur within a few months of placement of the fill—a time frame satisfactory to the plant construction schedule.

At the time of the Kitimat development, the presence, in coastal fjords, of deep marine deposits composed of highly compressible clay layers beneath the less compressible sand, gravel, and silt deposits at the river mouths was not generally known. Only Terzaghi, in work done at Grays Harbor, Washington in 1929, and later (the 1940s) at the new pulp mill sites at Campbell River and Port Alberni on Vancouver Island, had understood the problem posed by these "drowned valley clays." Very few, if any, case histories of recorded settlements were available in the engineering literature. In fact, the rule-of-thumb was that actual settlement would be in the order of 50 percent less than that predicted on the basis of consolidation tests.

Ripley attended several meetings with Alcan and Bob Hardy at the time he became involved on the project in late winter-early spring of 1952. He was concerned that projections as to the amount of settlement at the Kitimat site, and its rate, had been made on the basis of a limited amount of data, without any of the drill holes reaching bedrock. Ripley was aware that settlement could be quite variable over such a large area, and he felt that it would be important to know the degree of differential settlements beneath the proposed buildings.[8] Ripley's suspicion had been aroused that winter when some of the deeper holes drilled at the wharf site had encountered silt layers and, at the lowest levels, a small amount of clay. So he recommended that some deeper holes be drilled across the site, as far as bedrock. Furthermore, he recommended that four settlement gauges be placed on the foundation, after stripping and before filling commenced, so that the settlement could be measured from that day onwards and compared with the predictions.

Ripley's recommendations were received with a great deal of consternation by the Alcan design office in Montreal. They were reviewed by M. E. Hornbach, a retired chief engineer, who immediately felt that, given any degree of uncertainty, four gauges would not be enough. Instead, with his knowledge of the building layouts, Hornbach suggested placing fourteen gauges across the site. As it turned out, this was a very fortuitous decision.

Aluminum Company of Canada, Kitimat, B.C. – Smelter plant, ca 1963.
Photo: Alcan

By the time that the fill was completed, at the end of the summer of 1952, it was apparent that the settlement predictions were flawed. Settlement was very much greater at the west end of the site than at the east. (Deeper holes drilled during the summer had indeed found compressible clay, which had not been encountered in the first series of drillings.) And a larger degree of settlement was not the only problem revealed; it was now also clear that settlement would continue for an extended period of time. As a result, a number of remedial measures were adopted. First, building construction scheduled for the fall of 1952 was delayed until the spring and summer of 1953. This posed no problem for Alcan as this revised schedule tied in with the power phase of the project. Dr. Terzaghi, incidentally, did not have a part in the settlement predictions, but did give his blessing to the work of Hardy and Ripley. He attended one meeting, and Ripley kept him advised of developments.

As soon as the fill was completed, a large number of surface settlement gauges were placed and later transferred to the building footings. This has enabled the settlement pattern of the entire building area to be analyzed continuously from 1952 until the present time.[9] The maximum settlement of the first stage of the plant site is in the order of 7.4 feet—5.5 feet of this having occurred after construction of the buildings. These large settlements gave rise to a number of interesting problems related chiefly to setting the elevations of individual building footings, as well as to making the structural modifications necessary to minimize the effect of the settlements on plant operations within these buildings.

Most of the buildings containing potlines for the smelting process are 1,160 feet long. They have undergone differential settlements of as much as 2 feet. They are, however, relatively flexible structures, and a casual present-day observer at the site would be unaware of any meaningful settlement. Nevertheless, some of the service buildings had special problems that required ingenious solutions. The alumina storage area, for instance, contains tanks 100 feet in diameter and 60 feet in height. The refined alumina ore, in the consistency of fine sand, is brought to the site from mines in the Caribbean and elsewhere and stored in these

Aluminum Company of Canada, Kitimat, B.C. – Hydraulic fill placement at early stage of site development, spring 1952.
Photo: Fred De Lory

huge tanks. It was apparent early on that these heavy loads would produce very significant settlement of the tanks. Site preparation for these containers required stripping of the organic mantle at the surface tidal area and hydraulic filling of the hole thus created with material dredged from the shipping channel. The contractor, B.C. Bridge and Dredging Company, had years of dredging experience in coastal British Columbia. This experience did not, however, include the placement of an "engineered fill," whereby the silt is washed out by maintaining a rapid flow of water from the head of the dredge pipe to the spillway, allowing for the deposit of a relatively pure sandfill. A definitive photograph shows Ripley, sinking to the top of his knee-boots, testing the quality of the fill. At one point, frustrated at Ripley's exacting approach, the contractor's principal, William "Billy" MacKenzie, threatened to "run Ripley out of British Columbia."

Ripley's projections were also a matter of consternation to many of the construction people and so the butt of numerous jokes among these workers. They simply could not believe the magnitude of settlement predicted. The preload surcharge fill required to presettle the foundation under the alumina storage area created such a high mound that it was dubbed "Mount Ripley." In jest, a snow cover was imported and a poster erected depicting Ripley conquering the summit. Ripley's site staff countered with an adjacent sign, graphically illustrating the large settlement that would be removed by the fill.

At Kitimat, the alumina ore is loaded into the storage tanks by overhead conveyors and is withdrawn from below them by underground conveyor belts leading out through tunnels constructed beneath the tanks. Settlement of the tunnels under the heavily loaded tanks would be significant, but outside the perimeter of the tanks settlement would be very much smaller. Means of predicting and coping with the differential settlement that would occur between the two sections of tunnel were a puzzle. To prevent breakage of the tunnels, Ripley recommended the construction of a vertical butt joint that could allow movement of up to 1 foot. John Whitton (brother of then Mayor Charlotte Whitton of Ottawa)[10] was the superintendent of Kitimat Constructors, the principal contractor at the site. A very experienced, capable but no-nonsense construction man, he had to date co-operated fully with the engineering consultants. But in this instance he drew the line. He announced to Ripley that he would wager a bottle of whisky that this vertical movement would never occur. Whitton lost the bet.

The most important building in the first phase of construction is called the carbon paste plant,[11] a heavily loaded structure full of crushers and other vibrating machines. Ripley has cited this building as an example of the type of critical settlement prediction he was called upon to make. According to his best prediction, he felt that there would be a differential settlement, on the diagonal, of 3.5 inches, and he called for construction to compensate for this differential—one corner of the building was to be built 3.5 inches higher than its opposite corner. Ripley recalls that, "it was a challenge to the steel erectors to build the building that way—like a Leaning Tower of Pisa. The total settlement

Aluminum Company of Canada, Kitimat, B.C. – Charles Ripley testing quality of fill, alumina storage area, April 1952.
Photo: Alcan

Aluminum Company of Canada, Kitimat, B.C. – "Mount Ripley" and settlement diagram, alumina storage area, April 1957.
Photos: Alcan

was 4.5 feet. And the building went through a little more than 3.5 inches differential settlement, about on the diagonal of the prediction."

Ripley has also reminisced about the degree of responsibility and risk that he undertook on this project:

"It's good to be young and to have plenty of energy. And, when you're busy and have lots of responsibility, somehow you rise to it. I suppose that the project took a fair amount out of me. But, to me, it was such a privilege to work on it. The superelevations of the individual footings rested solely on my shoulders—trying to analyze carefully the settlement that had occurred and using semi-log graph charts to predict ahead. Some of the Alcan people told me afterwards that they were really quite worried about this young fellow who was pretty thin and seemed to be on the run most of the time. If anything happened to me, they could have had a problem in trying to pick up from where I might have left off. But, fortunately, that didn't occur."

The Kitimat project could never have proceeded without the small aircraft, about eight in number, that continually ferried men in and out.[12] For Charlie, the courage and skill of the pilots who flew these little float planes is phenomenal to recall: "If the ceiling was fifty feet, you flew at fifty feet, and if the ceiling shut down on you part way, they would land on the water and taxi to the nearest floating log camp, where you would spend the night.

"But there was a tremendous risk. When his company was doing work on the big construction camp in the fall of 1951, my brother Herb lost a partner, Al Rowand, on a Canso [aircraft] that crashed into the mountain at Nanaimo.[13] On another flight, we were coming out of Kitimat-Kemano to Vancouver on a Grumman Goose, a nice aircraft,[14] when we were fogged in. The pilot didn't have a co-pilot, so [after he landed and began to taxi] he opened the door to the passenger section and called back for somebody. So I went up front, and he said, 'We're going to be taxiing for quite a long way. If we hit a log, we're in trouble. I want you to watch for floating logs, and if you see a log, tell me and I'll lift up.' We taxied seventy-five miles that day, all the way to Namu. A month later, doing the same thing, that plane hit a log and capsized. Only the pilot survived—the others were overcome by the cold water. He swam to the shore—barely. The lower part of his body was in the water overnight, and he pulled himself out the next day. For months after he was paralyzed from the waist down."

At the same time that Charles Ripley began his consulting practice "on a shoestring," he and his wife Dorothy purchased a home at 5137 Angus Drive,[15] in the old Shaughnessy district of Vancouver. While the house was a modest, Craftsman-style bungalow, it was nevertheless located in a posh residential area. By late fall of 1951, with two major projects and an increasing amount of other work on his hands, Ripley was obliged to develop a laboratory of his own. Having no available space in his small Fir Street office and no surplus rental funds, he decided to establish the laboratory in the basement of his own home. On November 26, 1951, Charlie described the situation in a letter to his brother in Edmonton:

"We have finished up at Wahleach Dam for the season and hope to start in testing materials from other jobs right away. I have completed the plumbing in the house and should have the laboratory in good shape within a few days. I expect to leave here [Vancouver] tomorrow night for the Nechako Dam site in connection with the Aluminum Com-

Aluminum Company of Canada, Kitimat, B.C – Potline.
Photo: Alcan

pany development. . . ."[16]

The basement laboratory was set up, and various tests were under way by the winter of 1951–52.

In mid-April 1952, a lanky, twenty-one-year-old native British Columbian, W. A. "Bill" Richards, answered an advertisement that had been placed by Ripley and Associates in the Vancouver newspapers. Richards was born in Victoria, Vancouver Island, where his grandfather had settled in 1890. Graduating from high school in that city, he did odd jobs, then went to work for the provincial Public Works Department Highways Branch on topographic and highway surveys. His last job had been on the location of a proposed (and controversial) highway from North Vancouver to Britannia Beach, through the Greater Vancouver Water District watershed. On completion of that job, he had married, and in 1952 preferred to live in Vancouver rather than take on any further remote field assignments. So he quit the department:

"I was just looking for a job, and I saw an ad in the paper where they wanted somebody who had worked in a lab. I had worked for a year in the lab at B.C. Cement and had taken a dairy course at UBC, working in a dairy lab there, so I applied, and I got an interview with Charlie. I always enjoyed the lab work—chemistry and physics interested me at school. But I had never been exposed to any kind of engineering as such.

"It just sounded like an interesting job. Charlie was quite enthusiastic about it. But then he was always enthusiastic. I found in working for Charlie that you always knew where you were at. He was very intense, a hard taskmaster at times, but really a fair and good person."

In turn, Charlie liked this bright, young, and cheerful fellow who seemed so willing to learn, and he chose to hire Bill Richards as his first permanent laboratory technician, at a salary of $200 a month. The wage "was less than I was getting with the provincial government" admits Bill, "because with the government you got a cost-of-living bonus. [But] you could live on it—not well, but you could live." Richards proved to be an excellent choice. He learned all the soil tests—many of them self-taught, was a hard worker and a good team player with a sense of humour under even the most trying conditions. He remained with the company for ten years—throughout its pioneering period.

Richards can recall with great detail the company's first laboratory, a space barely 10 feet wide by 25 feet long, with a plain cement floor:

"Like most houses, there was a row of posts and beams down the middle which formed one boundary of the lab and the outside wall the other. Then, at the end, there was a reverse 'L' where Charlie had a desk, and there was a drafting table. I had a desk just outside the doorway that went out of the lab into the office-drafting area. And then, in the outer part of the basement, we had storage."

As for equipment, Richards recalls that, "There was an oven—I remember that because I used to warm my sandwich in it—and a sink to wash stuff in—and a concrete block for running Proctors [compaction tests]—permeability apparatus—places to run sieve and hydrometer grain-size tests—and a simple consolidation frame that ran two tests." Ripley had the consolidation apparatus and loading frames machined according to the models used by the PFRA. Later that year, when Earle Klohn joined the staff, he installed triaxial compression testing equipment, machined by the technician for the University of Alberta. And when Cyril Leonoff arrived, he set up asphalt testing equipment, such as the Marshall stability apparatus then in use at the University of Washington. Small offices were added in the basement to accommodate Klohn and Leonoff. Thus, by the fall of 1952, an elementary, but rather complete soil and asphalt testing facility was in operation.

Richards acknowledges that, at the time, he knew "nothing" about soils or soil testing. He relied upon a dog-eared copy of T. W. Lambe's *Soil Testing*,[17] referring to it as "the bible." If there were any questions, "Charlie knew enough from his experience in the PFRA, until Earle [Klohn] came, and I was responsible to him."

During these early operations, Bill Richards would sometimes bake mud-pie lapel buttons in the laboratory oven, about three inches in diameter, inscribed with the word "Hero!" He would hand these out to anyone who, from time to time, provided exemplary service on some given task.

For the triaxial tests, thin, flexible rubber sleeves were needed to support the sides of the soil sample as the load was applied. Local drug stores stocked an ideal product for this and other uses, and Earle Klohn relates an incident that occurred when Richards was dispatched to purchase additional supplies of this commodity:

First soils laboratory, Angus Drive, Vancouver, B.C., winter 1952.

Consolidation test apparatus, left; Charles Ripley at his desk.

Mark Olsen, left, and Dwayne Donald, at testing bench.
Photos: Gordon McKendry

"When we ran triaxial tests, we used condoms as the rubber membranes. Bill went down to the corner drugstore, and he asked for a gross of condoms. He got this big box of condoms, paid the clerk, and started to leave. But then he came back and said, 'I forgot, I need a receipt for my expense account.' Shocked, the guy looked at him and said, 'You must work for one hell of a company.' "

Richards has described working conditions at the lab that were far different from those to be found in the company's operation in years to come:

"I suppose there was an organization at that time, but it was a very loose organization. It wasn't like years later when the company got bigger, and there were different people looking after different areas. In those days you went wherever there was a need. I didn't actually do that much field work, but occasionally there was nobody left to go, so off I went. I was at Puntzi Mountain [airfield on the Chilcotin Plateau] doing field densities for a couple of weeks."

When Richards did attend to a field assignment, invariably, upon his return to the lab, he would find that required work hadn't been done, and so he would apply himself "twice as hard" as would have been necessary had he not been away. He remembers that on one occasion: "I worked 144 days straight, right through. And some of those days were till one and two o'clock in the morning, with no overtime. But Charlie always said, 'Well look at all you're going to learn.' Which I suppose was really true. I don't think any experience I had working for Charlie stood me in bad stead."

Despite its rough-hewn and early effectiveness, the quick dénouement of Shaughnessy's one and only soils laboratory was pre-ordained. The Ripleys had young children. The incessant hammering of the compaction tests disturbed normally good-natured Dorothy, as well as the children's naps. Moreover, the neighbourhood was zoned "single-family residential," and the neighbours began to wonder about the daily comings and goings of up to ten men through a mysterious basement door. To avoid attention, staff members were told to park their cars on Granville Street or to scatter them throughout the neighbourhood. Bill Richards recalls a complaint that was received concerning his "forty dollar 1927 Chevrolet":

"I wish I had that car now because it had nice mohair wing-back upholstery, four doors, and was painted black. I used to park it on Angus Drive in front of the lab. And it was there, well, every day. I guess the lady who lived across the street didn't think as much as I did of my 1927 Chev. She phoned Dorothy to request that the young man who drives the car park it around the corner 'so it didn't show.' That would be a real collector's item today. She'd be glad to have it in her driveway now!"

The major Kitimat field program was about to begin, and with the volume of other jobs also increasing, by the spring of 1952 Charles Ripley was in desperate need of added staff. Compounding the problem, by the end of that year the city had placed a "quit order" on the laboratory, and that precipitated a search by Ripley and Associates for a space large enough to accommodate the laboratory, as well as Charlie's and the secretary's Fir Street offices.

Terry Henderson, who had worked for Ripley at the PFRA, was hired as the firm's first permanent field technician. Ripley purchased a lightweight Franki penetration unit, consisting of a tripod, a drop hammer lifted by a motor, penetration rods, and points. Bill Richards remembers the unit as "just a frame on skids." Henderson would employ a trucking company to transport the rig to a job, then winch it around on the site. He did penetration tests in this way for a number of years.

The other notable addition to the staff was Frank J. Pells, who had just completed his civil engineering training at UBC. Frank, an imposing outdoorsman with a shock of red hair and an amiable personality, seemed to be just what Ripley was looking for as a field inspector on airport construction at a remote site in the Chilcotin. When he was first interviewed, Pells recalls Charlie asking whether he was in good health; this as Charlie himself lay in bed recovering from a trip to Kitimat. "That was on a Tuesday," adds Pells, "and on Thursday I was on my way up to Puntzi Mountain, wearing my toque." Pells's toque was to become his recognizable symbol of authority on all jobs.

Born in 1921 in Prince Albert, Saskatchewan to English parents, Pells spent his youth in British Columbia at Harrison Lake and Cultus Lake where his father was a fisheries officer. In these pristine rural areas, Frank developed his lifelong love for nature and the outdoors. Cultus Lake is now a popular resort area, but at the time only employees of the fish hatchery lived there:

"There were only four families when we moved there. And we had to walk two and a half miles to catch the local school bus to public school at Sardis. And it pretty well stayed that way till the war, when the army camp moved into Vedder. Then of course things exploded. To go to high school, there was a ten-mile bike ride into town [Chilliwack]. . . .

"As a matter of fact, the grade school was quite old. We had the centennial celebration there four or five years ago. [Now] they're going to tear it down. We're really quite upset about that because it looks like a school, a pretty nice school. And they're going to tear the high school down too, which is almost as old. They're seismically unstable, which is really too bad."

At Puntzi Mountain, Defence Construction Limited was building a radar station and airfield, part of the North American Pine Tree air defence system. Pells remembers the level of secrecy involved:

"They had the radar station up there [on the mountain] that was so secret we couldn't even go up and look at it. They had the auxiliary camp [below at the airfield] where we stayed. I took a few pictures around the runway—just some of the guys and the equipment. And the air force type who was supervising, that didn't appeal to him. He came along and opened my camera—exposed the film."

Pells's function was to inspect the airfield construction:

"They'd started and they had no inspection on it. So we were sent up to see if they'd done the right job, which they hadn't. I remember putting those test pits down in the middle of that darned runway with those scrapers [huge earthmoving machines] tearing around. They had to tear up quite a bit and recompact it [as a result of the tests]. I don't think the contractor was too upset, because it was cost-plus."

At the time, Herb Ripley and Associated Engineering were very busy on a great many water and sewer jobs in Alberta and were desperately in need of soil mechanics inspection services. Consequently, having survived his apprenticeship under fire at Puntzi Mountain, in the spring of 1954 Pells was outfitted with a Volkswagen van containing a field laboratory and directed toward Alberta:

"They had work all the way from Claresholm to Tofield to Vegreville, right up into Peace River. So we looked at a lot of sites: The sewer system at Griesbach Barracks [Edmonton], a water supply dam at Leduc, and a lot of little jobs. I was supposed to stay till the snow fell. Well, the nineteenth of December came and there hadn't been anything but sunny weather. But I came home anyhow for Christmas. Then the [bad weather] hit them right after Christmas."

Wandering about like a gypsy, Pells became the company's roving field engineer, assigned to a number of large dam and mill developments in Canada and the United States where he provided a variety of foundation exploration and inspection services. In the winter of 1958–59, along with Bill Richards and Alf Rustoen, he was doing the site investigation for the Squaw Rapids Dam near Nipawin in the cold belt of northeastern Saskatchewan: "[It was] one big job. And we were there all winter—September till breakup in April. We looked after all the drilling. Don Davison came in and took that job over when construction started. I never did see the dam built."

Frank was a married man and his wife, Laura, like other company wives, must be cited for their tolerance and endurance during the extended absences of their husbands:

"Two things I remember. In 1954 I left for Alberta on June the third, and on June the eighth our son was born. And in 1958 I left for Nipawin in September, and our daughter [Nancy] was born in September. So I didn't see either of them until they were several months old. I think at the same time Nancy was born, one of Charlie's kids was born, and he was out of town."

Another assignment that took Pells away from his home was inspection of the construction of a paper mill foundation in Gardiner, Oregon.[18] The foundation had been designed by Earle Klohn, and it called for 600 pipe-pile caissons, 14 to 24 inches in diameter, to be driven through a 150-foot-thick compressible soil profile and socketed into sound bedrock.[19] Pells does not recall the job fondly:

"That was kind of an unfortunate job [for me as the inspector] because we got off on the wrong foot with the contractor. I guess he'd lost a lot of money on the job, all of which he blamed on us. He had to go through a layer of gravel that was adequate for the tanks but not for the machinery. And that was the point of contention. He had an 'expert' pile driver there who claimed that was good enough. And we insisted on hammering these piles through [the gravel]. And of course they broke through eventually—went another twenty to forty feet before they hit good ground. But they never did accept that it had to be done.

Driving pipe-pile caissons through compressible soils, 150-feet deep, at International Paper Co., Gardiner, Oregon, 1962.
Photo: Earle Klohn

They had a surveyor on site that I had become good friends with. And it got to the point where his kids weren't allowed to play with my kids. That's how tense it was. I heard afterwards that the client told Earle we'd done too good a job [because] there was no settlement. So I guess we did the right thing one way or another."

In 1966 Frank Pells was appointed manager of field services for Ripley, Klohn & Leonoff Ltd.[20] That year the company began work on Brenda Mines near Peachland, B.C., and Pells went up to inspect the freshwater supply. He returned to the mine in 1967 to do the tailings dam investigation and in 1968 at the start of construction. When construction was completed in 1970, Pells transferred onto Brenda Mines staff as "hydraulics supervisor," a position where he continued to have contact with Klohn Leonoff throughout the years of the dam building:

"I liked both the investigation and the work. And when the opportunity came to stay at Brenda and see the dam through, it was a job that fitted my qualifications. . . . As the work progressed, and we got over those critical days when it was in question whether we were going to get the dam built high enough, fast enough, I got mixed up in the freshwater maintenance and the reclaim-water maintenance, and the reclamation [of the site]. We did all the water sampling and the snow surveys. So it turned out to be sort of a roving commission in the end, which suited me just swell. We finished the dam in July of '86, and I retired in September [at age] sixty-five. I was there exactly twenty years. I went in on Labour Day of '66 and retired on Labour Day of '86. . . . It was a nice job [and] quite satisfying to see the thing done."

In retirement, Pells has continued to reside in the Okanagan at Kelowna, where he has pursued an interest in history.

During the company's formative years, versatile men like Henderson and Pells were jacks-of-all-trades, filling in wherever required—laboratory testing, drafting, report compilation, carpentry, and equipment fabrication. Perhaps conditioned by his frugal Prairie background, Ripley believed in rugged self-sufficiency; neither could he afford the luxury of much store-bought merchandise. Most of the early office furnishings were built by staff members in their spare time—work benches, desks, drawers, and shelves were all handmade. Solid-core doors, for instance, served as table tops and drafting surfaces.

Such frugality was not surprising considering the surprisingly low pay that engineers on B.C.'s early major construction works received, considerably less than that paid to lawyers, accountants, or even construction superintendents. Ripley has noted the contract he signed with Alcan as an example:

Frank Pells, left, and Mark Olsen at Brenda Mines, Peachland, B.C., June 1970.

"Both Bob Hardy and I were paid at conventional per diem rates. But in the previous year, Bob had been doing a lot of work for Alcan where all staff and disbursements were at cost plus ten percent. I wasn't very happy with this, but it was difficult for me in the initial instance to protest. After a time, I reviewed the situation with Bob, explaining to him that it was contradictory to our professional code of ethics [which required cost plus 100 percent], and that the rate should be increased. Alcan was leaning pretty hard on anyone who was doing consulting work for them with the argument that, since Alcan was carrying all the overhead in the field—office space, accommodation, etcetera—this was a sufficient rate. In the end, we carried out most of the work at cost plus thirty percent."

Within a year of opening his consulting engineering practice, Charles Ripley was being thrust into key decision-making roles on multimillion-dollar construction projects which, in British Columbia, had no precedents. He was in dire need of people with soil mechanics training—people who could cope with increasingly sophisticated problems. So he sent out feelers into many different localities. He asked brother Herb if he would conduct interviews at the University of Alberta where there were people graduating with masters' degrees in soil mechanics. One of those people was Earle Klohn who, some time earlier, after completing his bachelor's degree, had in fact been hired by Herb Ripley as resident engineer on the Milk River water system. But when Klohn received an offer of employment from a firm in California, he informed his current employer that he felt he had to accept the offer. Herb Ripley was somewhat disappointed, but nevertheless wished Klohn well. However, in the spring of 1952 and coincidental with Charlie's request, Klohn was back at the University of Alberta completing the master's program.

"I didn't see Charlie," recalls Klohn, "Herb interviewed me and suggested to Charlie that I would be a good guy. The job sounded pretty good to me. I talked to Bob Hardy about this, as I knew him pretty well—not only was I one of his graduate students, I had also worked for him for a couple of years. Bob had started his own company and already had two or three senior people in it. He said I probably had a better chance for advancement with Charlie, so I accepted."

Klohn started as a salaried employee of Ripley and Associates in Vancouver on May 1, 1952. His initial work involved supporting Charlie in the work he was doing for Terzaghi—drilling at the powerhouse site below Bridge River—and in several other jobs the company was doing for B.C. Electric. He very soon set up triaxial shear strength equipment in the company lab and was busy supervising, doing classification work, estimating shear strengths, and helping to put reports together. As well, remembers Earle:

"There were many foundation jobs for small buildings—stores, offices, and things like that. Safeway was going through a major expansion period, for instance, and I did all their store work in B.C.—we always had a couple of stores going somewhere. From that it went into heavy foundation engineering, and the Port Alberni pulp mill for H. A. Simons was really the first big job that I was on."

The Safeway corporation, with head offices in Oakland, California, first called upon Ripley and Associates to investigate the foundation failure of a store on Fraser Street in Vancouver which had been constructed with a grade-supported floor slab over a peat bog. Large settlements, in the order of 2 to 3 feet, had taken place under the heavily loaded food shelves. Ultimately the store had to be demolished and replaced. Safeway today remains one of the company's longest-served clients.

In 1957 Klohn published an early paper covering several case histories of foundation failures of small buildings in British Columbia,[21] failures which had occurred before foundation investigations became standard procedure.

Uneven settlement of a supermarket floor built on peat, Fraser Street, Vancouver, B.C., 1952.
Photo: Earle Klohn

Cyril Leonoff would be graduating from the master's program at the University of Washington in the summer of 1952. With this fact in mind, by the winter and spring of that year, he was sounding out engineering opportunities in Canada. He wrote to a number of organizations and people, but he was particularly interested in two that he knew were doing soil mechanics work—Robert Peterson of the PFRA in Saskatoon and the National Research Council in Ottawa. Bob Peterson responded by saying that he currently had sufficient staff in the soil mechanics section, but that he would forward copies of Leonoff's application to the PFRA design office in Regina and to C. F. Ripley who, he wrote, "has just entered the field in Vancouver."[22] While the Regina PFRA office did offer Leonoff a job "as Engineer Grade I" at the lofty salary of $3,120 per annum,[23] the immediate response of Charles Ripley was notably more enticing:

"I have studied your application with considerable interest . . . and have a position open for an engineer with formal training in soil mechanics in my company. The type of work which the position offers includes supervision of laboratory testing, investigation of building foundation sites, professional reports on the above, and supervision of earthwork construction."[24]

Concurrent with Ripley's response, Leonoff had entered into serious negotiation with Robert Legget for a position with the other agency to receive his application—the Division of Building Research at the National Research Council. Ken Morton, Leonoff's former superior at the Department of Public Works in New Westminster, was also anxious for him to return, but while he had been away at university, Leonoff had been ignored, indeed passed over, for promotion. So, says Leonoff, "I was determined that I wouldn't return to that department." Ripley visited Leonoff in Seattle, and later Leonoff returned the visit to Vancouver. His initial impression of Charlie Ripley was consistent with that reported by many other of the early company staff members:

"A young, eager fellow, who seemed to have boundless energy. He was really just starting to get into interesting work, about which he was very enthusiastic. In turn, my wife and I had very deep roots in western Canada. We'd come out to the coast, loved it, and regarded it as our place of choice. Here was a new, private firm, with a chance for

Booklet to accompany refresher course, March 1953.

quick advancement, if things worked out. It seemed just a natural fit. Salary didn't matter that much—of course I was naïve—it was the possibility of good experience and an exciting career."

Leonoff's first day as an employee of Ripley and Associates was July 14, 1952. His salary was to be all of $350 a month. And it would seem that life at home during those initial months was equally unspectacular:

"We'd come back to Vancouver with a baby, three months old, and without a penny to our names. Affordable living accommodation was very scarce in Vancouver—especially for people with children. Through the help of a friend, we rented an illegal basement suite, with the living quarters wrapped around the house's hot-air furnace. Soon afterwards we managed to find a slumlike apartment, with mice running in the walls, in the Marpole district."

Leonoff had been at work for no more than two weeks when the firm received a request for an asphalt inspector for the airfield at Puntzi Mountain. Frank Pells was already on site inspecting the subgrade construction, but asphalt paving was about to commence, and Pells knew nothing about asphalt. Charlie asked Leonoff to go to the site for "a short time" to start the job. Leonoff was happy to go, but much less enthusiastic about leaving Faye and the baby to fend for themselves. "This was my first [of many] field jobs for Ripley," recalls Leonoff:

"And it was a lot of fun. They allocated for our use one of those surplus army jeeps, the sparsely outfitted legendary ones, not the fancy sportsman's models that are now all the rage. There were two manual gear shifts to coax it, grindingly, into four-wheel drive. Frank and I had both been in the services, so we felt quite at home running it up and down the site."

A typical Ripley "short job" turned into a six-week stay. Paving of the 6,000-foot-long airstrip was completed just prior to freeze-up.

The paving contractor at Puntzi Mountain was a firm named City Construction Co. Their on-site foreman was a stalwart man with thirty years of construction experience. Leonoff would soon come to describe the fellow as someone with "one year's experience thirty times over":

"I had done state-of-the-art design in the asphalt laboratory at the University of Washington. But here I was, only twenty-seven years old, with no grey hair and no actual experience of asphalt pavement construction. The foreman brusquely said, 'I'll give you our standard mix.' I had brought out to the site Marshall stability test equipment and a centrifuge to determine asphalt content. As soon as I tested this 'standard mix,' it was apparent that, while it may have been suitable for passenger car driveways, it certainly was incompetent for carrying the heavy wheel loads of military jet aircraft. So I designed a mix that required better-graded aggregate and more asphalt content."

Upon presenting this new design to the foreman, Leonoff and he "exchanged harsh words." But the foreman nevertheless followed Leonoff's mix, "with excellent results."

Such was the company's dilemma in those early years. The technical aspects of a job were not the only problem. There was also very often a more human dimension. It was frequently necessary to introduce new methods to people who had been using, for many, many years, old rules-of-thumb. And it was by no means an easy task.

In an attempt to counter this problem, in March 1953, Ripley and Associates offered to the construction industry a free Refresher Course on Compaction of Soils. The foreword to the program stated the objectives:

"The course is being held primarily to familiarize construction personnel with the methods used for the design and control of earthwork. . . . Through practical tests and demonstrations carried out in the laboratory, the practical construction man will obtain a better understanding of why certain construction procedures are necessary to ensure a good job. It is hoped that by this means . . . more co-operation between the contractor and the engineer may be developed."[25]

Other work in pavement design and construction soon fol-

Cyril Leonoff measuring pavement deflection with Benkelman beam, Kitimat, B.C., fall 1953.
Photo: Hans Dutz

Winnipeg Beach, Manitoba breakwater, July 1969.
Photo: Cyril Leonoff

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P. ENG. (CIVIL)
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RIPLEY AND ASSOCIATES
CONSULTING ENGINEERS
SOIL MECHANICS AND FOUNDATIONS
ASPHALT MIX DESIGN - PORT AND HARBOUR DESIGN
FIELD INVESTIGATION · LABORATORY TESTING · INSPECTION OF CONSTRUCTION

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VANCOUVER 9, B. C.

1953 letterhead indicating expanded areas of expertise.

lowed. The firm designed all of the pavements for the Alcan Kitimat wharf and plant site, and Leonoff spent the fall of 1953 and the summer of 1954 at the site supervising its construction. Large deflections were occurring under the extremely heavy loads of earth-moving trucks, resulting in the cracking of pavements, and so, for the first time in Canada, the Benkelman beam was used to measure deflection under dynamic, rather than static wheel loads.[26] This equipment had only recently been developed at the Western Association of State Highway Officials (WASHO) test road.[27] Ripley and Associates also designed, for H. A. Simons Ltd., a number of asphalt warehouse floors that had to be capable of sustaining the very heavy loads carried by forklift trucks as they handled huge kraft-paper rolls.

Unfortunately, Ripley and Associates was not as successful in selling the new technology of either soil mechanics or pavement design to most established governmental departments. The provincial Highways Branch was undertaking a massive highway construction program throughout the province at the time. And the city of Vancouver was tearing up streetcar rails and repaving all major arterial streets. But, whereas industrial clients were receptive to rational design, civil servants seemed slow to accept new methodology. A dispute arose, as an example, between the federal Department of National Defence and the provincial Highways Branch as to the thickness of pavement and base required on a section of the Northwest Highway. (The operation of this section was to be taken over by the province.) The federal department accepted the company's design recommendation, which suggested a thicker road section,[28] but this acceptance had a long-term detrimental effect on the relationship between the company and members of the provincial authority, who resented the implied criticism of their original design.

Another field in which Leonoff had training and experience was that of port and harbour design. This was indicated on the 1953 letterhead of Ripley and Associates.

Using Archie Paget (Leonoff's former superior at the Public Works office in New Westminster) as a consultant, the company designed two timber wharves at Victoria and at Ucluelet for Imperial Oil Ltd. Later Leonoff designed a large rubble-mound breakwater, subject to heavy wave and ice loads, in Lake Winnipeg to protect Winnipeg Beach, where he had vacationed as a child. There was also design work done for dredging and the building of beaches at Point Grey[29] and Burnaby Lake in British Columbia's Lower Mainland, and at Paul Lake, near Kamloops. And Leonoff did investigations for the Departure Bay Ferry Terminal for the original owners, Black Ball Line, before that operation was taken over by the governmental agency, B.C. Ferries. However, most of the work in this field continued to be done by government departments, so that there was limited opportunity for private consultants.

From his earliest days in British Columbia, Charles Ripley had recognized the potential for work in the forest industry, where there were a number of mill expansions planned. He first tried to contact the mill owners directly, without much success. It then occurred to Charlie to contact the two world-class pulp and paper engineering companies that existed in Vancouver, H. A. Simons Ltd. and Sandwell and Company Limited. Ripley was not, however, anxious to disturb a relationship which already existed in connection with Sandwell and Company. Paul Cook, with whom Charlie had first considered practising, had established himself with the Sandwell organization.

H. A. Simons Ltd. was to become Ripley and Associates' most significant long-term client, and the first assignment from Simons came in October 1953. Charlie was requested to evaluate the site of a proposed converting plant and box factory for Canadian Western Lumber Co. Ltd., which was then a subsidiary of the Crown Zellerbach organization of San Francisco. The site was next to a major sawmill at Fraser Mills, on the Fraser River, upstream of New Westminster. A number of test holes were drilled which encountered very sensitive, compressible clay[30] at a depth below the sand. A dredged river sandfill, 7.5 feet thick, would be required to elevate the site above flood level. Ripley, assisted by Klohn, carried out a conventional settlement analysis based on consolidation tests of the samples obtained from the drill holes, and this analysis indicated a settlement of up to 5 feet under the fill load.

Charlie Ripley recalls that "by nature" he would have been suspicious about the accuracy of this prediction, but, in this instance, he was particularly worried about taking the estimate to H. A. Simons. Charlie's deliberations were almost anguished:

"I thought, gosh, that couldn't be the only site along the Fraser River underlain by soft marine clay. I searched as well as I could, but could find no available records taken on any [other] site. The existing buildings [along the Fraser] were generally relatively flexible, timber-frame mill buildings which would be able to absorb a lot of settlement without showing much distress. The only evidence of significant deformations that I could gather was at the government grain elevator opposite New Westminster. I understood that the building had tilted over a foot at the top. It was pile-supported in the sand layer, but the load was then transmitted into the clay."

Charlie's report, with its dire predictions, was duly filed with Simons[31] and initially unchallenged. But Ripley was then asked to attend a meeting along with executives from Crown Zellerbach. However, Charlie was scheduled to be in Kitimat at the time of the meeting, so Earle Klohn attended in his place. Klohn had hardly sat down before it was announced that the client and Simons would like to obtain a second opinion. Someone from the Crown Zellerbach organization suggested Dames and Moore, soil consultants from San Francisco, whom the company was accustomed to engaging for their work in California. But Klohn knew this wasn't a popular name with his own firm, largely because, according to Ripley, "their people at the time did not believe in the theory of consolidation." Thinking quickly, Klohn suggested that, if they were intending to retain an outside opinion, it would make sense to "get the best—get Dr. Terzaghi." He didn't realize at the time that Mr. Simons had a long-standing relationship with Dr. Terzaghi, going back to their meeting in 1929 at Grays Harbor, Washington. Terzaghi was indeed consulted, and supported Charlie and Earle's analysis completely, stating that, "Whatever is put on that site will have to absorb substantial differential settlement."[32] As a result, Simons recommended that the client look for a different site.

Several new possible sites were then examined. One of these was the present location of the posh Bayshore Inn at Coal Harbour in downtown Vancouver. But this site was problematic inasmuch as it had been filled with a great variety of waste debris and old concrete pavements. The site finally chosen was at the foot of No. 3 Road in Richmond, again on the shore of the Fraser River, where the primary material used in the manufacture of paper boxes could be off-loaded. The difference between this site, three miles upstream of the river mouth, and the Fraser Mills site, fifteen miles farther upstream, was that no clay was encountered within the significant depth of 350 feet. Total settlement would be in the order of 2 feet, but most of this settlement and virtually all differential settlement, would be removed by preloading prior to building construction. The Richmond site was developed in the fall-winter of 1954–55, with construction supervised on a daily basis by Cyril Leonoff.

The Richmond Converting Plant was a precedent-setting project in the Greater Vancouver region, and perhaps in all of Canada, on several counts. It was the first documented case of the use of preloading for a manufacturing plant on the Fraser River Delta—whereby a heavy load is placed on the plant site, inducing settlement before the building is constructed. While the modern sampling and measuring techniques employed in preloading are new and sophisticated, the concept itself is ancient and simple. It was used, for example, in Europe for construction of huge medieval cathedrals. In order to settle the ground, the cathedral builders loaded the site with rock and masonry, often years ahead of the building construction. Present-day engineers use earth as the loading material. Before excavation work begins, undisturbed samples of the subsoil are taken and tested in a laboratory consolidation apparatus, which measures the compression under an applied load. The amount and time period of the settlement can thereby be estimated for design purposes. (As well, the actual settlement can be measured on the site by means of settlement gauges, and compared with the laboratory estimates.) The preload soil is then piled to a weight equal to or greater than that of the future building. After the settlement is completed, the preload is removed, and the structure can then be safely built.[33]

To prevent the earth-moving equipment from bogging down at the Richmond site, removal of the organic mantle was not attempted. Instead, the ground was simply rolled with a giant 50-ton "Roll-O-Pactor." This compacted the topsoil and revealed any weak areas in old stream channels, which were then excavated. To develop the 25-acre site safely above high tide and river flood levels, the grade was raised 6 to 9 feet with sandfill dredged hydraulically from the nearby river. The company had learned from its Kitimat experience how to wash the silt out of the sand by means of a downward gradient for the dredge water during placement of the fill. Dr. Terzaghi, when he visited the site, was amazed to observe the good quality and density of the sand obtained by this method of deposition. This was the first engineered preload fill placed in the Greater Vancouver

Crown Zellerbach, Richmond, B.C. – Paper Converting Plant and Box Factory, 1956.
Photo: Crown Zellerbach

Crown Zellerbach, Richmond, B.C. – Placement on plant site of hydraulic fill dredged from the Fraser River, December 1954.
Photo: Cyril Leonoff

region, a procedure now routinely used.

When completed, the 8½ acre manufacturing plant was the largest in British Columbia under one roof,[34] and it was the first large industrial plant on the delta not supported on piles. Instead, the building and machinery were supported on spread footings founded within the fill, with floor slabs at grade on compacted fill, a more economical design. With no prior case histories, prediction of the magnitudes of total and differential settlements had been difficult. A 200-foot-long corrugating machine, which could tolerate virtually no differential settlement, was the greatest concern. A fixed 350-foot-deep bench mark was placed within the building, which, at this depth, would be unaffected by the settlement. This allowed, for the first time, the true settlement of a building on the Fraser Delta to be measured. Fortunately the predictions turned out to be quite accurate. Up to 2 feet of settlement was removed by the preloading method prior to building construction and post-construction settlement of 1½ to 4 inches has been safely absorbed by the structure without any adverse effects.[35]

Another innovation at the site was achieved in carrying the preload fill 100 feet beyond the walls of the original building, so that any future extensions could be made without damaging the existing plant.

A paper on this project was presented by Leonoff and Ripley to the Fifteenth Canadian Soil Mechanics Conference.[36] In a discussion of this paper Dr. Terzaghi remarked, in part:

"The paper illustrates quite strikingly the benefits which can be derived from the application of soil mechanics to the design of building foundations in those instances in which the subsoil conditions preclude the possibility of a rigorous settlement forecast. . . . No boring was made and no test was performed which was not . . . based on a realized appraisal of the economic benefits which could be derived by further investments in subsoil exploration. The remaining gaps in the knowledge . . . were clearly recognized and bridged by intelligently planned observations during construction. That is the goal towards which every designer should strive. It is obvious that the procedure requires that the designer remain in close contact with the construction operations until the job is completed."[37]

Ripley too has commented on the significance of the Richmond Converting Plant job to his company:

"I feel that the report[38] was a very good one for its time, and it impressed the Simons people greatly. Ned Beaton, Simons's representative on that project, had never dealt with any soil mechanics people before. He read that report and came into my office. He didn't know whether it was just hot air, idealism, or what. He said, 'Tell me what it means and why.' I spent two hours with Beaton going through that report as to why everything must be done as we had recommended. Otherwise there would be trouble. He went out of there fully convinced and thereafter supported us very well. It also confirmed to Dr. Terzaghi that we were serious in our work."

In the mid-1950s, the pulp and paper industry in British Columbia was about to expand exponentially, with the construction of several new plants for which H. A. Simons Ltd. was to do the engineering work. Howard Simons approached Dr. Terzaghi about the large amount of work ensuing and asked if he could rely on Terzaghi's continued advice. Terzaghi in turn spoke to Charles Ripley, indicating that he had told Howard Simons that he would not be able to involve himself in this work to any detailed extent. Instead he was recommending that Simons turn over to Ripley the reports that Terzaghi had written on Elk Falls (Campbell River) and Port Alberni (where Terzaghi had consulted since 1946), so as to give Ripley an opportunity to study them. Terzaghi had also told Simons that he should rely upon Ripley's firm to do all of the detailed engineering for the mill foundations.

From that time on, until 1961 when Dr. Terzaghi was no longer able to travel, he reviewed all of the reports that the company did for Simons. In so doing, he consistently reinforced the confidence that H. A. Simons Ltd. developed in the firm Charles Ripley founded, and that confidence has carried on to many projects outside of Canada—to the United States and abroad.

The foundation for the MacMillan Bloedel Limited pulp and paper mill at Port Alberni, constructed in 1955, was to consist of 26,000 piles—an astounding number, even for a major logging firm anxious to use its own product. The piles were to be mainly timber, having an average length of 50 feet, but some as long as 125 feet. They were to be driven to end-bearing in the underlying glacial till, sand, and gravel strata of the tidewater site.

Howard Simons himself called Charles Ripley in, gave him Terzaghi's reports, and impressed upon Ripley very emphatically that he would be "counting on [him]." The mill would have very limited tolerance for movement. The contractor would be driving "a literal forest" of timber piles into the ground, very close together. These piles would be displacing a huge volume of soil, squeezing it out of the ground.

Simons then went on to inform Ripley of all that he knew about pile foundations of this kind, which appeared to be considerably more than Charlie knew at the time. The piles had to go in very rapidly—several pile-driving rigs were to be simultaneously employed on the work. Leonoff recommended that, in order to ensure that the job start out on "the right track," Charlie again engage Leonoff's old colleague Archie Paget, which Charlie promptly did. Paget had considerable experience in driving pile foundations for wharves and knew every driver and crew on the coast and thus gave credibility to the firm's work on the site.

Earle Klohn became the company's engineer on this massive project:

"In today's terminology, Simons was the client, Terzaghi the project consultant, Charlie the project manager, and I was the project engineer. This was the case on the Alberni work and on many subsequent mills. We were hired by H. A. Simons to do the whole bit—supervise the drilling, carry out pile tests, recommend the penetration and loading on the piles. It was all reviewed by Terzaghi, who approved things that he liked or changed things that he didn't like."

There were tremendous heave problems on the site, a phenomenon which occurs as the volume of the piles displaces the earth and pushes it upward. The ground heave was as much as 3 feet, and the pile heave could be as much as 2 feet, and so it had to be ascertained which piles had heaved, how much, and which required redriving.

At Terzaghi's suggestion, Earle Klohn wrote a technical paper on the Port Alberni Mill work entitled, "Pile Heave and Redriving,"[39] published by the American Society of Civil Engineers. It won the Alfred A. Raymond Award of 1960 "for the best original manuscript on design and construction of foundations for structures." In recalling the event, Klohn points out that, "It was one of the top international awards—$1,000 plus a big dinner event. Some very top engineers were competing, and it was a highlight for me, a young engineer, to win."

Earle Klohn has expanded upon what it was like for him, at the time of the Port Alberni mill construction, to work closely with Terzaghi and Arthur Casagrande, Terzaghi's long-time associate:

"Karl Terzaghi was the father of soil mechanics, the unchallenged leader in the world, and what he did or said, that's the way it was. Arthur Casagrande was the number two man in soil mechanics and had to play second fiddle to Terzaghi. Casagrande never liked that, although he accepted it. But this situation created some embarrassing problems. If you were working closely with Terzaghi, Casagrande looked at you as if you were some kind of an enemy—just a conflict of egos. When I was working on the Port Alberni job, about twice a year I would pack a couple of briefcases full of data and go to Harvard to brief Terzaghi. He would review the work and then write a report for the client. At Harvard, I was always a little leery of Casagrande, who was very aloof and didn't want anything to do with me because I was dealing with Terzaghi.

Macmillan, Bloedel and Powell River Ltd., pulp and paper mill, Port Alberni, B.C. – Mill buildings, foreshore fill, and deep-sea dock trestle, November 4, 1959.
Photo: George Allen Aerial Photos

"On one of these trips, I remember briefing Terzaghi in his office, and he then immediately wanted to write his report. So he said, 'I'll have Arthur show you the lab.' I shuddered, but said 'Okay.' Casagrande was busy as hell—he worked seven days a week. And, at that time, his back was bothering him a lot. He had a cot in his room that he would lie down on to relieve the pain. Terzaghi picked up the phone and said, 'Arthur, I have Klohn here from Vancouver. He is coming down, show him the lab.' Bang! Terzaghi hangs up. So, Arthur is waiting for me at his door. I try to start a friendly conversation, but he just cuts me off—real cold. What else would you expect? He calls one of his graduate students and says, 'Show Klohn around the lab.' And while we're standing at the doorway to this student's office—everything had been freshly painted—right there were some dirty hand prints on the door jamb. Casagrande looks at this, turns to his student and says, 'That's a disgrace—wash those goddamn hand prints off that door! It was just painted.' And with that he stomped off. But that is how Casagrande operated."

And how did Terzaghi's personality compare, in Klohn's mind, to that of the sometimes perturbable Casagrande?

"Terzaghi was a perfectionist and an autocrat. He was the world's expert, and he let everyone know that he was. It goes without saying that he was brilliant—very perceptive, with a keen analytical mind. He could pick out the wheat from the chaff very quickly. He was also a very good judge of people—whether they were honest, dishonest, and whether they were giving all out or not. He wouldn't put up with anybody who gave him an answer without facts to back it up—if you didn't have the correct answer you had better say, I don't know—otherwise you could have very serious problems. Most people who operate as Terzaghi did have to be that way or they don't survive—someone they can't trust can easily get them into trouble. Let me say that Terzaghi wouldn't be my favourite person, but as an engineer he was splendid."

Macmillan, Bloedel and Powell River Ltd., pulp and paper mill, Port Alberni, B.C. – Pile driving at Newsprint Machine Building.
Photo: Earle Klohn

Bob Maartman, one of Klohn Leonoff's most experienced engineers, has perhaps put Terzaghi's attitude into a correct perspective: "It takes time to become an expert—you simply have to wait until you're into your sixties and seventies. Then people begin to listen to you. Today, Charlie and Earle are getting into the same spot that Terzaghi was in. People don't argue with them anymore."

The work that Klohn Leonoff Ltd., and its corporate predecessors, did with H. A. Simons Ltd. brought the firm into contact with an international engineering organization whose work in the pulp and paper industry was of the highest possible calibre. The personnel at H. A. Simons Ltd. were dedicated to a quality of service that they have been able to successfully market world-wide. While some people have accused them of doing a "Cadillac" job when it may have been possible to "get by with a Ford," there is no doubt that, in the end, Simons's meticulous approach to building sound mill structures has saved their clients money. Quite simply, and to this day, H. A. Simons Ltd. are known as the best pulp and paper engineering people in the world.

Howard Simons himself was something of an enigma. In person he was a modest, shy man who shunned publicity and avoided the public eye. Engineering came first. Yet, within his own company, H. A. Simons was dictatorial. His staff members either produced according to Simons's rigorous standards or found themselves called to account. Even though he was wealthy in his own right and could have retired as a relatively young man, Simons remained until his senior years a very serious, hard-working, and dedicated engineer. He assumed prime responsibility for all the work done by his large organization and therefore was often under terrific pressure. Fortunately, he was a natural leader of men. He was able to choose his senior men wisely and then train them to expect his own high standards. Although he was feared by his staff, they respected him greatly and somewhat affectionately referred to Simons as "the old man."

Karl Terzaghi is on record as saying that he had never dealt with another project engineer of Simons's calibre. Charles Ripley has said that he considered it "a real privilege" to have had the opportunity to do work for Howard Simons. Like Terzaghi, Ripley considers Simons the most outstanding project engineer he has ever been in contact with:

"Mr. Simons demanded excellence and he knew how to put responsibility on young people, to make them rise above anything they had ever done before. That's what he did with me, and with Earle Klohn. Sure Mr. Simons could be blunt. He phoned me up on a couple of occasions and chewed me out, yet he was one of the most polite and courteous men that I have ever met."[40]

Charlie Ripley has pointed out that Howard Simons was extraordinary on another count as well, inasmuch as Simons discerned very clearly the problems inherent in the engineer-contractor-owner relationship. Simons understood, when it came to the construction period, that there is automatically an adversarial relationship between the inspection staff and the contractor—the contractor having to meet the specifications, yet trying to build things as cheaply as he can—the inspector being charged with the responsibility of making sure that the specifications are met and the quality maintained. "While Mr. Simons would listen carefully to the contractor," points out Charlie, "he never failed to call us in to ask for our side of a dispute before making his judgments—and he usually backed us up."

Earle Klohn was the person who did most of the initial detailed work for the Simons organization and therefore attended many of the Simons project meetings. In the process, he came to know Howard Simons very well and to think highly of him:

"I liked Mr. Simons—I admired Mr. Simons. With him it was quality first—you did it right or you didn't do it at all. With some of his own staff, when they made mistakes, he could be very hard. He smoked cigars incessantly. He would chew on his cigar and say, in very intimidating fashion, 'Why did you do that?' With others, and usually with myself, he was an absolute gentleman. He thought the sun rose and set on Terzaghi—always called him Doctor, very polite. I was always a little concerned about him jumping on me—he could give you hell. I remember his project manager and myself being called into his office one day after we had just finished the preliminary foundation work on one particular project. After some discussion, Simons asked me, 'Are you sure you know what you're talking about—are these answers right?' I said, 'Yes, they are correct.' He said, 'Well I was only asking because you know what they do now; they sue people. There is nothing personal in this, Klohn, but if something goes wrong, you'll probably get sued for half a million dollars.' The other people at the meeting turned kind of white, but he was just making sure that I understood the importance of the decision."

Howard A. Simons, honoree American Society of Mechanical Engineers, Vancouver, B.C., April 1980.
Credit: Simons Update, July 1980

Earle Klohn can recall another occasion when Howard Simons had cause to be "direct" with him. It was either Christmas Day or Boxing Day, to the best of Earle's recollection, when the water supply pipeline to the Crofton Pulp Mill failed:

"In this particular section, the contractor hadn't put the pipe quite where we had indicated it should be put. In going down a hill, and trying for a better alignment, they moved off the rock bed and put the pipeline across an old swamp. It was a four-foot-diameter pipe composed of spun concrete over steel lining. It of course had settled, opened up at an O-ring in the bell and spigot joint, and washed out a hell of a hole in the swamp. Mr. Simons phoned me up and said, 'The pipeline's failed, Klohn. You better get over there and find out what's happened. Shumas is going with you.' Poor old Fred Shumas was head of the Hydraulics Department—responsible for the pipeline design. So, Christmas Day or not, Fred and I got out there, and it was just pouring—about two inches of rain a day. We started at Cowichan Lake and walked every inch of that pipeline, about twelve miles. It took us all bloody week, and every day we got soaked to the skin. We didn't find any more failures, but when we got back, we had to report to Mr. Simons that we had gone over it all very carefully."

George Fletcher was the executive vice-president of H. A. Simons Ltd., even though he was not an engineer. He oversaw the business side, including the execution of contracts, and this brought him into repeated contact with Earle Klohn, who remembers George well:

"He was very clever, very astute. And he was the salesman personified: 'Yes sir, no sir, have a cigar.' At Christmas he always offered you cigars. But he was tough as hell when our bills went over what they should have been. I remember being called in and he said, 'Well Klohn, I can't help it but you're over your budget, and we don't have any money in our budget for it. I think you should absorb that, because you want to keep doing more work for us. We enjoy your work, but we can't do anything about it.' I didn't know very much about business in those days, but he was just saying, 'You went over your budget, damn it, so take it out of your own pocket.' But they were good clients and are still good clients today."

In the latter years of Howard Simons's direct control over the company, whenever he encountered a foundation problem anywhere in North America, he was likely to phone L. S. "Mike" McLennan, head of his company's Structural Department—by reputation a very good and conservative structural engineer. Simons would then tell Mike to call Earle Klohn. As Earle remembers these occasions: "We would fly off to wherever, look at the problem, come back and report directly to Mr. Simons. To my mind, it was a real honour that 'the old man' felt that he could trust me to look at the soil mechanics problems, although Mike McLennan was there to make sure I didn't get too wild and woolly about the structural problems."

On April 9, 1980, near the end of his long life, at a meeting convened in Vancouver and attended by 200 guests, Howard Allan Simons was honoured by the American Society of Mechanical Engineers with a commemorative medal for "outstanding contributions to engineering."[41] Charles Ripley was happy to come from his home in Victoria to attend the meeting, largely because he felt that H. A. Simons had been "almost ignored in his lifetime," despite the fact that Simons's company was probably the largest employer of professional people in the province. Charlie was of the opinion that Howard Simons should have been awarded an honourary doctorate degree by the University of British Columbia, and so he was "more than pleased" when a senior executive of the ASME arose at the meeting to say that he found it very strange that Howard Simons should be unknown in his own country when the reputation of his firm is known world-wide and that firm looked upon with envy by all of its competitors. "To me," adds Charlie, "that was a tremendous tribute to H. A. Simons."

In the early days of Ripley, Klohn & Leonoff, the company's other major client was the Greater Vancouver Water, Sewerage and Drainage Districts. There were actually two boards overseeing the water and sewer responsibilities of the district (these later became part of the Greater Vancouver Regional District [GVRD]), but the same engineers were involved in both. Dr. E. A. Cleveland was the original commissioner of the districts, and, under his regime, a landmark engineering achievement in 1933 was the completion of the water supply shaft and tunnel from the Capilano River, underneath First Narrows of Burrard Inlet, and into Vancouver.[42] Cleveland must have been a remarkable man, if only because of the attitudes he fostered in his successors—Theo Berry, Ken Patrick, and Frank Bunnell. Although their agency was semi-governmental, these men ran a tight, efficient organization. From the engineers to the works foremen, members of the staff were very competent, and morale was invariably high. The agency did a lot of innovative and unique work in building pipelines and was always receptive to new methods in both engineering design and construction.

Charles Ripley's first chance meeting with Frank Bunnell had taken place on the same automobile trip on which Charlie had met Mark Olsen, the company's senior employee. But Theo V. Berry was the commissioner under whom Charlie's company did most of its early work. Although his position was mainly administrative, in large part dealing with the different boards, Berry was a civil engineer who understood the problems and responsibilities inherent in the large, post-World War II public works that were being undertaken in the districts.[43] According to Ripley, "Berry was the one who had to make decisions on projects where we did, in effect, pioneering work, and I always appreciated the degree of confidence that he showed in us."

The early major projects which the company carried out for the Water and Sewerage Districts were four: control of seepage in the Districts' two main water supply dams in the North Shore mountains, the use of well points to dewater pipeline excavations in water-bearing sands of the Fraser River flats, and—the boldest preload fill job ever undertaken in the region—the laying of the foundations for the Iona Sewage Treatment Plant, built on a submerged island at the mouth of the Fraser River.

Cleveland Dam is a 102-metre-high and rather narrow concrete dam and spillway set in the Capilano River canyon. The dam was designed by B.C. International Engineering Company, under W. G. Huber and Glenn Crippen. Because of the company's work at the Wahleach Dam, in 1952 Ripley and Associates were invited to participate in construction inspection of a compacted glacial-till blanket, to be placed covering an upper aquifer and extending 700 feet upstream of the left abutment of the concrete dam. The soils composing the abutment were very dense deposits, of complex stratigraphy, laid down by glaciers during their advancements and recessions in the ice age. While the upper aquifer could be easily seen on the upstream side in the reservoir area, it didn't appear to be present on the downstream slope. These conditions give rise to the possibility of high water pressures within the aquifer which could in turn cause instability of the downstream slope.

The Water District had earlier sought advice from a number of geologists. Dr. Victor Dolmage, who had guided the initial drilling, was consulted, as were Dr. H. C. Gunning, from the University of British Columbia, and Dr. Charles P. Berkey of Columbia University, who was the eminent engineering geologist for dam projects in the United States. They had reported that it was impossible to predict the stratigraphy of the immediate area.[44] There was no evidence of the aquifer carrying through to the downstream side, but there was the likelihood of springs developing on the downstream face. The designers had decided that these springs would be treated as and when they developed.

Towards the end of the construction period, the chief engineer of the Water District, Ken Patrick, asked Charles Ripley to review the stability of the downstream slope of the abutment. Patrick was concerned for two reasons. The water supply pipeline leading from the reservoir rested on

Cleveland Dam, Capilano River, Greater Vancouver Water District, June 13, 1959.
Photo: George Allen Aerial Photos

that abutment, and a chlorination house tied into the pipeline was just a short distance downstream from the dam. This building housed large tanks of chlorine and the system's chlorinator itself. The concern was that any instability disturbing the chlorination house might release a cloud of chlorine gas, which would be an extremely serious matter. Ripley has commented upon the fact that the technology available to him for the job was at "a very low level." Methods of analyzing the unknown stratigraphy were "totally inappropriate." Ripley had to essentially guess the location of tunnels that would intercept the natural drainage channels, and the project has required close attention ever since. Frank Pells recalls his encounter with Dr. Dolmage on this occasion: "He was so down-to-earth, just a neat fellow. He was very careful too. When we were doing the drainage tunnels there in '55, and I was logging them for him, he quizzed me at great length over my classifications. But he went away and I didn't see him back there again. So I guess he was reasonably satisfied."

As Charlie describes the inspection of the Cleveland Dam, "It has been a continuing process of refining the drainage to keep the pore pressures down, to ensure that the downstream slope remains stable, to reduce and control the loss of any soil with the seepage water, and to keep the flows at a reasonable level." Ripley continued as a review consultant on this project until the end of 1985:

"I felt that, with my age, it was time to bring others in, so that there would be continuity. I recommended that a complete review of Cleveland and Seymour Falls dams be made for two reasons: we now have better methods of analysis, and the seismic forces that may have to be faced at some time in a future quake are now considered to be very much higher than we thought of in the 1950s."

Klohn Leonoff Ltd. has been retained to do much of this review work.

Seymour Falls Dam, a composite concrete and earthfill structure, was another unique and very challenging project, since it was founded on both pervious and compressible deposits. Crippen Engineering were the overall project engineers, and they had designed the spillway section—a slab and buttress concrete dam which sits on a small rock spur. Ripley and Associates were asked to consult on the construction of an earth embankment portion which was to extend westward, to the right of the concrete dam. The embankment was to be founded on "the Cougar Creek cone"—a sloping, cone-shaped fan composed of talus deposits brought down by snowslides from the hillside above. The cone, extending outward from the right side of the valley, had eventually joined the rock spur, thus creating a lake behind. Since the end of the glacial period, the lake bottom had been gradually covered with soft, organic sediments which were now abutting against both the rock spur and the talus cone. The earth embankment, resting on the highly pervious cone where it joins the concrete dam, was also to rest partly on these highly compressible lake deposits.

So the engineering challenge was to design a dam that would inhibit excessive leakage through the cone and one that would accommodate the large settlement that would be caused by the weight of the embankment on the compressible soil, this without breaching of the dam. Only simplistic methods—*in-situ* permeability tests in drill holes—could be used to estimate the seepage out of the reservoir. As well, predicting and measuring the settlement, which was thought to be potentially as much as 10 feet, was particularly difficult. The design included upstream impervious blankets, covering 28 acres, to reduce the leakage to tolerable limits, measures to accommodate large settlement, and drainage facilities to control the substantial seepage flows. Dr. Terzaghi provided guidance throughout the project.

Zoned construction, Seymour Falls Dam, Greater Vancouver Water District.
Photo: David Campbell

Seymour Falls Dam, having a total crest length of 1,510 feet, was completed in 1960 to a height of 88 feet, with design provisions for an ultimate height of 145 feet in order to fully exploit the watershed. Fortunately, both seepage and settlement occurring since completion have been within the ranges predicted, and the dam has been in successful operation for thirty years without a serious problem.[45]

Ripley and project engineer Dave Campbell presented a paper on the Seymour Falls Dam to the Engineering Institute of Canada and in 1964 were presented with the Institute's Gzowski[46] Medal for the best paper of the year on a civil engineering subject.[47]

Two other early projects, where the methodology was devised by Charles Ripley and the project supervision carried out by Cyril Leonoff, are also illustrative of the company's work for the Sewerage and Drainage District.[48]

The Manitoba Street outfall was a major sewer pipeline crossing the Fraser River flats, below Vancouver's Marine Drive, to the north arm of the river. Previously, in trying to lay the pipeline, the district had encountered no end of very time-consuming and costly trouble in digging an open trench through water-bearing sand. Ripley and Associates were called in, and auger holes were drilled along the pipeline route which showed silt on top of the flats and fine water-bearing sand beneath. Years earlier, on a large, open excavation conducted by the PFRA in the riverbed of the Saskatchewan River, Charles Ripley had gained experience with the use of well points to dewater sand. But, in this instance, laboratory tests indicated that the silt-sand soils along the sewer line were only marginally susceptible to well-point technology. Nevertheless, Charlie recommended to the client that the Stang Company, well-point specialists, be consulted. Stang thought that well-point technology would work, provided the well points were in excellent condition—free from corrosion and plugging. The system was installed and worked "like a charm."

Iona Island Sewage Treatment Plant, Greater Vancouver Sewerage and Drainage District, opened April 19, 1963.
Photos: George Allen Aerial Photos

Preload fill in place, December 3, 1960.

Excavation for deep pumphouse, August 21, 1961.

Perhaps the most striking local project of the first decade of the company's practice was the Iona Sewage Treatment Plant—the first major sewage plant constructed in the Greater Vancouver region.[49] The plant designers were Brown and Caldwell of San Francisco and Crippen Wright Engineering of Vancouver. Ripley and Associates was the foundation consultant. Without a doubt, choice of the plant site on an island at the mouth of the Fraser River was governed by the needed hydraulics of the sewerage system, rather than by the desirability of the site's sub-surface geology. The site had unusually poor subsoil conditions—recent deltaic deposits of soft silt, clay, and sand to hundreds of feet depth. Before filling, 75 percent of the building area was in fact submerged by high-tide waters. Development of the site safely above sea and river levels called for raising the grade 6 to 11 feet above the original ground, using sandfill dredged hydraulically from the riverbed. Compounding the complexity of the project was the maze of reinforced-concrete structures that were to occupy the 600-by-800-foot building area. These ranged from a deep pumphouse, 38 feet below ground surface, to huge "floating" treatment tanks founded on slabs at or below grade. In order to allow for the flow of sewage through the various treatment stages, these structures were all to be interconnected.

Plant construction nearing completion, January 28, 1963.

The major foundation problems related to the total settlement of the compressible subsoils under the heavy fill and plant structures, but even more critically to the differential settlements that would occur beneath the various structures because of their uneven loadings. Compounding these problems were the hydraulics of the lines coming into the plant from the Vancouver sewerage system, and those going out, after treatment, discharging the sewage into the ocean. If the settlements were more or less than predicted, by any significant amount, the hydraulics of these lines would be seriously impaired. Studies showed that the settlements would vary from 1 to 5 feet across the site and would occur over a period of fifteen years. A secondary yet equally difficult problem was that posed by the deep excavations needed for placing the pumphouse and other structures down to a depth 30 feet below river level.

The principal feature of the site-development technique devised was the removal of a large portion of the total settlement prior to plant construction and the "ironing out" of the future differential settlements. This was accomplished by preloading the site for two years prior to start of building construction, thereby removing an average of 3 feet of settlement. By varying the height and weight of the fill over the various structure sites in proportion to their ultimate loadings, differential settlement was virtually eliminated. A carefully controlled method of dewatering, using a combination of deep wells and well points, was employed to dehydrate and stabilize the deep excavations, without the need of sheeting and bracing. The result was a successful and economical project.[50]

Charles Ripley recalls the project as something of a breakthrough for his company:

"The Iona Treatment Plant would have been a foolhardy project if we hadn't had the background from Kitimat and from the Richmond Converting Plant. I referred to it as a bold project, but with our knowledge it was reasonable. There was a lot of careful work done by our staff with regard

Reservoir filled, September 1958.
Photo: Cyril Leonoff

to the detailed settlement calculations, the reports that explained the problems to the client, the specifications [for fill placement, excavations, and dewatering], and the technical supervision of construction. Leonoff's experience on contract work from the Department of Public Works, and his interest in preparing these specifications in a very thorough manner, to a degree that had not been done previously in the province, added to our skills."

RKL completed the Iona foundation job entirely on its own, without any review consultant.[51] Ripley later confessed to the fact that he was actually too worried about the project to inform Karl Terzaghi of its inception and progress. He felt Terzaghi would think the design too complicated. Adds Charlie, "I told him afterwards, but he didn't say much."

Another smaller, but still sophisticated water supply project for the company was the design and construction, in the mid-1950s, of a 2-million-gallon water storage reservoir for the city of Prince George and their municipal consultant, Associated Engineering Services. The reservoir was to be built entirely of soil, without the use of concrete or plastic liners. The site, overlooking the city, is located on the top of a drumlin, a rounded glacial hill rising 200 feet above the surrounding countryside that acts as a natural elevated stand for the reservoir. It was estimated that the cost-saving in utilizing the drumlin would be as much as 50 percent, as compared with construction of an elevated steel tank of equivalent capacity.

Donald Davison running levels on top of impervious lining, September 14, 1956.
Photo: Cyril Leonoff

The reservoir was designed to occupy all of the 1-acre site, resulting in steeply sloping hillsides at its immediate perimeter. The subsoil consisted of a glacial-till cap, underlain by pervious gravels and sands. Any appreciable water loss from the reservoir could result in extra pumping costs and, in the extreme, instability of the hillsides, with rupture of the reservoir as a possibility. The special features of the design included the use of excavated glacial till to build an impervious lining, the use of a pervious gravel underdrain beneath the main lining to collect and remove all seepage water, and a second glacial-till lining below the underdrain. This complex cross-section of fill layers required extremely careful construction procedures, to both provide continuity and prevent contamination of the various pervious and impervious layers. The layers were designed to act as filters that would prevent movement of the soils, and the result has been that virtually all seepage into the subsoil has been eliminated and the stability of the hillsides maintained. Cyril Leonoff later presented a paper on this unique job to the Municipal Engineers' Division of the Association of Professional Engineers of British Columbia.[52]

In retrospect, the jobs cited above and others to come were major technical achievements for the company—avant-garde for civil engineering in British Columbia at the time. The personnel at Ripley and Associates had been well trained in leading universities, but while the principles employed may have been clearly understood in textbooks and classrooms, in practice these methods were

B.C. Electric, Head Office Building, Vancouver, B.C., May 30, 1959.
Photo: George Allen Aerial Photos

often untried. Moreover, site conditions always varied from one to another, and invariably they differed in some way from the textbook cases. But, with some trepidation, Charles Ripley and his young staff were eager to apply their new ideas. No doubt they were considered by some people to be too bold and daring and by others too technical and impractical. But decisions taken were never capricious or in any way reckless. As Earle Klohn has put it: "I have never made a precipitous decision in my life. They were based on detailed analyses or on experience from previous projects." As well, the company was fortunate at the outset to have the guidance of experienced, senior men such as Terzaghi, Dolmage, and Simons. Karl Terzaghi, in particular, seemed to provide leadership that was of benefit along both practical, and more metaphysical avenues. Charles Ripley has confirmed as much:

"There were so many philosophical comments that Dr. Terzaghi made to me which I have treasured, and proved extremely valuable in my career. On one occasion I had proposed a rather complicated scheme, which he was reviewing, and he said, 'Ripley, you should always remember, if it isn't simple, it won't work.' And he blew my complicated scheme right out the door. Another time, he made this little comment: 'It's important to get to the truth as soon as you can, both for your sake, and for the sake of your client.'" Such were the strictures that the company tried to follow.

By the latter half of the 1950s, soil mechanics was being widely accepted as a legitimate engineering discipline by the design professions and construction industries. Consequently, Ripley and Associates had developed an extensive base load of work on building and industrial foundations, dams, and highways. This included the pulp and paper mills at Port Alberni, Elk Falls, Crofton, Gold River, Castlegar, and Gardiner, Oregon. Additionally, high-rise buildings were beginning to dominate Vancouver's skyline, and, in 1955, the company was engaged as foundation consultants for the "New queen of [Vancouver's] skyline," B.C. Electric's $6.5 million head office building at the junction of Burrard and Nelson streets,[53] and several other downtown landmarks.[54] At that time, B.C. Electric was the major power utility in the province, and Ripley and Associates were hired as consultants to their engineering arm, B.C. Engineering Company, in the construction of electric substations, transmission lines, natural gas stations, and the Port Mann Thermal Power Plant. Jobs on Department of National Defence stations included those at Comox, Coquitlam, Chilliwack, and Vernon, as well as those at Griesbach and Namao in Alberta. And there were a number of small dams for the B.C. Power Commission and for irrigation districts in the dry-belt Okanagan. The B.C. Department of Highways was engaged in an extensive expansion of the provincial highway system, and the company was engaged as soil mechanics consultants on the Vancouver-Richmond Freeway[55] and the Deas Island Tunnel.[56]

The oil industry, too, was undergoing major expansions of refineries, pipelines, tank farms, as well as ocean and land-based distribution marketing terminals. Ripley and Associates did virtually all of the foundation work in the Greater Vancouver region for this industry, including work for such companies as Imperial Oil, Standard, Shell, British-American (later Gulf, now Petro-Canada), and Royalite in Kamloops. The local refineries were situated at the eastern end of Burrard Inlet, abutting tidewater, on steeply sloping ground at the toe of Burnaby Mountain. These sites are intersected by deep gullies, carved out by streams originating on the mountain (the area has a high rainfall—heavier than downtown Vancouver). Originally the plants, built before World War II, were small, posing little in the way of foundation problems at the sites. But, after the war, the refineries were being enlarged by the filling of gullies with waste materials and by making massive cuts into water-bearing silt and sand hillsides, thus creating a great deal of instability on these slopes.

The stability problems at the Shellburn Refinery, built by Shell Oil, were particularly acute.[57] Cyril Leonoff made an exhaustive soils and stability review of the site, recommending remedial measures for twenty unstable areas. Stabilizing measures, consisting of drainage and blanketing of slopes with sand, gravel, and rock, were carried out over a number of years.[58] "On one particularly unstable slide area," notes Leonoff, "I suggested that the slope would fail within fifteen years—I think it failed in eighteen."

In 1957–58 the British-American Oil Company was building a brand new state-of-the-art refinery on a virgin 220-acre site situated on the northeastern shoulder of

British-American Refinery, Port Moody, B.C., 1958.
Photo: George Allen Aerial Photos

Burnaby Mountain.[59] The M. W. Kellogg Company of New York City were the designers. Their Engineering Department had their own soils engineer on staff, who would liaise between the design office and the site. Because of Ripley and Associates' local experience, the Kellogg Company employed the firm to consult on the foundation design and to inspect the site grading in order to ensure that the specifications were met. It was a large job, as the project involved the handling of 1 million cubic yards of soils, often complicated by wet conditions.

Kellogg had a very experienced construction supervisor whom they brought in from the United States to build this refinery. He was an impressive man, tall in stature, and a real "driver," appropriately nicknamed "Tex," whose performance in expediting jobs was highly respected by the home company. "But the design people lived in terror of this fellow," remembers Leonoff, "because in the field he was purportedly the absolute boss—would suffer no interference from the design office. Their geotechnical engineer, from his experience, had warned us about this formidable 'obstacle' that we would face."

This was perhaps the best example, of many cases, where the human problem loomed larger than the technical. At the outset, Leonoff proceeded cautiously: "I thoroughly reviewed the site with this construction man, explained the problems of handling the fine-grained soils in our local weather conditions, and recommended construction procedures for the earthwork." The upshot of the story, according to Leonoff, was that, "From day one, all the dire warnings of him rejecting our methodology vanished. Because of his experience, he was shrewd enough to appreciate that adequate foundation preparation under the process areas and tanks and proper compaction of fill areas and retaining dykes would make this job easier and result in a trouble-free site, probably at no more cost." Throughout the entire two-year construction period, the British-American project turned out to be one of the smoothest-running jobs the company ever undertook. The Kellogg design people were amazed, and it remains today the best refinery site in the Vancouver area.[60]

Another precedent-setting site was the Imperial Oil Bulk Terminal built on the south slope of Burnaby Mountain, intended to supply refined petroleum products to service stations in the Greater Vancouver area. Development of the site required excavation of the top of a hill, composed of glacial-till soil, then the filling of a deep ravine with the excavated soil. The ravine contained a stream which had to be carried through the site in a large-diameter culvert, under the toe of the fill. In order to utilize the site, the oil tanks had to be placed on varying thickness of fill, ranging from 2 feet to 21 feet.

Traditionally, oil tanks had always been placed on rock or on dense natural soil such as glacial till. This was the first time, recorded in Vancouver, that heavy oil tanks were to be founded on fill. Naturally the client was concerned. Ripley, Klohn & Leonoff Ltd. designed and supervised the placement of an engineered fill. The ravine was stripped of organic soil, the fill placed in thin lifts, heavily compacted with a roller, and a stabilizing rock toe was built at the bottom of the slope. Settlement gauges were installed, and the measured settlements proved to be within 2 inches, well within the tolerance for this type of structure.[61]

Charlie Ripley's early contact with the Canadian National Railways had come to fruition in the late 1950s and early 1960s with the procurement of two challenging geotechnical jobs, both involving very soft and wet soils.

The Messiter Tunnel was located on the CNR main line near Blue River, B.C., 150 miles north of Kamloops. Situated in the heart of British Columbia's interior wet belt, the railway there was bordered by a canyon section of the North Thompson River on one flank and steeply rising slopes on the other. A 410-foot-long tunnel constructed through this section in 1916 had been reportedly very wet when excavated, and consequently a concrete lining was installed in the tunnel in 1918. The wet conditions continued throughout the life of the tunnel, with ice removal posing a major problem every winter. Deterioration of the concrete lining began in the 1930s, and, by 1950, cracks had developed in the walls and roof, as well as the portals.

Replacement of the tunnel with an open cut was first attempted in the summer of 1950. However, during the excavation, a 55-foot-thick deposit of saturated silt, stratified with thin seams of water-bearing sand, was encountered. It was believed to be the remnants of a large lake, and, because of its liquid nature (the danger of the cut slopes collapsing), this was very treacherous material to deal with. The contractor was forced to abandon the excavation.

In 1958 Ripley and Associates was engaged to investigate the soil conditions. The resultant study indicated that,

CN Rail, Messiter Tunnel removal, Blue River, B.C., 1963
Photos: Mark Olsen

CN Rail, Deas Island Spur Line, Delta, B.C.

Hydraulic fill placement of roadbed, January 16, 1961.
Photo: George Allen Aerial Photos

Double-casting of excavated peat by two draglines.
Photo: Cyril Leonoff

with suitable design and construction methods, an open cut was feasible. Analyses by the railway indicated that the cost of the excavation would be no greater, or possibly less than the cost of a replacement tunnel. So RKL designed and supervised construction of a stable open cut, 150 feet deep. Design features included: stable cut slopes on a ratio of two horizontal to one vertical, installing berms and interceptor drains on the cut slopes to handle seepage flows, blanketing the silt exposed in the cut with a gravel layer, and procedures to maintain safety of the existing tunnel during construction.[62]

Construction in the constricted site, carried out in 1963, posed two serious logistical problems. First, the main line train traffic could not be disrupted. This was achieved by widening the excavation to provide for a temporary "shoo-fly" bypass line, then removing the concrete tunnel, and finally restoring the rail to its original alignment. Secondly, 300,000 cubic yards of excavated soil had to be disposed of without contaminating the river fishery. This was accomplished with the assistance of a work train hauling away the wet silt.

Originally planned for two construction seasons, exemplary co-operation between the contractor (Square-M Coleman Construction Company of Edmonton), the engineer, and the owner resulted in completion of the work in a single season.[63]

About the same time (1959–61), under the supervision of Cyril Leonoff, Ripley and Associates was engaged by the CNR to design and supervise construction of the Deas Island Spur Line, seven miles of railbed on the south shore of the Fraser River serving the industrial area of Tilbury Island and the CNR ferry terminal to Vancouver Island. For three miles of its length the railway crosses the Burns Bog, an immense water-saturated area overlain by up to 23 feet of soft organic peat and underlain by very soft clay and silt.

Several methods of construction through the peat bog were considered, including "floating" the railway on a pad on top of the peat, construction of a trestle, and excavation and replacement of the peat with a more granular soil. The floating method was considered unsuitable because of probable excessive settlements, the danger that shear failure might plunge a train into the bog, and the likelihood of costly maintenance after construction. A trestle would require long piling and would have been excessive in cost.

The method adopted was removal of the peat by dragline and its replacement with sandfill dredged hydraulically from the nearby river. Double-casting of the excavated peat by two draglines working in tandem was adopted to prevent any instability caused by overloading the shoulders of the excavated trench. The fill soil was placed directly into the railbed from the dredge pipe. This was a particularly economical method because it eliminated the cost of trucking. Excavation and fill construction were scheduled concurrently to minimize the time period of open cut and thus reduce the amount of sloughing of the sidewalls into the trench. This innovative method proved successful and resulted in a stable, low-maintenance roadbed to support the heavy train loads.[64]

Chapter Five

AT THE CORE OF THE COMPANY

During the 1950s, Ripley and Associates built up a highly competent staff of engineers, technicians, and secretaries (Appendix II). The engineers employed included Scandinavians Mike Hoy and Willie Norup, K. S. "Wylie" Peters from New Zealand, Pat Carr from Manitoba, and David Campbell, Bill Jubien, Gordon Hughes, Ken Lee, and Ian Morrison, all graduates of the University of Alberta, which, through the 1950s, remained the principal soil mechanics school in Canada. Hughes and Lee later entered the academic field, while Jubien became soil mechanics engineer for the Canadian National Railways on their western lines. Technicians employed in the field and lab included Lars Anderson, Tom Flynn, Anker Mosumgaard, Dick Read, Bill Richards, Alfred Rustoen, Peter Wiens, and Alfred Vandenberg.

Of these men, four are representative of the people who can be said to have formed the core of the company, and three were to become career employees.

Early in its history, Ripley and Associates had been fortunate in acquiring the services of an excellent field technician and equipment designer. A. G. L. "Lars" Anderson was born in 1924 in Gothenburg (Göteborg), on the west coast of Sweden. He trained in a three-year technical course in mechanical engineering, then, upon graduation, gained employment as a designer with the Swedish Geotechnical Institute in Stockholm. At that time, under T. K. E. Kallstenius, this institute was the world leader in soil equipment design, having produced the first vane shear apparatus and wick drain.

(The Stockholm Institute was later surpassed in prestige by the Norwegian Geotechnical Institute [NGI], a school which, under the capable and inspiring direction of Laurits Bjerrum [1918–1973],[1] gained international repute as well as the confidence of Karl Terzaghi. Over his long, diverse, and widespread career, Terzaghi had meticulously documented his professional life, not only in his books and over 250 published papers and discussions, but also in the form of diaries, notes, reports, and supporting materials for lectures. It was NGI who transformed his "well-organized piles" into the Terzaghi Library, which is now housed in that institute.)[2]

Despite the Swedish Institute's stellar reputation, after four years there, Anderson chose to leave Stockholm:

"I had a good job—we had a month's holiday, which would eventually escalate to two months and good pay. There was no way that I could find a better job in Sweden. So I decided, well, I'll take a five-year period, and I'll just go around the world. And so I did some research. I had also read a lot of books on Canada in my youth—about the wolves and the hunters in the North. So I had a sort of longing for it. I guess it was also easier to go west than trying to head for Australia or Russia.

"I didn't know anybody in Canada. I had studied the English language in school but what was taught at that time was useless. You'd get a Swedish piece of paper, you'd translate that to English and vice-versa. It's useless—you never learn to speak. You're thinking in your own language and then translating. But I had taken night school classes with an English teacher who spoke no Swedish at all. And consequently, when I came here, I was thinking in English already.

"I stopped off for a week in Toronto in July 1952. It was hot, I sweated a lot and lost about ten pounds and decided that was not the place at all. There was no way I was going to stay in Toronto and have the same conditions as in Stockholm. Anyway I had decided that Vancouver was the place to be."

The intended five-year sabbatical and world trip ended for Lars in Vancouver where he became a life-time resident. He first worked in the drafting office of Boyles Bros. Drilling Company, but Lars quickly perceived that there was limited opportunity for him with the firm:

"I could see that there was no future in that particular office. So I looked around and went to various mechanical places. There was a chain saw place in Vancouver and the guy looked at my credentials and said, 'Look, you've been working in offices all the time in the soil field—you should get out and really do something in the drilling field.' So with that thought I applied at Ripley and Associates, and was hired right away."

At the time, the Boyles Company was doing most of the soil drilling for Ripley and Associates, who considered Ralph Smith of that firm the best soil driller in British Columbia. When Anderson walked into the offices of Ripley and Associates, the firm was quickly impressed by this tall, handsome Swede who had such valuable training. He was hired in July of 1953.

And almost immediately he was out in the field, travelling on his first job to Prince George where he was to do road-building inspection. The company had purchased an old white milk truck to do field work, and Lars drove the battered vehicle up to Prince George on the old Cariboo Highway:

"It was my first auto trip in British Columbia, and I sure do remember it. When you got up to the Fraser Canyon, there was actually one stretch around a vertical cliff where you went on a wooden boardwalk that had been built hanging out over the edge of the cliff. And two cars couldn't pass. You were just creeping around this corner at five miles an hour. There were many, many places that you couldn't pass. And, when you got up past Quesnel, there was a narrow gravel road with cows on it. After two days of this, when I finally got to Prince George the job was totally 'for the birds.' But what was interesting was being up in Prince George."

That winter Anderson and Cyril Leonoff were surveying for the Black Ball Line (a Seattle-based private ferry corporation) at their Departure Bay terminal on Vancouver Island, near Nanaimo. They worked on the Island for three days, with Lars as the 'rod man,' Cyril as the surveyor, and Ralph Smith of Boyles, the driller. They were heading home, about to board one of the comparatively small (by today's standards) Black Ball ferries, when a fierce wind blew up. Leonoff recalls that night vividly:

"One of those squally winter snowstorms that occasionally arise came up suddenly, but, regardless, the ferry decided to take off. We travelled all the way across to Horseshoe Bay on the mainland. I remember that everything on the boat—tables and benches—was sliding back and forth like crazy. When we arrived, a fierce Squamish wind was still howling down Howe Sound, and we couldn't land. So the ship had to come all the way back to Nanaimo. Black Ball decided to try again. But, after spending four hours on this rolling boat, Lars and I had had enough and shrewdly decided to spend the night at the Malaspina, a nice heritage hotel that overlooked the harbour. Some of the people that we had met on the boat went for another trip across the strait in the hope that they could land a second time. Next morning we met them, all bleary-eyed, at breakfast in the hotel. They had spent the whole night—eight hours—on that ferry. That morning was perfectly calm and we all had a pleasant if uneventful trip home."

Such was the state of the highway and ferry systems in British Columbia at the time. Soon after, the government embarked on a massive highway construction program throughout the province that would eventually bring virtually all populated areas within relatively easy reach by automobile. And then in 1958, the government took control of and expanded the provincial ferry system, forming an agency which would eventually be called the British Columbia Ferry Corporation.

Richard J. "Dick" Read, another of the core group at Ripley and Associates, was born in April 1919 and brought up in Edam and Meota, small towns twenty-five miles northwest of North Battleford, Saskatchewan. He was of English parents who had come to the Canadian prairies in 1908. Dick's father had been schooled at Eton College, but, during those early days in Canada, even educated Englishmen had to fend for a living, doing whatever gainful tasks were available to them. So Mr. Read joined the Royal Northwest Mounted Police and acted as an undercover agent in Vancouver during the "Tong Wars."[3]

Returning home to Saskatchewan, the senior Read operated a steam threshing engine and did some farming. During the Great Depression he managed the local rural telephone company. And Dick assisted his father in this concern, operating the switchboard as well as constructing and servicing telephone lines.

After completing high school, Dick Read enlisted in the army and was sent to England in June 1940. He was stationed at Canadian Military Headquarters, London, as a staff clerk in the Cryptographic Section, working (under MI5 Military Intelligence) at breaking ciphers and codes. He survived the Battle of Britain when 35 percent of his fellow staff members were killed in the bombing. The closest brush Dick had with death was when an exploding bomb blew the steel door off their office. After the war he spent a year with his unit in Germany. Dick sees his military experience as a fortuitous time, overall: "It took me out of the village and the farm right into a metropolis that was so advanced—there was so much life and information in London. I realized that we were a hundred years behind—and never had any intention of going back to the little town."

Dick Read married an Englishwoman and in 1946 returned to the University of Saskatchewan where he took two years of engineering before becoming ill and dropping out: "I didn't enjoy [post-war] university in Saskatchewan at all. They weren't trying to teach us, they were trying to get rid of us." Dick had grown up knowing fellow townsman Norm Iverson, and Iverson was to succeed Bob Peterson as director of the soil mechanics section of the PFRA. Through Iverson and while at university, Dick spent the summers on field investigations in Saskatchewan, Alberta, and Manitoba with the PFRA, where he met Charles Ripley. Ripley struck Dick as "a young engineer, enthusiastic, and a pretty nice guy." Ripley already had his master's degree by this time, and Dick also couldn't help but notice that both Charlie and his mentor, Bob Peterson, were "very dedicated to soil mechanics."

In 1948 Dick Read returned to England:

"I went over for a job interview with the British Research Station. After a tough interview, they offered me a job in soil mechanics under L. F. Cooling, who had written a lot of papers and was well known in the field. They offered me a salary of £253 a year. I said, 'I'm sorry, I can't live on that.' Cooling himself said, 'That's ridiculous, they should pay you five hundred a month anyway.' So, through the recommendation of Cooling, I worked instead for Ground Explorations Limited, a small soil mechanics company. I did everything there—field exploration, operated their lab, and did all the drafting. But after two years they wouldn't give me a raise. So I next went to work for Distillers Central Engineering in London. There I got experience in a large drafting room with over a hundred draftsmen—working on pipe detailing. But the pay in England was always very low."

Dick Read came back to Canada in 1953. Leaving his wife Joyce with his parents in Meota, he travelled to Vancouver that August looking for employment. He applied at Canada Manpower and was told that someone was looking for a man like himself "with some experience." That someone was Charles Ripley. "So, I went and saw Charlie and Mark at eight o'clock that night," remembers Dick, "and I started work the next day." Just a few days later, Dick was shipped off to Kitimat where he helped Cyril Leonoff in the asphalt work that was under way there. Dick stayed on at Kitimat until the end of the construction season in November:

Richard Read

"I was being paid $450 a month plus board in Kitimat. Charlie wanted someone in the office to do drafting but said that he couldn't afford to pay me what they were paying at Kitimat. He offered me $250 a month in Vancouver. I said to him, 'I don't know if I can live on it or not, but I'll try.' Meanwhile Joyce had come to Vancouver to stay, and she and I had taken over the management of [an] apartment block in North Vancouver—so we were able to subsidize my money from Charlie. Joyce and I struggled a bit over the years, as did the company, with the ups and downs in the economy."

With his varied experience, Dick worked as the company's jack-of-all-trades for many years. He had taken courses and learned both typing and shorthand during his work with the military, and sometimes, in fact, Dick filled in as a part-time secretary:

"There was one woman in the office, Phyllis Middleton, who was very competent. She did all the stenographic work, answered the phone, did the books too, along with Charlie. Then she married and became pregnant. She went about three weeks past her time—the doctor was pretty slow in getting around to her—and, tragically, she and the baby died in childbirth. After we lost Phyllis, we had a terrible time getting a secretary. Her replacement was seldom there—always off with her kids sick or having some problem. I spent more time doing the typing and answering the phones."

Finally Joan Gartrell (Smith) was hired. Joan was rather quiet, but by all reports tended to her job very well. A pianist, she was very dexterous with her fingers and was always to be heard "clacking away" at high speed on the mechanical typewriters of the day. Then another secretary, also named Joan, was hired. Joan Barter was more outgoing than her secretarial-pool partner, but equally efficient.

Dick was an unofficial guiding hand in running the office at that time: "Wherever there was a space that needed filling, I tried to fill it to the best of my ability. I was very involved with the filing system and helped with the billing. During slack times, I worked in the lab and was doing some field work too." Additionally, Dick was called upon to do a considerable amount of drafting for the firm:

"I had come from a drafting office, at Distillers, where they had fully adjustable boards. But with Charlie, it was very primitive. We had a little drafting area at the back where I started drafting on an old door. I worked from 8:00 A.M. to 10:00 P.M. every day of the week. I did a lot of drafting for Herb Ripley, mostly at night, on his municipal work to clear up some of his army contracts. I was drafting for eight or ten engineers. I brought all the drill hole logs, the lab data, and the geology together on the drawings. The engineers didn't do that; I did. I was just part of the team, that's all. In retrospect, perhaps, I was more valuable to the company than I thought at that time. Later, when Bob Maartman came [to work for the company], one day he said, 'Dick, you've got a tough job, you handle yourself well in this office.' Coming from Bob, that was a real compliment."

With his long experience at the heart of the company's Vancouver operations, Dick is able to articulate many of the factors which seemed to lead to a strong staff nucleus with a solid reputation:

"I've often thought about the thoroughness of the company in not leaving anything to chance. The company had to be conservative in all its decision-making because when you're dealing with 'the ground' it can get very abstract. I'm naturally cautious anyway, but the company's principals followed that course as well and instilled that ideal into everybody who was working for them. And those who couldn't stand that way of working left."

In 1968, when Eric Pharey was hired as a permanent, full-time draftsman, Dick Read did increasing amounts of field work. In so doing, he quickly encountered many of the same problems that other field workers for the company did: "Early days with the contractors in the field were difficult. We had a lot of trouble with superintendents on the job. A number of them were heavy drinkers. We were trying to teach them new methods and so we were resented. We trained a lot of contractors in British Columbia in those days, and engineers from other companies too."

It is interesting to note that, according to Dick, if resistance at the higher echelons could be overcome, such problems were not nearly so pervasive at the lower levels:

"If I got co-operation from the superintendent and foreman, the labourers who did the work were easy to get along with and willing to learn. I gave them instruction on the use of backfill materials and fill compaction. I talked to more labour union members than I can remember, and the labour unions were always co-operative."

In doing more field work, Dick Read was also to encounter some of the more physical travails of working outside the office in those earlier times:

"I broke my leg skiing, and I was in hospital for three weeks and then on crutches for six months. But I was always paid a salary, and I eventually got back into work with my leg in a cast. I changed the drafting stool to a set-up that would hold my cast and leg. I was just off my crutches when Ian [Morrison] asked me if I could go to Prince Rupert for two or three days to look at some tank foundations, which I did. And while I was there, he phoned me and asked, 'Can you go to Stewart for a month?' He said, 'They're doing some drilling out on the concentrator site at Granduc Mine.' I said, 'Oh sure.' So I went up there the beginning of November and, except for sneaking out at Christmas time by helicopter, I was there for four months. On that site we got heavy snowfalls, and I was just having a terrible time walking in all the snow. We spent most of the time moving snow so we could drill for the site exploration. But, just before Christmas, they were hurrying to finish off the drilling before flying out. It was twenty-five degrees below zero, the deck got pretty icy, and then the rods got jammed down the hole. The drillers were heaving on it, so I grabbed a wrench too. With all of us yanking, the rods suddenly broke loose, the two drillers lost their grip on the pipe, and all this string of pipes came onto my wrench. Well, my knee had been very stiff up to that point, all the tendons had been stiff, and then I got all this weight on my knee. Boy, I was in agony for half an hour. But the tendons had loosened, and after that I could walk properly. And it's never bothered me since."

In the latter part of his career, Dick Read continued to work mainly on major field assignments. He saw the office "only in passing" and kept a travel trailer parked outside, "popping in at night on [his] way to another project." He retired officially at the end of 1982, but even today, at the age of seventy-two, Dick continues to work on field projects for the company on a job-to-job basis:

"I don't think I really feel as though I've ever retired. I know when I go to Vancouver [from his residence in Nanaimo] and come near the office, the old fire-bells start to ring. I want to get back to work. And now, with grey hair and a lot of experience, if I say to the contractor you haven't got enough equipment on the job, no questions are asked—bang it's there. Ian [Morrison] says that I've become hard-nosed."

Peter Wiens's family was of Mennonite extraction and came from the Ukraine as part of the great Eastern-European migration in the early decades of this century. Peter was two years old when the family arrived at Hanley, Saskatchewan in 1923. At the time, the Canadian government was accepting only those immigrants who would agree to act as farm pioneers. Peter's father accepted this condition, but not without some trepidation. "My father was not by profession a farmer," concludes Peter. "The Depression and dry years came to Saskatchewan, and we lost the farm in 1932."

Peter studied civil engineering at the University of Saskatchewan for two years. During those summers he worked with the PFRA, where his father had also been employed since 1938. Then Peter left university to become a full-time professional surveyor. He spent five years surveying on the South Saskatchewan River project near Outlook, Saskatchewan, then left the project in 1952:

"I came into the office in the fall of the year. Because surveying couldn't be done out there in the wintertime, I asked, 'Well, what do I do now?' And the answer was, 'There's a seat over there, you may as well sit on it.' And that was my winter's work. Now I may not have been very ambitious, but that was too little work. So I decided to look in other directions for something where there was work in the wintertime."

In 1953 Wiens landed a job in British Columbia with the surveying company of Underhill and Underhill working mostly on the construction of transmission lines through the mountains. But in 1955 he broke his kneecap on the job and was on Workmen's Compensation for nine months. Finally off his crutches, Wiens was however unable to return to his former employment because of the rugged "uphill and downhill" work required, and so he checked at the local Canada Manpower office. The economy was good, and Wiens soon had three job offers. Ripley and Associates was his eventual choice, and there he would spend the remaining thirty years of his career:

"Partly, I was a little leery of how my leg would stand up, and the survey work here [for Ripley and Associates] was less rugged than in other places. Although we had never met, there was also the factor that Charlie Ripley had come out of PFRA, with which I was familiar. And I thought that there was a good chance of advancement. They sent me to Kitimat, where a lot of precise levelling was to be done in setting superelevations on the foundations of various buildings. At PFRA I had spent one whole season just doing precise levels, and I was familiar with the instrument being used."

Coincident with his joining the firm, Peter had married and, while he was still fairly new with the company, he and his wife flew to Kitimat in a twin-propeller DC-3:

"We started from Vancouver, tried to land in Terrace and were fogged in. We went to Sandspit, sat around for about six hours there and tried again, and again we couldn't make it. We then went back once more to Sandspit, took a water taxi to Queen Charlotte City, spent the night there, and tried the next morning. Next morning, we still couldn't get into Terrace. So we flew as far as Smithers, took the train from there to Terrace, spent the night in Terrace, and took the train next day to Kitimat. In those days the roads were poor or nonexistent—at least from Terrace to Kitimat. That was my wife's first experience flying—three times on that trip we couldn't land where we were supposed to land."

Wiens worked at Kitimat for two years, then continued to spend a month there every summer, doing precise surveying of the existing buildings to allow for the opening of expansion joints wherever the stresses were becoming extreme.

In Vancouver, Peter worked on a variety of projects. The first large-scale one was the Iona Island Sewage Treatment Plant where there were differential settlements to be measured. But, in addition to surveying, he began to learn the soil mechanics investigation and inspection business. At Iona he was involved in field sampling. And, whenever there was free time, he was learning whatever he could about laboratory testing from Bill Richards. Eventually he began to do major field assignments for Ian Morrison, who had taken over the firm's responsibilities in pulp mill work from Earle Klohn. Morrison and Wiens developed a good working relationship:

"Ian was the man who was normally my supervisor. Having classified soils in the lab under Bill Richards and Morrison, I was able to describe them in the field as well. The two dovetailed rather well. Ian told me, 'It doesn't matter so much exactly how you describe things in the field, just as long as I can understand it.' But, because we'd worked together so much, he could interpret my descriptions pretty easily. That's why I was valuable to him in the field."

Peter also did his fair share at many of the pulp mill projects and mines where the firm was under contract: "I don't know how many pulp mill projects I worked on, there were so many of them—Powell River, Port Alberni, Elk Falls, Crofton, Quesnel and Prince George in the Interior. I also worked at Bethlehem Copper, and pretty well all of the mines that were in the Highland Valley."

In later years, when the company developed international work, Wiens, with his long experience, was an important field inspector on several isolated projects—pulp mills in Poland, Czechoslovakia, Nigeria, and a dam in Sri Lanka. Wiens has described the pressure that field inspectors like Dick Read and he would typically operate under at a construction site:

"We would be all by ourselves—the only representative of our company. That made it necessary sometimes to make decisions that may have been beyond our expertise, because we were not engineers. Eventually we knew what decisions we could make ourselves and what had to be referred back to the head office. I recall one time in particular [when] Charlie Ripley sent me out on a job and he said, 'We're not really welcome there. I want you to go out and play it by ear. If you think they're doing something really wrong, then let me know. If things are going reasonably well, then don't rock the boat.' That's the sort of situation that we were in quite often."

The tradition of integrity which had begun with Karl Terzaghi's rigid standards was something that men like Peter were also called upon to apply from time to time. And although such standards could at times be problematic for the firm, sometimes alienating clients, there were numerous occasions when Peter felt proud to be associated with Klohn Leonoff's traditional character:

"I was on one job where the contractor and the owner got together and more or less vetoed what Klohn Leonoff was trying to do. That went on for a while, until Klohn Leonoff finally said, 'In that case we cannot take the responsibility. We're pulling out.' Because we would not compromise the quality of work that was being done. And I recall the young engineer in charge saying, 'That means we'll never get another contract with a good client.' Three months later we got an even bigger contract with that same client."

As did so many of the firm's employees and principals, Peter found himself away from home for long stretches of time. The only compensation for these absences was perhaps the diversity of the work that he performed—in the lab and in the field:

"If I'd been surveying only, I think I would have been out in the field all of the time. My wife is very self-reliant, so that she was able to cope well. But it did mean that I was away from the children half the time during the year, and that's not really ideal for family life. Yet the family is still together—we have good relations with all [our children]."

Bill Chin, a later-generation engineer, has appropriately remarked on the invaluable services provided by the company's field technicians on these remote sites:

"Dick Read and Peter Wiens . . . were soil technicians when I joined KL in 1976. I learned a lot from these guys! I remember thinking at the time—they know so much about engineering . . . why aren't they engineers? Well, I asked Peter one day, and he replied that he loved doing engineering but did not want the responsibilities that came with the title, like making decisions. But you know, many of my decisions (as well as those by people like Ian Morrison and Mark Olsen) were made based on their engineering judgment! Somehow, the knowledge that either Dick or Peter was on site during the construction of a project I was responsible for, allowed me to sleep better at nights."[4]

Peter Wiens retired in 1986 at the age of sixty-five. But, five years later, he still returns to the company to do the occasional job. His most recent involved twelve-hour days, with two hours added for travelling. Comments Peter, "Fourteen hours—that becomes a little difficult when you're getting older."

The fourth person who can be said to have operated at the core of the company for many years is Kenneth Ian Morrison. Ian was born in Grande Prairie, Alberta on Boxing Day 1932. The Morrison clan had originated from the islands off the northern tip of Scotland, and they had travelled to Prince Edward Island in 1803 as part of the first Selkirk Settlement.[5] The family possesses a deed signed by Lord Selkirk for the original Morrison property in Prince Edward Island.

In December 1991, Ian made his first-ever visit to P.E.I.—on business related to a proposed bridge crossing of Northumberland Strait. Researching his family's "roots," he found 138 Morrison names listed in the directories of the district and was able to contact a few of these "lost" relatives.

Ian's grandfather, originally a harness-maker, came to British Columbia at the turn of this century as a general merchant. But in the early 1920s the family moved to Grande Prairie where they established a general store.[6] Ian's father, Ivan Wilfrid Morrison, had trained as an auto mechanic at "Calgary Tech" but later operated the family's store at DeBolt, a small town thirty-five miles east of Grande Prairie.[7] Ivan also operated a bulk oil distribution centre to serve farmers and supply oil exploration rigs. Says Ian of his father: "He was a general merchant in the farming community but, during the harvest, he spent more time doing volunteer repairs to farming equipment than anything else. If a farmer ran into a problem that was beyond him, he immediately ran to the store, not to purchase groceries, but to get Dad to get the tractor running again or something like that." In 1980 Ivan was honoured for "providing the first bus service in the Peace Country"[8] during World War II.

Around DeBolt in mid-winter, with the blowing snow, roads were often impassable. Ian recalls that the first vehicle he rode in during the 1930s was "a ski-equipped snowmobile with a five-foot propeller up in the air, driven by an automobile engine mounted in back. The brake was a lever in the floor with a piece of spring steel, which bit into the ground when you pulled up on the lever."

In growing up in a semi-rural setting, Ian was interested in "things like hunting squirrels to sell their skins." The village was so small it didn't have a covered skating rink, and there was enough snow to make outdoor skating and hockey "not that prevalent." But the town did have a two-sheet curling rink half a block from the family store,[9] and,

Ian Morrison surveying on DEW line, northern Canada, March 1956.

as with so many Prairie towns, the curling rink functioned as a recreational and social centre for families from miles around:

"It operated seven days a week, two games every night, serving the town and farmers from the surrounding areas, perhaps 150 families. Although [curling was] considered an old-man's game, I used to hang around the curling rink a lot. And there would often be a farmer or two who couldn't make it to the game, so even as a youngster in grade school, I would be picked up to play that empty spot. During the summer there was fishing, and in school, every recess and every noon there was immediately a softball game—all ages and all sizes, from grades one to nine."

Ian Morrison's early schooling took place in the legendary all-grade country school:

"It was a one-room school,[10] heated by a barrel-type stove, burning wood, with an oiled wooden floor and outhouses. The teaching was good—almost exclusively female teachers. It was reading, writing, and arithmetic. There were not many of the extra-curricular subjects that they get now in school. I walked just slightly under a mile to school. One of the senior students, who lived closer to the school, had a paid job to arrive early and light the fire to get the building warmed up. One day, sometime in the 1940s, my mother sent me to school on one of the coldest days on record—the thermometer may not have been exactly accurate, but it read sixty-two degrees Fahrenheit below—all bundled up with double everything on. There were the teacher and five students in class that day. Afterwards I asked my mother whether she was trying to get rid of me. But she said, 'I could see you down the road all the way.' "

This was before the days of school bussing, and after grade nine Ian was obliged to attend a residential high school in Grande Prairie:

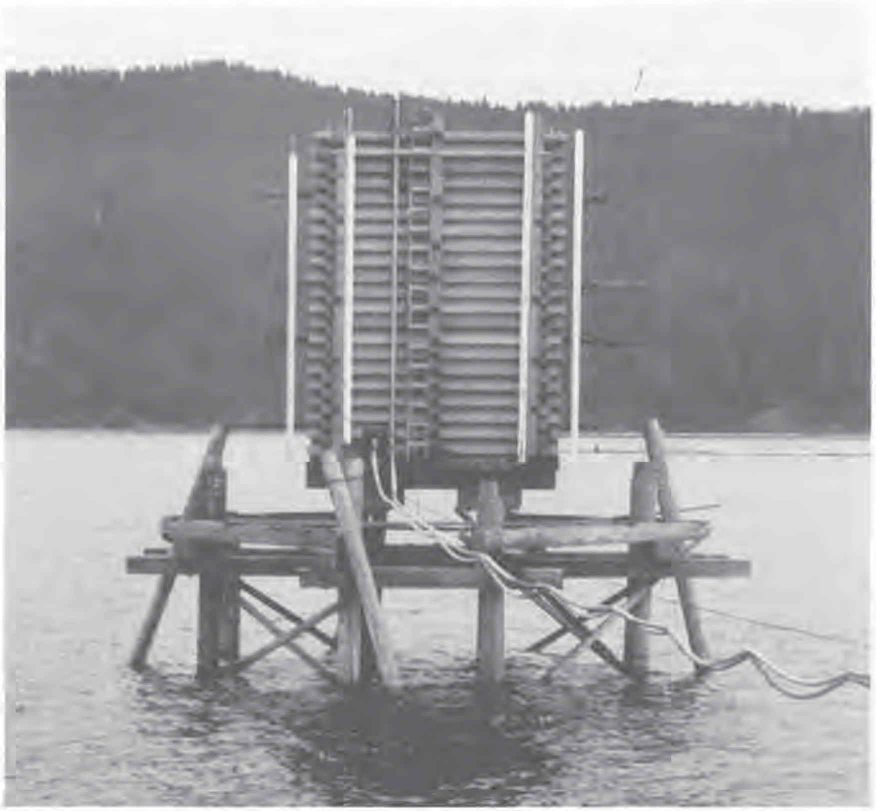
"In those days there was a dormitory operated for students from the country. It was actually an old army barracks, with meals taken from the former army kitchen. While staying at the dormitory, there were jobs allocated on a weekly basis. You would be assigned to sweep the building one week, to stoke the three pot-bellied, coal-burning stoves the other week, to wash dishes another week, and to set the tables. So it was almost like prison."

Following his graduation from high school, Morrison was intent upon a professional career. Unlike many of the staff at Klohn Leonoff Ltd., his entry into engineering seemed almost pre-ordained:

"My father was very mechanically inclined. He was pretty inventive—claimed he invented a few things which later appeared on the scene, and I think a bit of it rubbed off on me. Then one summer the hamlet of DeBolt was kind of officially surveyed. This surveyor arrived on the scene one day and needed an assistant. So I got the job holding the end of the chain and the rod as he surveyed all the lots in this country subdivision. I don't know how true or well surveyed these lots are. Around grade ten or eleven, I basically made the decision to go into engineering—it just seemed to suit my personality. And civil seemed to be the branch of engineering of the day to go into."

Ian Morrison attended the University of Alberta from 1951 to the spring of 1955. There he took introductory courses in the general disciplines of civil engineering, such as structures and sewerage but, recalls Ian, "You automatically got more than your fair share of soil mechanics courses because R. M. Hardy was the dean." However, Ian's early practical experience in civil engineering, doing summer work while attending university, was largely in municipal engineering. The first summer he worked on highway construction at a salary of $200 a month: "I got the job a few days earlier than some of my classmates. Whereas they were out in the field at the end of a chain getting the data, I got twenty dollars a month more and had the pleasure of staying in the office doing all of the earthwork calculations."

Buckling test of timber piles, Port Alberni pulp mill wharf, 1956.



Weighted test platform.
Photo: Earle Klohn

The following summer Morrison landed a job as assistant to the city engineer in Grande Prairie. The office there had only one "fairly senior" engineer who looked after all the engineering for the city. According to Ian, "he was a master at switching costs from one budget item to another to cover them." But that summer Ian gained a lot of surveying and inspection experience on sewer, water, and sidewalk construction, and "a few extra little jobs of staking out people's property." Engineering in these northern Alberta towns was still primitive, even in the 1950s. The town did not possess even a transit, so all of Ian's surveying that summer was done "with a chain—lining up with stakes from the available legal documents."

Ian's final summer while attending university was spent working for Associated Engineering in the town of Willingdon, northeast of Edmonton. The town was installing its first water and sewer system, which was to be supplied by two drilled wells and a water tower: "During the commissioning of the system in the fall, when I, the town foreman, and the contractor's representative went around and turned on the water, we didn't make it all the way around because everybody had some 'white lightning' to celebrate the event—it was pure white, but it sure wasn't water."

After graduation Ian continued with Associated on water and sewer installations, and on an army barracks in Edmonton, constructed because of the Korean War. Then in the

After failure.
Photo: Earle Klohn

spring of 1956, he travelled to northern Canada as a site engineer on one of the intermediate radar stations of the DEW (Distant Early Warning) Line, then being built by the Canadian and American governments:

"My duties included surveying and keeping track of hundreds and hundreds of drawings for the modular buildings. And with every aircraft that came in, there would be a new batch of drawings with 'change orders' for construction. The technology was new, and if they had built something at one station that didn't work, they would modify it at the others. None of us got inside these modules after a certain point in the construction—once the electronic gear came in. After that they were only accessible to American personnel with a certain security rating. The most delicate task was setting the reference points for the radar and aircraft alarm towers, one hundred miles apart, so that they pointed at each other. One of the other surveyors had oriented a tower sixty degrees out of position, and they had it built a couple of hundred feet up in the air before they realized this. They had to redo the brackets and other things that held the antenna. So that's what I was afraid of doing, but I think I managed to get it pointing in the right direction."

For Ian it was all a very interesting adventure. He recalls an Inuit family that travelled by the site via dog team on two separate occasions—a mother and father with a boy and girl, both under twelve years of age. "They were probably hunting," speculates Ian, "migrating alongside their prey. They camped down on the beach right on the Arctic Coast."

The pay was good—$500 a month, which in 1956 was a good deal of money, and he had no expenses. Personnel went up for a six-month term, living in wooden-floored tents the entire time, then came out for a month. Ian was just about to depart for one such month-long hiatus when, quite unexpectedly, he received a letter that was to shift his career focus to soil mechanics and foundation engineering. The letter was from Herb Ripley: "Herb was acquainted with me from Associated Engineering in Edmonton. He asked me, when I finished there, if I would like to come to Vancouver with Ripley and Associates. So I decided that I had had enough of the Arctic and took him up on his offer."

Morrison arrived in Vancouver in the fall of 1956 and was almost immediately shipped off for a year to the Port Alberni pulp mill. Most of the pile driving had been completed, but there was still plenty of work to do on the deep-sea dock and the asphalt paving.

Karl Terzaghi made one of his regular visits to British Columbia during Ian's stay at Port Alberni, and Ian remembers Terzaghi, Charlie Ripley, and the Simons representative taking a routine stroll around the mill. The three men walked to the end of the trestle for the deep-sea dock, which had just been decked, noting that the contractor was just beginning to drive piles for two or three of the dock bents. This was not a specific review item for Terzaghi, but, as Ian says, "he just liked to walk around and look at things." Terzaghi shook his head and said it was "not enough." A little rattled, the Simons representative quickly asked for clarification, and Terzaghi's reply indicated that he felt there were not enough piles beneath the dock. Undoubtedly, if anyone else had made that casual observation, he would have been ignored. But because it was Terzaghi attention was paid. Terzaghi wasn't referring to the soil-bearing capacity but to the buckling capacity of the piles. This was a deep-sea dock with ship berths on both sides, so he knew that the water must be deep and the piles long. The piles would be subject to heavy lateral loads from the docking ships. He also knew that a heavy paper warehouse was to be built on the dock. And based on his experience at other docks with similar loadings and depth of water, Terzaghi had immediately sensed that there were not enough piles called for in the structural design. (H. A. Simons Ltd. had subcontracted the dock design to another consultant, supposedly experienced in dock design.)

As a result of this episode, Earle Klohn devised a special "pile test" set in the ocean. Piles, approximately 100 feet long, were driven into the soft subsoil, with half the length unsupported above the soil line, and a platform built upon them, with a large wooden box set on top of it. The intention was to pump the box full of water until the weight of the water buckled the piles, thereby demonstrating the ultimate load capacity of the piles. This was done, but the platform stood firm. So the water was pumped back out and the box filled with old engine blocks and scrap metal, all of which had to be carefully weighed. This time, as predicted by Terzaghi, the piles buckled and the test platform failed. As a result, the pile capacity was reduced in the future design in order to attain an adequate factor of safety against buckling.[11]

Continuing his work at the Port Alberni mill, Morrison went on to inspect the plant site paving. A complete asphalt

From left: Ian Morrison, Earle Klohn, and Karl Terzaghi at Port Alberni pulp mill, April 20, 1957.
Photo: Charles Ripley

laboratory was set up on the site containing all the basic tests—grain size, asphalt content, and Marshall stability. The firm's old "friend," City Construction, was again the contractor and as before, according to Morrison, "it seemed always to be a fight to get the asphalt content right." To add the asphalt to the mix, the City Construction operator turned a valve by hand. And, as asphalt was the costly item, not surprisingly he usually went "quite easy" on that lever. Relates Morrison: "It all came to a head when they paved half of the deep-sea dock one day and the asphalt was off specification. I discussed it with Cyril Leonoff, and we had them remove it all—they lost a whole day's production. The next day they had a meter installed on the mix plant."

At the Port Alberni mill, the Simons organization was particularly concerned about the asphalt decks and warehouse floors on which the paper was stored. Not only did the forklift trucks that handled the paper rolls have extremely high wheel loadings, they also dripped oil, which softened the asphalt and resulted in scuffing of gravel out of the pavement. A roll of paper would be ruined if it was set down on the gravel. The design solution, which was unusual in British Columbia at the time, was to use a very hard, low-penetration grade of asphalt.

As a learning experience, it was common practice by Ripley and Associates to arrange voluntary site visits for staff members to projects on which they may not have been personally involved. This was done on weekends, on staff members' own time. On one such occasion a group from the office took an automobile trip to the Bridge River dam site, travelling in two cars. Typically the roads into such mountainous sites were narrow, winding, and unimproved; they were also travelled by all sorts of construction vehicles and logging trucks. Ian Morrison was on this particular trip and recalls one of the hazards encountered:

"We went via Lillooet and drove in. We looked around Mission Dam, and there was also a timber-faced rock dam located upstream [at Lajoi]. We were going up there on a narrow road. I was in the lead car that Mark [Olsen] was driving. Without warning, Mark had to instantaneously sandwich our car between a rock knob and a huge truck, with about an inch to spare on both sides. It was one of those moments when you wonder whether you're going to survive."

On an earlier occasion, Leonoff had been part of a group that visited Mark Olsen at the Cheakamus Dam site. The group took the train to Squamish but, since the train did not stop at Cheakamus, they had to walk along the tracks for a number of miles to the dam site. "During the walk," recalls Cyril, "the frequent trains would swish around the corners almost unseen and unheard. There were several long trestles that we crossed where, had we met a train at that point, we would have been lost."

Staff field trip to Cheakamus Dam, from left: Gordon Hughes, Cyril Leonoff, Earle Klohn, Mark Olsen in back, Charles Ripley, Bill Jubien, and Lars Anderson, in borrow area, October 13, 1956.

Ian Morrison may properly be dubbed an "engineer's engineer." In 1963 he took post-graduate studies in soil mechanics at Harvard University,[12] and in 1966 Ian was appointed Chief Engineer of the company.[13] In 1981 he became staff consultant. For a third of this century, he has been involved in industrial plant foundations throughout British Columbia and internationally. Following in Earle Klohn's footsteps, he has been the company's contact man with the Simons pulp and paper people. Within the company and with its clients Morrison is recognized as one of the best foundation engineers in the province, regarded as an expert on the settlement of soils. Says Ian, "I have a reputation which sometimes I have a hard time living up to. It's not possible, in many cases, to have the same degree of accuracy in settlement estimates that there is in other disciplines of engineering." His reputation, according to Ian, comes as much as anything from estimating settlements on a number of projects and under different soil conditions, then, over time, gaining an appreciation of how the actual settlements may agree with or vary from the estimate.

Chapter Six

THE BUSINESS OF ENGINEERING

In "Consultants, Clients and Contractors," Karl Terzaghi had outlined not only his own *modus operandi*, but also the dilemma that a young engineer would likely face if he wished to establish his own engineering firm:

"A consultant is a person who is supposed to know more about a subject under consideration than his client. Once an engineer has acquired a reputation for superior knowledge and discovers that there is a demand for his services, his future career depends upon what he expects to get out of life. If he longs for financial success and social prestige, he will find that his aims can hardly be satisfied without the assistance of an engineering organization. Once the organization exists, he becomes a slave to it. His income increases, but so do his worries. Sometimes he has sleepless nights because he does not know how to handle all the orders which have rained into his lap, and at other times because his overhead charges begin to exceed his income. In any event, the tax collector sees to it that his income does not assume staggering proportions. He may still believe that he is a consultant, but in reality he has turned into a businessman and executive, equipped with all the prerequisites for stomach ulcers.

"On the other hand, if he derives his principal satisfaction from practising the art of engineering, he will desist from establishing an organization and concentrate all his efforts on broadening his knowledge in the field of his choice. In order to be successful in this pursuit he must be not only willing but eager to spend at least half of his time on unprofitable occupations such as research or the digest of his observational data. Therefore, his money-making capacity remains limited, but in exchange he has fewer worries and retains his freedom of action. That is the type of occupation which turned out to agree with my disposition."[1]

Herbert Angus Ripley seems to have had a different disposition, and when, in the wake of World War II, he established his own engineering firm, Ripley and Associates, in Edmonton, it was directed toward the municipal engineering field, providing so-called "ground services"—water supply and sewerage and sewage treatment. Prior to this time, municipal engineering in the Prairie provinces had been done almost exclusively by civic government departments, so that Herb Ripley was a pioneer in providing such consulting engineering services in the region. In part because of this fact, the business was soon successful, so much so that Herb took on other partners in 1950 and founded Associated Engineering Services Ltd., which was to go on to become a major consulting firm in the Prairie provinces and British Columbia. At the same time, Herb continued to operate Ripley and Associates, to carry out his private business, and fulfill contracts dating from earlier periods.

During this time, his brother Charlie was studying in universities and working for a governmental agency, the PFRA. Then in the spring of 1951 Charlie came to Vancouver to establish his own engineering practice. While he had valuable, specialized training and experience in soil mechanics, Charlie had little money or business background. On the other hand, Herb Ripley had by this time accumulated capital and had considerable experience in a consulting engineering business. So an arrangement was worked out between the two brothers—Charlie would provide the technical skill, and Herb would provide initial financing and give the business his experienced although remote supervision. Charlie would be resident manager in Vancouver, while Herb would continue his residency in Edmonton, making periodic trips to Vancouver. The Vancouver operation was also to be conducted under the name of Ripley and Associates. In effect, the Vancouver business was intended as an equal partnership between the two principals.

Initially the arrangements were verbal. By November 26, 1951, a partnership agreement was drawn up, but it remained unsigned.[2] On April 30, 1952 a partnership insurance agreement was executed, whereby H. A. Ripley and C. F. Ripley insured the life of each other in the sum of $10,000.[3]

By September 22, 1953, the firm's accountant, Bruce

Sangster, had "determined that [H. A. Ripley had made] cash contributions to this business through salary to [C. F. Ripley], advances, transfer of car and other items, amount[ing] to some $10,000."[4] At that date, a formal partnership was established. A cheque was issued by Charles Ripley and acknowledged by Herb Ripley:

"I hereby acknowledge receipt of your cheque for $5,000 representing the purchase of a one-half interest in the assets and business of the Vancouver branch of H. A. Ripley, operating as Ripley and Associates.

"It is hereby agreed that a partnership exists between you, C. F. Ripley, and myself, H. A. Ripley, effective July 1, 1953, and from that date the Vancouver operations are to be carried out under the name of Ripley and Associates."[5]

Herb Ripley was not, however, the only person to finance the beginnings of the business. Charlie's wife, Dorothy, who had money in her own right, put up security for the bank loans. In this regard, Charlie had written to Herb on August 29, 1952:

"In connection with the loans which I have obtained from the bank and for which Dorothy has put up bonds for security. . . . It had been our thought that such a note would not be necessary because we felt that, with the credit rating established with the bank, we would be able to lift these loans several months ago. However, with the expansion of staff in the past few months we have needed much more money to finance the business than was anticipated, and I have been unable to lift the loans on Dorothy's bonds . . . in the sum of $3,750."[6]

While such pre-inflation sums may seem trivial in terms of today's multimillion-dollar business, they are indicative of the conditions under which the business was established and the difficulty, at the time, in obtaining bank financing for a beginning business. Charles Ripley recalls the particulars of the latter problem:

"I needed a line of credit, and the bank manager in that branch [south Granville] was very difficult to deal with, almost impossible. I was on the point of leaving that bank when they changed managers. The fellow who came in was from one of the branches in the Fraser Valley, used to dealing with smaller businesses—a country sort of fellow. He was just a complete turnaround from the initial manager, and there was no problem from then on with the Royal Bank in establishing the line of credit that we needed for an expanding business. Of course, we went through a number of managers."

Herbert A. Ripley
Photo: Grecia Estudio

Similarly, Cyril Leonoff recalls what banking conditions were like when he took over management of the business in the 1960s:

"The Royal had built a new building at Granville and Broadway. In fact I had been the foundation consultant on that building. By then a lot of new businesses had moved into the south Granville district, and this branch was a pretty sizeable bank. The manager there, for many years, was James McConnell. He had his office in the middle facing the front door and saw everything that was going on in the two wings to his right and left. His door was always open. You could literally just walk into his office unannounced, and he would give you any sort of financial advice that you wanted—whether it was on company matters or how the stock market was doing—and it was good advice. He never refused us any requests for loans. He was just a good old-fashioned bank manager—so much different than today when it's difficult to even find the manager."

By the end of 1952, the burgeoning Vancouver engineering office of Ripley and Associates was faced with the pressing problem of finding accommodation which would provide more space, thereby allowing for consolidation of the operation. Neighbours' complaints and city zoning bylaws had obviated the need to vacate Ripley's basement laboratory, which had only been frugally conceived because of the lack of working capital. Staff size was increasing, and it was inefficient to operate a business where the principals were separated. (Ripley, at the Fir Street office, was in the habit of returning to the house at the close of the business day and discussing the day's events with Klohn and Leonoff in the laboratory office.) Says Leonoff of those days: "Who knew when we would eat dinner? We often came back to work at night too."

Ripley and Associates offices at 1930 West Broadway, Vancouver, B.C., shortly after occupation, 1953. Klohn's A-40 Austin in front.

So, in the fall of that year, Ripley and Klohn searched for new premises and found a two-storey building at 1930 West Broadway, a block and a half west of Burrard Street. This proved to be an excellent location. Broadway was then becoming the main business street south of False Creek. Because of the need for truck access to haul field equipment and soil samples to and from the laboratory, it was impractical to be downtown. Yet the Broadway location provided quick and easy access by means of the Burrard Bridge to downtown clients. The building was an Edwardian-style wood-frame structure occupying a 40-foot frontage on a 50-foot lot. It dated from the turn of the century and had two stores on the ground floor and a central doorway and stairs leading to two apartments above. The basement, entirely below ground, was only partially dug out and had old-style rubble-masonry walls. During heavy winter rainstorms, having poor drains and porous masonry, the basement would invariably flood with 1 to 2 feet of water, which then had to be pumped out. Despite such initial conditions, the firm was to remain at the West Broadway address for twenty-three years.

Ripley, Klohn & Leonoff Ltd. offices, 1930 West Broadway, Vancouver, B.C. – After remodelling, March 31, 1963.
Photo: Commercial Illustrators

The building was purchased by C. F. Ripley and D. A. Ripley as joint tenants for the price of $20,500, by an Agreement for Sale, and the assumption of an existing mortgage in the amount of $10,255.96. "Date of adjustments" was February 1, 1953, with immediate possession subject to existing tenancies.[7] (The ground floor was vacant, but the apartments above were occupied.)

As it happened, Associated Engineering Services (Herb Ripley's second company) was doing some work in the province at the time, and was therefore interested in establishing an office in Vancouver. The arrangement made was that the ground floor and basement would be occupied by Ripley and Associates, and the second floor would accommodate Associated Engineering Services. So the Deed of Land executed on July 22, 1954,[8] stated that D. A. Ripley, H. A. Ripley, and Norman A. Lawrence (Herb's associate in Edmonton), would share in the purchase and be beneficial owners in the property, each having a one-third interest as "tenants-in-common."[9] After some alterations to the premises, Ripley and Associates moved into the building, and Associated Engineering shared occupancy from March 1953 to March 1956, first on the ground floor, later occupying the second floor when it became vacant at the end of 1953. Thereafter, with increased space requirements, Ripley and Associates occupied the entire building. The main business offices were located on the second floor, accounting and equipment storage on the first floor, with the laboratory in the basement. The fragmented ownership of the property and businesses would eventually prove highly troublesome for the company's principals.

As the number of jobs and employees grew, and with an increased number of automobiles and other pieces of equipment present, along with their related liabilities, the firm's legal and accounting consultants advised the replacement of the existing partnership agreement with the establishment of an incorporated company.

Consequently Ripley and Associates Engineering Consultants Ltd. was incorporated on December 21, 1953 under the British Columbia Companies Act.[10] This awkwardly long legal name was suggested by the company's solicitor, Evans Wasson, because the Registrar of Companies at the time was insisting that the nature of the work be stated in the company's title.

The beneficial ownership in this engineering company was held by Charles F. Ripley, who became president and director. Bruce Sangster was to act as secretary-treasurer and director. Sangster, who became the company's able, long-term accountant and auditor, was the Vancouver-resident partner of Winspear, Hamilton, Anderson & Company, chartered accountants, a company which, following several mergers, today operates under the name of Deloitte & Touche. Charlie had known Bruce from their student days at the University of Alberta. The new engineering company took over assets of $45,414.71 and assumed liabilities of $28,708.70, with the balance of $16,706.01 secured on the books of the company as a deferred liability due to Charles Ripley.[11] Concurrently, because the stringent tax laws required an arm's-length relationship between the brothers, another company, Soil Mechanics Services Ltd., wholly owned by Herbert A. Ripley and his family, was established to undertake his personal business affairs and some of the routine laboratory testing and non-engineering consulting work.

Subsequent to this restructuring, as his company grew in size and complexity, Charles Ripley faced the dilemma so clearly enunciated by Terzaghi. He recognized that his interest was firmly with the technical side of the company's operations, rather than in anything to do with administration and management. And this inclination was not purely discretionary. High-quality consulting engineering was the substance of the company's operation. Job and client demands were onerous, and Charlie was the most knowledgeable and experienced engineer on staff. Projects such as the Kitimat plant site and Cleveland Dam were at the threshold of engineering knowledge and therefore demanded his detailed attention. On the other hand, staff had to be hired and overseen, financing secured, bills issued and collected, taxes paid, accountants, lawyers, and insurers consulted, premises maintained, and work promoted.

Suddenly a suitable, if temporary, solution presented itself, as explained by Charlie:

"Prior to 1956 Herb would make periodic trips out here, partly in relation to Associated Engineering's work in British Columbia, and partly relating to our business. In 1955 he suffered a serious deterioration of health and had to stop work and take time off. My feeling is that this was brought about by overwork on his part—he always tended to overwork. After he had taken this rest period, he was wondering what he would do. I suggested that he move his family out to Vancouver and take an active part in our firm. He spent the summer of 1956 in Vancouver, and after a few months out here, he felt that his health was sufficient that he could become active on a steady basis. . . ."

Herbert Ripley joined the staff of Ripley and Associates

Engineering Consultants Ltd. on April 16, 1957 and held the position of Business Manager until May 1961. He departed for Europe for a two-year stay in September 1961.

Prior to Herb's arrival, Charlie Ripley, in his own tenure as manager, had set the company on three courses of action that were progressive for their time and were to have a permanent impact. The first came in 1952 when Charlie hired Earle Klohn and Cyril Leonoff. Charlie wanted "people who could become partners rather than just employees," and so, on December 17, 1954 Earle J. Klohn and Cyril E. Leonoff purchased a number of preferred shares in Ripley and Associates Engineering Consultants Ltd.[12] This was the first step in a long-term policy whereby the company would be owned exclusively by its staff, who would be regularly offered the opportunity to participate in its future growth. (Today there are forty-eight shareholders in the company.)

On January 1, 1956, the first Employees' Pension Plan was instituted through the Canada Life Assurance Company.[13] While this was an early, rudimentary insurance-based plan, heavily "front-loaded," it was an early step toward the institution of comprehensive benefits for the company's employees. It was later replaced by a more suitable money-purchase plan administered by professional money managers.

In addition to the innovations of the shareholder and pension plans, the company was also the first in Canada in the soil mechanics field to purchase professional liability insurance. Because of the high risk involved in underground work, very few commercial insurers were anxious to bond the work of a firm like Ripley and Associates. (This was before the day when group plans, organized by professional associations, were available.) But Charlie Ripley persisted in his efforts, and he explains his philosophy in doing so:

"We were working on very large projects, and the potential liability from faulty work on our part was very great. With dams, and even with major industrial projects, you couldn't obtain enough insurance. The amount of our insurance was a couple of hundred thousand dollars, the maximum coverage. But the basis on which I initiated that was not to protect us. I felt an obligation to our clients that we should be insured to the degree that our income permitted, in the event of claims. And of course the philosophy of all professions is different now. You take out the policies to protect yourself, and necessarily so, in today's environment."

During the 1950s, at least in Canada, it seems that clients still felt that the engineer did the best that he or she could, and if the work proved somehow deficient, it was to be construed as an act of God.

Another philosophy developed by the firm from the beginning might best be termed client selectivity. Generally speaking, there are two levels of foundation engineering, the first being one that is less intensive but where the answers arrived at involve more risk. It was discerned early on by Charlie and his associates that certain small-job architects, structural engineers, and developers were satisfied with a lesser service and willing to accept greater risk. Soon it was decided that there was no proper fit between the requirements and budgets of such small-scale operators and the type of service that Ripley and Associates provided. So such clients were better avoided. There were competitor firms willing to serve their needs. Ripley and Associates would concentrate on providing a more complex and high-powered consulting service to larger-scale clients.

Consulting Engineering Firm Announces Name Change

C. F. Ripley, P.Eng. E. J. Klohn, P.Eng. C. E. Leonoff, P.Eng.

Messrs. **C. F. Ripley**, P.Eng., **E. J. Klohn**, P.Eng., and **C. E. Leonoff**, P.Eng., are pleased to announce a change in the name of their consulting engineering practice from—Ripley and Associates, Engineering Consultants Ltd.—to RIPLEY, KLOHN & LEONOFF LTD. The firm, originally established in British Columbia in 1951 by C. F. Ripley, will continue to offer specialist consulting services in Soil Mechanics and Foundation Engineering. A new, fully-equipped soil mechanics laboratory has recently been constructed and is available for the performance of all recognized soil tests. Engineering offices and soil mechanics laboratory are located at 1930 West Broadway, Vancouver 9, B.C.

Credit: B.C. Professional Engineer, June 1961.

At the time Herb Ripley joined the firm, Ripley and Associates was operating at full capacity. The economy was buoyant and the company had as much business as it could handle. In fact numerous problems had developed as a result of the pressing work load. There were now more than twenty-five people on staff, but additional experienced employees were difficult to recruit. Charlie Ripley was totally involved in directing technical work, while Earle Klohn was heavily engaged in the construction of various pulp mills. Cyril Leonoff was working on a potpourri of foundation jobs in the Vancouver area and around the province. And this meant that none of these three company executives were in a position to devote focused energy toward the pressures arising in the office. As well, the premises for the business were proving to be old-fashioned and inadequate. The two senior secretaries married and left the work force and proved difficult to replace. Organization was nearly chaotic. There were no formal management meetings to handle immediate problems or to do long-range planning. Herb Ripley had a great deal of experience in running a municipal engineering business, but problems in this new business were demonstrating themselves to be more onerous. On the Prairies he had dealt with municipal councils—small-town folk and farmers. But Ripley and Associates' clients were large corporations who tended to be more sophisticated, more demanding.

Nevertheless, with Herb's arrival, a number of improvements were initiated. Until this time, internal accounting journals were being kept by support-staff members under the supervision of the auditing company. But Ripley and Associates was experiencing persistent problems in accounting for time and issuing invoices—sometimes this wasn't accomplished until long after the job was completed. Not only did this jeopardize the firm's cash flow, it was also an annoyance to clients. By 1957 the auditors were of the opinion that the business was sufficiently large to employ an in-house accountant, and so, in the winter of that year, S. Patrick Dodd joined the staff. "Pat" Dodd was then enrolled in the Certified General Accountants program and later achieved full accreditation. A quiet, serious, and competent person, he stayed with the firm for seven years and consistently provided the level of bookkeeping required, working for all that time without the benefit of the computer-assisted accounting programs later instituted by the company.

A far-reaching step for the company was formalized in December 1958 when Earle Klohn and Cyril Leonoff joined in official ownership of Ripley and Associates Engineering Consultants Ltd., acquiring 45 percent of the common stock, with C. F. Ripley retaining 55 percent.[14] Reflecting this participation, on July 1, 1961, the firm name was changed to Ripley, Klohn & Leonoff Ltd., with C. F. Ripley, president, Klohn and Leonoff, vice-presidents.[15] Herb Ripley supported, indeed promoted, these moves.

Another improvement sought by Herb Ripley during his tenure as manager was the securing of a good medium-sized law firm which would handle the growing corporate affairs of the company and provide both barrister and solicitor services. He selected the firm of Ellis, Dryer & McTaggart. David Melvin, a junior lawyer in their office at the time, became the firm's solicitor and was later to rise to become the senior partner in his firm. A soft-spoken, well-organized and thoughtful man, he remained the company's corporate solicitor for over a quarter century until his retirement from active practice in 1985.

Perhaps the most vexing problem the company faced at the time was the need to upgrade the offices and laboratory. In the early 1960s there was a considerable amount of testing, particularly on the Portage Mountain Dam project, being conducted in the old basement lab, which was small, dank, and without temperature or humidity controls. In 1956 Herbert and Charles Ripley purchased a property on West Eighth Avenue as a possible site for the business. However, this site required municipal rezoning from residential to commercial. In the spring of 1957, when Herb became business manager of the firm, he made enquiries regarding rezoning and mortgaging of the Eighth Avenue property and selling of 1930 West Broadway, which was then appraised at a value of $33,000.[16] But the Broadway property wouldn't sell. Thus, in the spring of 1959, active consideration was given to expansion of the West Broadway premises. On May 12, 1959 Broadway Holdings Ltd. was incorporated,[17] which was to be the real estate holding company for all the firms' offices and laboratory space and was to "undertake or direct the management of the property, buildings or lands of the company."[18] Shareholdings in this company were held equally among the two Ripleys, Klohn, and Leonoff, with H. A. Ripley as president.[19] The intention

Ripley, Klohn & Leonoff Ltd. offices, 1930 West Broadway, Vancouver, B.C., April 19, 1961.
Photos: George Allen

General office.

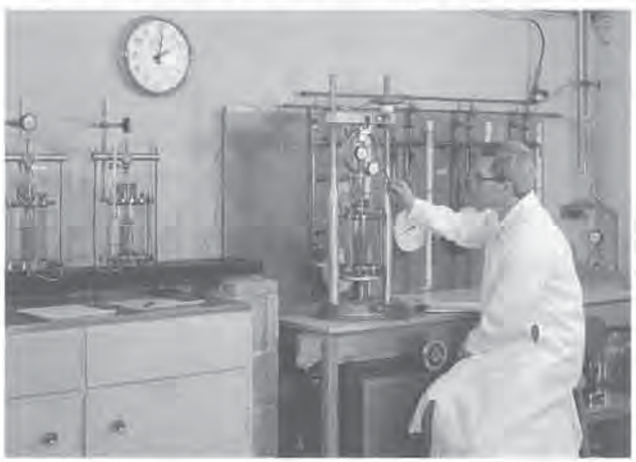
Accounting, Patrick Dodd.

Drafting room, from left: Richard Read, Lars Anderson, Kerry McManus.

Library, Virginia Kinikin.

The new soil mechanics laboratory, 1963.
Photos: Commercial Illustrators

General testing room, 18-inch-diameter triaxial machine at left.



Triaxial testing bench, Peter Wiens.

Consolidation test machine, Peter Wiens and Joyce Clarkson.

was that Broadway Holdings would purchase 1930 West Broadway from the present owners at an agreed cost plus 6 percent interest.[20] But a snag developed when N. A. Lawrence, Herb's Edmonton associate and part-owner of the Broadway property, refused to sell his interest in the building until he and Herb, who were winding up all of their business interests at the time, had reached a final settlement.[21]

Pressed with the immediate need for more and better accommodation, notwithstanding the knowledge that they were enriching the value of a property owned by others, in November 1959 the directors of Ripley and Associates Engineering Consultants Ltd. decided to proceed with a laboratory extension of the Broadway building, based on the verbal assurance of Herb Ripley that his affairs with Norman Lawrence would be settled within a reasonable time period. This decision would later result in a bitter dispute and court action. Effective January 15, 1960, Broadway Holdings Ltd. purchased the residential property at 1935 West Tenth Avenue, directly across the lane from the Broadway property, for the price of $14,500,[22] with the intention of providing additional parking that would in turn allow for expansion of the Broadway building.

The new laboratory was designed as an underground concrete structure to be built under the existing parking lot at the rear of 1930 West Broadway, with the roof at ground level such that it could be used for parking. An amusing if somewhat frustrating experience occurred when the planning and zoning bureaucracy at city hall received the plans for the new lab during the development permit stage. The plans included a room indicated as a "WAR Office." The city hall people were seriously concerned about an underground bunker that contained a WAR Office, wondering what deadly weaponry was to be manufactured there. It took much explanation to convince them that the WAR Office was merely the office of William A. Richards, the laboratory supervisor. As an additional problem, the Broadway property was zoned commercial, but the city deemed the laboratory to be industrial. Eventually sanity prevailed, the city staff were brought to recognize that the soils laboratory was only an adjunct to a commercial enterprise, and a development permit was issued.

On March 22, 1960, Ripley and Associates Engineering Consultants Ltd. signed a contract with Metro Construction Company entailing a total budget of $31,756.06.[23] Construction took place from April to September 1960. Herb Ripley acted as the project engineer during the development, contract, and construction phases. The laboratory was equipped, and at the end of June 1961 Ripley, Klohn & Leonoff Ltd. moved into its new state-of-the-art soil mechanics laboratory. Two years later, in 1963, the Broadway office building was remodelled. *Construction World* showed a photograph of the building with the caption: "WHAT YOU CAN DO with an old building. . . Ripley, Klohn & Leonoff, Ltd. Vancouver Soil Consultants, used their artistic heads on their old premises on West Broadway in the heart of the Pacific Coast city and came up with a handsome 'new' building . . . a credit to Vancouver's swiftly-changing face."[24]

Since the day (November 1, 1951) Charlie Ripley had drawn his first salary cheque on the company's bank account, there had been a steady increase in professional fees earned by the company, to a peak in 1958 of $278,724, with a net income of $59,443. Then in 1959 began the first of several low cyclical periods that the company was to experience throughout its history. The volume of work on large projects began to drop off and thereafter came a steady decline, although sufficient carry over of work and smaller jobs kept the company profitable until 1960. The first yearly loss shown by the company came in 1961 and overall losses continued through 1963.[25] Thus at the beginning of the 1960s the company was losing money, depleting its reserve funds, and reducing its staff. This was not altogether negative since it gave pause for study, reflection, and a chance for reorganization.

In 1958 Cyril Leonoff was away from the office attending a special summer program at the Massachusetts Institute of Technology on the "Design and Construction of Earth Embankments."[26] And in 1960, leaving the running of the business to Klohn, Leonoff, and Herb Ripley (with Earle Klohn in charge), Charlie Ripley was able to take a year's sabbatical in order "to undertake a program of advanced study in soil mechanics." Ripley stated his objective in taking the sabbatical:

"The program of study which I am about to undertake is a further application of this firm's long-range educational program which was instituted some years back for the purpose of improving the technical capacities of our office. We are fortunate to work in an area where the problems are so complicated and challenging. We have realized however that, in order to keep pace with the future expansion of British Columbia, we must increase our capacity and knowledge in order to properly undertake the more difficult problems ahead."[27]

Charlie Ripley had considered pursuing doctoral studies through a university, but instead he followed Dr. Terzaghi's more pragmatic recommendation:

"Part of the year shall be spent away from the office on intensive study. In this way I hope to bring myself up-to-date on recent advances in theory and practice in soil mechanics, with which I have been unable to keep abreast fully during the past several years. The other part of the year shall be spent on travel to other parts of the world. I hope to meet and have discussions with many of the outstanding people in soil mechanics in other countries; to visit projects of pertinent interest and thus to become acquainted at first hand with the way in which problems similar to ours are being tackled elsewhere."[28]

Herb Ripley too had been under considerable pressure in the years 1957–61 and felt that, upon Charlie's return and given the continuing low economic conditions, the company could function without his participation. So, in the late summer of 1961, Herb left for an extended period in Europe. Except for two brief return visits during the following two years, this departure ended his association with Ripley, Klohn & Leonoff Ltd.

As with a vacuum in nature, the departure of Herb Ripley left Ripley, Klohn & Leonoff Ltd. with a management void that had to be filled. The question was how. Both Ripley and Klohn were deeply engaged in technical engineering problems on major industrial foundation and dam projects of long duration that demanded their undivided attention. Leonoff, too, was working on a great variety of foundation jobs which required a high calibre of engineering. However, upon examination, it was apparent that the projects with which Cyril Leonoff was occupied were generally less sophisticated and of shorter duration than those being handled by the other partners. Moreover, Leonoff had shown a certain propensity for management and had in recent years worked more closely than the other principals with Herb Ripley on resolving the day-to-day office problems.

In recalling this time of transition, Charles Ripley has said:

"My brother Herb had left us at that time and it was obvious that the work he had been doing needed to be replaced by a principal. I had to think about how we were going to do this. And I thought that Cyril's natural characteristics were more suited to that job than either Klohn's or my own were. I can say this without any criticism of myself or of Earle, but Cyril was more thorough in his work than we were. So I asked him to take over the [management] duties, and he very willingly said that he would. And I know that it wasn't an easy decision for him to take."

Leonoff remembers his decision as one wherein he set new goals for himself:

"My partners were brilliant engineers and loved the technical aspects of the work—they were more dedicated to this than I was. And I appreciated that the heart of the company was in the sophisticated engineering work that they were doing. On the other hand, if the company was ever to grow and prosper, good management would be equally as essential as the engineering. This was a challenge that I was prepared to accept. So I determined to set up a strong management structure 'stone by stone' and 'brick by brick' over an extended period of time."

At the outset of this new arrangement Leonoff handled both management and engineering duties. But, during the latter half of the 1960s when the company began to establish other offices, he was heavily involved in the ground work of opening and liaising with these new offices. By the beginning of 1968 his duties were exclusively related to management. With the benefit of hindsight, Leonoff now considers his post-1968 career serendipitous but not without its own rewards. "Chance plays a key role in life," reflects Leonoff. "Determined at the outset to be a skilled civil engineer, I would spend the larger part of my career as a businessman—albeit in an engineering business."

Leonoff had no particular management training but proved very willing to learn. He took a number of sales and marketing, public speaking, and management courses. Chief of these, in Leonoff's mind, was the Banff School of Advanced Management program offered in October-December of 1967:[29]

"The Banff course was an eye-opener to me. Managers from all over Canada attended. They came from small and large corporations, professional firms, and governmental agencies in many fields. To my surprise, several of the attendees had come from an engineering rather than an accounting, commerce, or legal background. The course gave me a good chance to compare our management practices with others. And, for the size and degree of development of our company at that stage, I felt that our management practices measured up as well or better than the average. This gave me a great deal of confidence to proceed on the course that we had set."

A lesson learned in the downturn of the early 1960s was the need for a public relations program. Competition at the time was stiff, and no longer could the company rely on the familiar "if you build a better mousetrap" adage. As early as 1953 Ripley and Associates had issued simple brochures outlining the scope of services and qualifications of staff, but the first professionally designed and illustrated brochure of Ripley, Klohn & Leonoff Ltd. was not published and copyrighted until May 1963.[30] It was produced by Leonoff working with Denis Gray-Grant, a freelance public relations consultant. For this brochure and a new letterhead, a company logo depicting soil stratification was designed and remains the official logo of the company to this day.

The introduction to the brochure stated the company's credo for the time:

"Soil Mechanics and Foundation Engineering – Fundamentals in Modern Construction"

A series of questions was asked of the reader interested in constructing a "man-made" structure: "Is the soil strong enough to support the building without collapse? What settlement will occur and will it damage the building? Can the soil [comprising an earth dam or reservoir] be made watertight? Will the soil rupture under the tremendous force of stored water?" The answers, according to the brochure, were a combination of science—"field explorations and measurements, laboratory testing and mathematical theories"—and art, an art to be found "not in field borings, laboratory tests and office analyses alone, important as these may be," but rather "in intelligent observations coupled with experienced judgment of how the complexities of natural conditions apply to the simplified assumptions of Soil Mechanics." The brochure concluded by claiming that, "Progressive firms are enlisting the aid of Soil Mechanics and Foundation Engineers on all major and the majority of smaller projects." These firms were addressing construction problems "that would have been dismissed as uneconomical or impossible only a few years ago."[31]

In the summer of 1967, Ripley, Klohn & Leonoff for the first time hired a staff person whose specific responsibility was to market the firm's engineering services. Carl F. Hunter had taken his engineering training at the Royal Military College in Kingston and after graduation served four years with the Royal Canadian Engineers. He then took a master's degree in soil mechanics at the University of Alberta, graduating in 1967.[32] Hunter was outgoing and well disciplined, and until 1971 he aggressively marketed the company's services both in British Columbia and Alberta.

In the fall of 1964, Pat Dodd resigned as the internal accountant and assistant secretary-treasurer of the company. Early in 1965 he was replaced by Norman B. Scott, an older man who had held his chartered accountant (CA) certification in Ontario. Scott was a meticulous accountant who kept accurate and beautifully handwritten books using the traditional manual methods. But, as the company expanded into branch offices in the Prairies, the manual system was proving to be totally inadequate; time sheets were being submitted irregularly, invoices issued late, and delinquent accounts remained uncollected. Nor were statements of the company's financial position available until months after the fact. Fortunately at about this time, Don Davison in the smaller Winnipeg office was successful in developing a more rigorous manual system of project financial control and billing in which time sheets were collected and processed on a weekly basis, with chargeable time and disbursements allocated to the individual projects.

As a result, in June 1968 meetings were initiated by RKL, and Leonoff, Davison, and Scott met with Bruce Sangster and Harold Loiselle of the Winspear accounting firm, with the aim of developing a better system.[33] Following those meetings, in September, Davison was recalled to Vancouver to work with Loiselle in designing a computerized project control system for processing time and disbursements.[34] However, by the end of that year Davison had been called to Calgary and his place on the project team had been taken by Mark Olsen. During 1969 input forms were set up and a "batch" system was placed in operation that processed time and disbursements using an off-premises computer service. The accounting was still done manually. This computerized system, while still rudimentary, was a significant improvement in invoicing clients promptly and came on-line, in Leonoff's words, "just in time." By the beginning of 1970 the system was adequately processing the work of six offices having a combined staff of sixty persons. It served the company for ten years until an integrated Management Information System (MIS) combining accounting, time, and disbursements was instituted in the early 1980s when the staff level had reached more than 200 persons.

In the midst of the implementation of the batch system at the end of 1969, Norman Scott died as the result of a deteriorating heart condition. He was replaced early in 1970 by Robert John Melling. At the time of his hiring, Melling was a 1967 UBC Commerce graduate employed as a student accounting apprentice by the Winspear Company in the auditing of RKL's books. Melling went on to serve as head internal accountant for the firm from 1970 to 1981. During this period his principal assistants were Ethel Connolly (who had started with Scott) and, as of 1972, Mary Robinson. Also at the end of the 1960s, Phyllis Barrington, who had studied economics and business administration at the Universities of Saskatchewan and McGill and gone on to hold a senior office position with the MacMillan Bloedel company, was engaged to handle the Vancouver project accounts. Until her retirement a decade later,[35] Barrington's competence and reliability were key to the successful operation of RKL's Vancouver invoicing department.

One of the early actions taken by Leonoff when he assumed management duties was a complete redrawing of the company's pension plan. Using William H. Mercer Limited as pension plan consultant and actuary, on February 1, 1965 a new Employee Pension Plan was inaugurated.[36] The type chosen was a more flexible and profitable money-purchase plan replacing the earlier insurance system. Under the new plan, contributions were shared between employer and employee. Canada Trust Company was appointed trustee of the funds. A Retirement Committee composed of management and staff representatives was appointed to administer the plan and approve investment policy. This plan remains essentially in effect today, having been amended through the years as required to meet new pension legislation. In 1982 B. N. Shepp and Associates replaced Mercer as the actuaries and benefit consultants.

On February 1, 1973, Phillips, Hager and North [PHN] were appointed money managers for the company's pension funds. This proved to be an astute decision. A small but rising investment company at the time, PHN has since grown to be western Canada's largest investment firm, administrating assets of $5.5 billion. Its "stellar performance" has recently been described as "one of the most remarkable developments on the local investment scene." During the five years ending June 30, 1991, for example, the firm's balanced pension funds—a combination of stocks, bonds, and cash—generated a 9.8 percent annual return, placing the firm in the thirteenth percentile among Canadian money managers, a rank characterized as "rarefied air indeed."[37] Today the value of the Klohn Leonoff pension plan assets is in excess of $8 million.

In September 1974, in conformance with the best current practice in the industry, new comprehensive benefit plans were instituted by the company,[38] and over the years a complete range of cost-shared health care, income protection, life and dismemberment insurance plans have been added, resulting in a model benefits package available to every current KL employee.[39]

Herb Ripley had terminated employment with Ripley and Associates rather abruptly in May 1961, and at the end of September 1961 he left for Europe (Spain and the Canary Islands), where he remained for two years. His departure left a number of unresolved matters in its wake, including questions as to the "right, title and interest" in the lands and premises at 1930 West Broadway, the laboratory equipment and soil investigation practice of Soil Mechanics Services Ltd., and Broadway Holdings Ltd., which had been set up as the real estate holding arm of the companies. As well, the setting of salaries and distribution of earnings among the principals had not been formulated.

Herb Ripley made a short visit to Vancouver on his own business in September 1962 and, at a meeting of the directors, was fully briefed on the company's activities.[40] However, matters came to a head early in 1963 when Herb, back in Europe, objected to the figures contained in the company's year-end accounts' closings.[41] A dispute arose via a series of letters exchanged between the two Ripleys.[42] The essence of the dispute was over the amount of Herb's contribution, past and especially present, to the company's operation. While the brothers had started out as equal partners in the Vancouver operations, at this stage Herb was contributing little if anything to the enterprise. And, since it was the skill and energy of Charles Ripley and his two younger associates, Klohn and Leonoff, which had brought the engineering practice to its high level of productivity and reputation, it was Charlie's contention that they deserved the bulk of the rewards from the business.

Upon Herb Ripley's return in 1964, repeated negotiations were held to settle the dispute. Finally an offer was made in August 1964 by Ripley, Klohn & Leonoff Ltd. to purchase H. A. Ripley's interests in the properties and assets of Soil Mechanics Services Ltd. at "fair market value" ($45,000), but to no avail.[43] Because of RKL's considerable investment ($66,000 in leasehold improvements, laboratory building, repairs and maintenance) in the 1930 West Broadway property, it was felt that RKL had no other option than to sue.

To compound matters further, Herb Ripley had acquired N. A. Lawrence's one-third interest in the building[44] and in November 1964 had transferred his now two-thirds interest to his wife, Patricia M. Ripley.[45] On June 21, 1965, the plaintiffs, Broadway Holdings Ltd. and Ripley, Klohn & Leonoff Ltd., filed an action in the Supreme Court of British Columbia against the defendants, Herbert A. Ripley and Patricia M. Ripley, requesting a court-ordered performance of an alleged agreement to sell 1930 West Broadway to the plaintiffs.[46] The defendants counterclaimed, referring to their own declared interests in what they termed the "Vancouver Enterprise."[47]

The case was heard before Justice J. J. Gould in May-June 1966 and June 1967, and a judgment rendered on June 18, 1969.[48] While the judge acknowledged that, "There is no doubt that Ripley, Klohn & Leonoff Ltd. has a claim against the owners of the property for an amount in excess of $30,000 [the laboratory extension] which it spent on the property," he dismissed the original action as well as the counterclaim on the grounds that the alleged agreement was part of a larger plan which had in fact never been carried out.[49]

The result was that the court action resolved nothing. And each of the parties to the action had little choice but to go their own way. RKL vacated the 1930 West Broadway premises in January 1971, and in July of that year the property was sold for a reported $80,000. Broadway Holdings Ltd. sold the Tenth Avenue property for $26,400,[50] liquidated its assets, and wound up its affairs on December 31, 1971.[51] And Charles Ripley, Klohn, and Leonoff continued on with their engineering practice.

In July 1966, E. J. Klohn and C. E. Leonoff purchased from C. F. Ripley additional common shares in RKL, so that the share holdings of the company then saw Ripley retaining 38 percent with Klohn and Leonoff acquiring 62 percent equally.[52] Thus for the first time Charles Ripley held a minority ownership in the company. This change reflected the increased engineering and management responsibilities that had been assumed by Klohn and Leonoff in the Vancouver head office while Ripley was resident in the Winnipeg office.

On May 8, 1967, Ripley, Klohn & Leonoff International Ltd. (RKLI) was incorporated under the Companies Act of British Columbia.[53] The share ownership was the same as that of RKL. The initial reason for forming the new company was that it was to become part of Cancon, a consortium of Canadian consulting firms (Chapter 11) bidding on projects abroad. However, because of the ongoing lawsuit, the directors made a decision to carry out all of their jobs under RKLI effective May 1, 1968.[54] RKL was dissolved in January 1978,[55] and RKLI, later changed to Klohn Leonoff Ltd., continues to be the operating company today.

Charles Ripley had always maintained a keen interest in professional affairs, so that from the outset and lasting to this day members of the company were imbued with the idea of serving the engineering profession and its public.

In 1953, soon after beginning his engineering practice in Vancouver, under the urging of R. F. Legget, Ripley established the Vancouver Soils Group, a forerunner of the current Vancouver Geotechnical Society. Founders included UBC faculty members, geologist W. H. Mathews and soil scientists L. Farstad and C. A. Rowles. This group, comprised of geologists, pedologists, and soil mechanics engineers, held meetings and organized lectures related to the interdisciplinary studies of soils. From members of this group a local committee was formed under the chairmanship of Ripley to organize the Ninth Canadian Soil Mechanics Conference, the first ever held in British Columbia. The conference took place at UBC in December 1955, and the theme of the conference was "the inter-relationship of pedology, geology, and engineering in dealing with the complex soils of British Columbia."[56] Earle Klohn presented his first paper, "Problems of Foundation Settlements in British Columbia," to this conference.[57]

In a challenging editorial written for *The B.C. Professional Engineer* of February 1962, Charles Ripley posed the question, "Apathy in Engineering?" Remarking on the fact that attendance at technical discussion meetings of the Engineering Institute of Canada, Vancouver Branch, had averaged in recent years less than thirty of a membership of 600 persons, "though the program has featured outstanding speakers in different fields of engineering and science," he asked, "Can the engineering profession in Canada fulfill its obligation to society and to this nation on the basis of such limited effort and attendance to technical and professional matters?"

With some foresight as to what would become Canada's principal economic problem in the 1990s, Ripley went on to state: "The purpose to which Canadian engineers profess to be devoted is the efficient development and use of our natural resources. Thus, the welfare of Canada is directly related to the level of performance of her engineering profession. Canada cannot effectively take her place in this highly competitive world unless her engineers excel." In his conclusion, Ripley reminded professional engineers that only the development of "strong and active technical societies which stimulate excellence will make Canada more competitive and will bring greater international recognition to the engineering profession in Canada."[58]

In an article, "Are You a Real Professional?" Charles Ripley took a further critical look at the engineering profession, stating in his introduction:

"Engineering is a rewarding calling. Throughout their careers engineers can find challenge and variety in their work. Engineering . . . is creative and can give continual stimulation and gratification. Engineers have reason to be enthusiastic about their calling. However, by comparison with the fields of medicine, law, and theology, theirs is a young calling, with problems that are currently almost overwhelming. The large size and rapid growth of the membership, the wide range of technical activities of its members, the spectacular advances in technology it must keep pace with, and the diversity of conditions of employment of its members, all present special problems of developing cohesion within the membership that are unknown to the older professions."[59]

In the conclusion of this article, Charlie re-emphasized the need for Canadian engineers to continually seek new knowledge and skills:

"The real professional will always be seeking to improve his technical competence and to sustain a professional outlook. Far different from an academic degree that once obtained is always held, real professional performance is a living virtue, as obtainable in youth as in age, and more quickly lost than gained. . . .

"The real professional will have confidence in himself and in his profession, and a sense of humility about himself in society. He will have faith that if he applies average intelligence to his problems and works hard, he will do a good job. If he continues to do a good job, there will be a demand for his services and he will earn an adequate income."[60]

In April 1963, Charles Ripley was elected chairman of the Vancouver Branch of the Engineering Institute of Canada.[61] In 1964, after serving terms on its Board of Examiners and Editorial Board, he was elected to the Council of the Association of Professional Engineers of British Columbia (APEBC).[62]

After Ripley took up residence in Winnipeg in September 1964, Cyril Leonoff became the firm's representative on various engineering bodies. He served on the Board of Examiners of APEBC. And in 1964–65 he served as chairman of the B.C. Engineers and Architects' Chapter of the University of Manitoba Alumni Association.[63]

In September 1965, following the Sixth International Conference on Soil Mechanics and Foundation Engineering held in Montreal,[64] a post-conference study tour was organized and reported on in the Vancouver press:

"Engineers On Trans-Canada Study Tour"

"Vancouver—The Engineers Club here took on the appearance of a miniature United Nations recently, when more than 50 engineers from nearly a dozen countries met with local engineers at a gathering marking the wind-up of a four-day visit to British Columbia.

"The international conferences are held every four years, and for the first time since they began thirty years ago, Canada this year hosted the 1,600 persons attending from fifty countries.

"Travelling by air, the post-conference study tour made stops at various points across Canada, where members viewed a number of the country's outstanding engineering projects.

"They visited Portage Mountain Dam at B.C. Hydro's Peace River Power Project. From there they moved to the Columbia River Power Project, to visit Duncan and Arrow dams.

"While here they saw Greater Vancouver Water District's Seymour Falls Dam, and visited B.C. Highways Department's Port Mann Freeway, Port Mann Bridge and Deas Island Tunnel.

"At the Engineers Club they joined with engineers representing organizations which had hosted the B.C. visit, at a reception and dinner chaired by Cyril E. Leonoff, P.Eng., regional head of the Canadian Committee that organized the conference and tour.

"Commenting on their trip across Canada, members of the visiting group were unanimous in expressing surprise at the vastness of this country, and in particular, at the scope of engineering developments being undertaken here.

"They were impressed, they said, and a little amazed by the engineering skills and facilities they found being displayed in a country having such a comparatively small population as Canada."[65]

In October of the following year, the Canadian Soil Mechanics Conference was held in Vancouver, and this time Cyril Leonoff was head of the conference Organizing Committee. The theme of the convention was "Earth Dams," and Hugh L. Keenleyside, chairman of B.C. Hydro, was guest speaker at the closing banquet.[66]

As well Leonoff served on the Revision Committee on Foundations of the National Building Code of Canada 1965.

In May 1968, like Charlie Ripley before him, Earle Klohn was named chairman of the Vancouver Branch of the Engineering Institute of Canada.[67] Twenty years later, in 1988, he would receive the distinction of fellow of this the oldest organization representing engineers in Canada (founded in 1887), "in recognition of his excellence in engineering, and for services rendered to his profession and to society." In the late 1960s, Klohn became the first extramural lecturer of the UBC Civil Engineering Faculty, giving an introductory seminar in soil mechanics[68] and a senior course, "Case Histories in Geotechnical Engineering." Klohn has now held this tenure for more than a quarter century.

Chapter Seven

RETRENCHMENT AND REVITALIZATION

In the late 1950s and early 1960s, despite continuing stagnation of the British Columbia economy (and consequently the ledgers of Ripley, Klohn & Leonoff Ltd.), steps were already under way in the province that would harbinger a great spurt of construction activity and industrial growth for the decade of the mid-1960s to the mid-1970s. In August 1961, Premier W. A. C. Bennett's Social Credit government had "provincialized" the hydroelectric power resources of the province by expropriating the privately owned B.C. Electric Company, merging it with the provincially owned B.C. Power Commission and forming the British Columbia Hydro and Power Authority. Shortly thereafter, Bennett announced his grandiose "Two River Policy"—damming of the Peace River Valley in northern British Columbia, and simultaneously, by treaty between Canada and the United States, construction of three storage dams on the Columbia River in southern British Columbia. The Peace River project was to provide major hydroelectric power supply for domestic use, while the Columbia system was to increase power generation at American plants downstream, and thus to reap "downstream benefits" to be paid for in advance by U. S. electric utilities. The money generated would supposedly pay for these dams, as well as future power generation facilities in Canada.[1] In fact, these developments did precipitate a great deal of construction and engineering activity in building the dams and power facilities and also provided a major power source that helped stimulate and support rapid industrial growth in British Columbia in the ensuing years. For Ripley, Klohn & Leonoff Ltd. the break came in 1964 with a sudden spurt of jobs that would expand the company's work load over the next ten years.

As effusively described in the media, construction of "the Western World's greatest hydroelectric project" was begun in 1962 "in rugged reaches of northern British Columbia where the surging Peace River crashes through a massive canyon seeking its outlet to the Arctic Ocean." Portage Mountain Dam (later renamed the W. A. C. Bennett Dam), "a staggering colossus of imagination and daring," some 600 feet high, a half-mile thick at the base, and one and one-quarter miles long at the crest, would be constructed to "completely control" the headwaters of the Peace in a canyon where, 170 years before, a band of men led by Alexander Mackenzie "clawed their way" past the rapids below Portage Mountain. In this "remote wilderness location," where "the grizzly still prowls and the wild antelope springs," the dam would impound a lake 680 square miles in area (the largest man-made reservoir in the world, seven times the size of Lake Roosevelt behind the Grand Coulee Dam) and ultimately generate 2.3 million kilowatts of power.[2]

Recognition of the power potential of the Peace River had occurred to the B.C. government in 1957 as an offshoot of Swedish millionaire Axel Wenner-Gren's overly ambitious surveys of the "vast storehouse" of mineral wealth, forest resources, and power potential found in the Rocky Mountain Trench region of north-central British Columbia. These studies indicated that the power potential of the Peace was much greater than that of the Columbia and could be developed at less expense.[3]

The British Columbia Hydro and Power Authority entrusted the engineering design and supervision of construction of the dam to its engineering arm, International Power and Engineering Consultants Limited (IPEC) of Vancouver. IPEC sought advice on various aspects of the development from other authorities, including Dolmage and Campbell of Vancouver; Balfour, Beatty and Company of London, England; and Dr. Ralph B. Peck of Urbana, Illinois.

As is customary for such major projects, B.C. Hydro asked a panel of world-renowned engineers "to review the plans and designs of IPEC, and to study and report on all matters affecting the safety of the Portage Mountain Dam project." Members of the panel were Geoffrey M. Binnie, senior partner of Binnie and Partners, London, England; J. Barry Cooke of San Rafael, California; and Tore Nilsson, Civil Engineering Director, Swedish State Power Board, Stockholm. After holding two meetings in Vancouver, the

Eric Lazenby, left, and Victor Dolmage, right, examining dinosaur track, Portage Mountain Dam site, June 15, 1965.
Photo: Charles Ripley

panel requested that "a second opinion be made available on the soil properties and parameters of the Portage Mountain site and structures."

As a result of this request, in December 1962 Charles Ripley received a letter from J. H. Steed, chief engineer and manager of the Engineering Division of B.C. Hydro, stating:

"As outlined in your recent conversations with our chairman, Dr. G. M. Shrum, we would like the benefit of your advice and assistance as a soil mechanics consultant to report to the Authority and to the panel. Your terms of reference would be to respond to questions put by the panel, and further comment on any matter concerning the properties of materials to be excavated from moraines or other available sources, and their most effective use in the dam."[4]

Sixty million cubic yards of construction materials were required to build Portage Mountain Dam. Fortunately, suitable dam materials composed of mixtures of silt, sand, gravel, and rock were found in a glacial moraine only four miles from the site. The materials were processed into the various components required in the dam, then delivered to the dam site by means of an elaborate conveyor system. In the fall of 1962 Mark Olsen was resident on the site for Ripley, Klohn & Leonoff Ltd. His job was to investigate the properties of the materials in the moraine. He also supervised a full-scale field test of the clay proposed for use as the impervious core of the dam. The clay was found to be overly wet and unsuitable for this purpose.

Ripley's major contribution to the dam was the recommendation "that [the moraine] deposits were the most suitable [and economical] source not only for shell and drainage zones, but for the core zone as well."[5] And this was the way the dam was built.

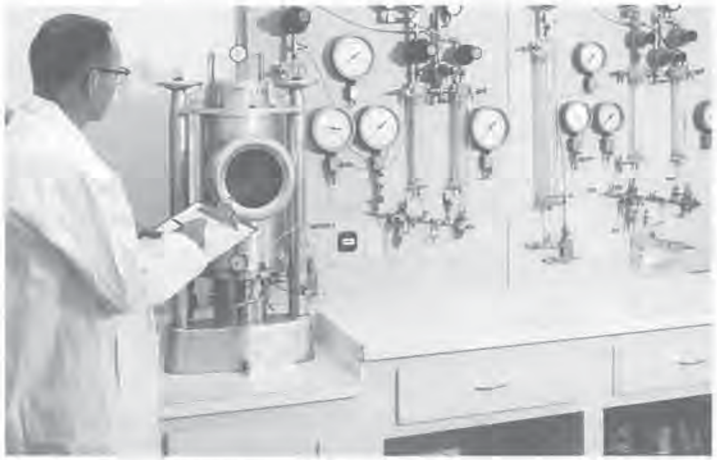
In what turned out to be a case of serendipity, one of the young engineers working for IPEC on construction of the Portage Mountain Dam was Raymond P. Benson. Benson was originally responsible for a large field investigation, but when this program was concluded for the season, he was briefly seconded to RKL, working for Mark Olsen when Mark was testing the clay for the potential core of the dam. In the ensuing weeks, Mark was to have a direct influence upon Benson's career, as "Ray" himself recalls: "Mark recommended that I should take graduate work at the University of Illinois—because he had been there not too much earlier—and that I should talk to Ralph Peck, who was retained by IPEC as a consultant on the dam. Dr. Peck agreed to take me into Illinois on a trial basis, because he had taken a number of Canadians on the same basis, and he said, 'I have never been disappointed in a Canadian.' I knew I would have to succeed so that I didn't let the Canadian side down."

In 1964 Benson took one semester towards a master's degree, then returned to construction work on the dam, earning enough money to complete his degree in 1966. Adds Ray, "I had done very well at Illinois—worked very hard and always got top marks. So they asked me to come back to take a Ph.D." After being out in practice for a time, Ray received his doctoral degree in 1970. Not only had he not let the "Canadian side" down, he had enhanced its reputation by being one of the most highly regarded engineering students to ever graduate from the University of Illinois. Benson was later to join Klohn Leonoff Ltd. and rise to the top post of company president.

In subsequent years, Ripley, Klohn & Leonoff Ltd. was not able to generate any appreciable work on the Columbia River developments. Other engineering firms, perhaps more politically astute, were to obtain the assignments on these projects. Such an outcome was a disappointment to the principals at RKL, who felt that, with the building of RKL's new laboratory in Vancouver and the large testing programs being generated by the Peace and Columbia River dams, there was the opportunity (and the local expertise available) for the formation of a central, state-of-the-art facility handling all of the soil-testing work generated in British Columbia—an opportunity that was eventually lost.

In this regard, and as Ripley, Klohn & Leonoff Ltd. grew in size and sophistication, Lars Anderson's talents were being utilized more productively. By 1962 his time was fully occupied on innovative laboratory and field equipment design, as well as in supervising the firm's small but specialized field testing group. When the testing program began for the Peace River project, one of the first pieces of equipment designed by Lars was a gigantic vacuum-type triaxial compression machine that could accommodate a specimen size 18 inches in diameter by 40 inches in height. Says Lars: "I worked mainly with Earle Klohn on that, and it was very

W.A.C. Bennett Dam, Peace River, B.C.
Photo: Lisle Jory



High-pressure triaxial machine.
Photo: Mathieson Photo Service

successful. Designed with a beam on top, instead of a proving ring [to apply and measure the load], it was definitely innovative." As well, a filter test apparatus was designed and built by Lars to check the adequacy of filter zones in earth dams.

At the time, the high-tech, high-pressure triaxial machine was the state-of-the-art unit of soils equipment. In view of the large dams being planned on the Peace and Columbia rivers, which would need to utilize this machine, Charles Ripley approached B.C. Hydro about the possibility of his company providing such a testing facility. The equipment would have to be designed and built and front-end costs would be high, but initially Charlie received a positive, if tentative, response. Recalls Anderson:

"This was in the early stages of the dams that were planned in British Columbia [Portage Mountain on the Peace; Mica, Duncan, and High Arrow on the Columbia]. So there was a big demand for high-pressure triaxial testing. There was some such testing being done in San Francisco, some in Mexico, and some in Europe. But nobody in Canada was doing it. The company looked at what could be done—equipment had to be developed and so on. So I was given the go-ahead to start designing high-pressure equipment. And, you know, our parameters were laid out in accordance with what the demands of B.C. Hydro would be."

A small prototype triaxial unit was built. Applying a 10-ton load, it tested 4-inch-diameter specimens at 200 pounds per square inch (psi) and 6-inch-diameter specimens at 125 psi. Pore pressures were measured at the top and bottom. The prototype functioned well; Lars called it nothing less than "beautiful."

"We were looking at becoming the world leaders in high-pressure triaxial—we were talking about 500 psi," continues Lars, recounting the story:

"I travelled to Europe looking at such equipment in Germany, Switzerland, and France. Also to New York and Mexico.[6] So we knew of everything that existed. I'd never believed in reinventing the wheel, and I also believed not just in copying but in improving on things. There's no question that we would have had the best equipment. We were all geared up and had excellent designs laid out. And we were really fired up about all of this when, one day, B.C. Hydro came back and said, 'No we're not going to do this; we're going to farm it out to various people all over the world.' That was a black day in my life. Yeah, it was really sad. I think that we would have had work from all over the world coming to Vancouver."

Today, of course, the company possesses and routinely uses 500 psi equipment purchased elsewhere.

Anderson was also innovative in designing and building light, portable field testing equipment:

"At that time there was no equipment available that was portable. We used Boyles Brothers' diamond drills for a lot of the drilling, and the common situation would be that they would take two days to move onto a site before the drilling even started. We had a Franki rig with a 250-pound weight, winch operated. It was a good piece of equipment, but it wasn't portable—and often you couldn't get into where you wanted. So I came up with a light tripod affair, a rope and cathead, very, very simple equipment, to drive a cone and count the blows. Eventually we had two of these working—for years. In fact the other day [1990] I saw the tripod still in use at this earthquake site in Richmond."

Lars's best known invention was to be the Anderson Piston Sampler, which was patented in Canada and the United States. The off-shore rights were sold to the Norwegian Geotechnical Institute, which marketed it all over the world. "It was totally my own idea," asserts Lars:

"I had never seen anything like it in Sweden or in Europe. It was advanced into the soil by the tripod and could go down to a depth of one hundred feet. We made two sizes. The common size used was a one-and-a-quarter-inch sampler. But there was also a two-inch sampler. The piston samplers that had been in use before had two sets of rods—operating by an interior string of rods. Ours was unique in that it had only one string of rods—light and very simple to operate. It had the ability to retain the sample because we were able to apply a vacuum when we pulled it out of the ground. Consequently we were able to get samples out of the Fraser River where virtually no other method could."

Another innovative Anderson design that received media attention was a Styrofoam raft, conceived by Lars after he read about the use of foamed-plastic rafts for carrying dredging pipes. Why, he wondered, could not a similar type of raft be developed for transporting drilling equipment? Where it could often take two or three days to build a standard wooden raft, with his own design, says Lars, "In a couple of hours we could have a raft out there. It was limited to protected waters, but for that it worked quite well." Styrofoam had been introduced by Dow Chemical, and the first job where Ripley and Associates used the raft was at Tilbury Island in the Fraser River—for a Dow Chemical plant. According to Lars, "They thought this was terrific and put it out in the newspapers":

"A Vancouver firm of engineering consultants has developed a lightweight foamed styrene raft for use in underwater soil exploration. Ripley and Associates Ltd. has used the Styrofoam raft on several assignments and company officials report they are delighted with its performance. The raft, which is buoyed by five Styrofoam logs, has several advantages:

"It is lightweight (it weighs about 300 lb.) and extremely buoyant.

"It can be assembled by two men in less than three quarters of an hour.

"It can be transported in the back of a half-ton panel truck."

"Coincidentally," continued the story, "The Styrofoam logs used in the raft are manufactured by the Dow Company."[7]

Eventually Lars found himself more often out of the design office and in the field, as he was when he was working under Charlie Ripley, supervising the drilling on the abutment of the Cleveland Dam:

Light drill rig – On Styrofoam raft, piston sampling for borrow material in the Fraser River, March 1960.
Photo: Lars Anderson

Light drill rig – Driving cone penetrometer.
Photo: Lars Anderson

"That was extremely difficult exploration—used to take two weeks with the diamond drill or a churn drill to get down a hundred feet. Primarily it was a matter of trying to identify the soil we were going through. We drilled with water or drilled with mud and even tried drilling with air. And most of the time we didn't know what soil we were in—gravel or glacial till. Then the new Becker drill came out, and the salespeople did a demonstration for us. We drilled the hole in one day, which was incredible. But most importantly, I knew every foot we were going through. With that equipment you don't have to grind the material up, you're lifting it with air, so you're not washing away the fines. This just sold me on that drill."

With the benefit of such experiences, Lars inevitably became something of an expert in the business of drilling. Then, after thirteen years with RKL, Anderson chose to leave the firm:

"Not having an approved engineering degree, I was very limited within the company—I couldn't sign any reports. So, while it was enjoyable work, there was a definite ceiling beyond which I couldn't go. And by that time the laboratory equipment design had disappeared. But I had certainly learned an incredible amount. You know, whenever you're designing you're turning inwards—everything else is not as important. That design is all important. With the company I got out of just sitting in an office and drawing lines on paper. While there were aspects I didn't like, such as being out on field work for long periods after having a family, I got into dealing with people. And to my surprise I found that I could deal with people, and I enjoyed dealing with people. But eventually I went to Norm Becker [of Calgary] and said, 'Look, I think you should set up an office in Vancouver and I should run it.' And that's what happened in 1966."

The Becker drilling company went through several takeovers and changes of ownership in the ensuing years, and today Lars Anderson is western manager for Specialized Drilling Services (SDS). Says Lars of his work and adopted city:

"Leaving Sweden was one of my best decisions. The reason that world trip didn't materialize [was that] I met my wife here, married, and had two beautiful daughters. I love going to work. I could have made a lot more money in other places—could have been head of the [SDS] U.S. Division, but I just didn't want to leave Vancouver. Vancouver is a beautiful place, and, from the point of view of quality of life, this is the place to live."

Beginning in 1959, a major new field of engineering was to open up for the company in the mining industry, and today the Mining Services Division is one of KL's largest departments. The first such job came to the company in 1959 when Leonoff became foundation consultant to the Consolidated Mining and Smelting Company of Canada Limited (Cominco), a vast mining and smelting complex in the West and East Kootenay regions of British Columbia.[8]

The initial contact with Cominco came through their chief geologist, who had known Karl Terzaghi. In fact, Terzaghi had been a consultant to Cominco, which gave rise to a story illustrative of his uncanny ability to size up not only jobs but men. Terzaghi was advising the company on a major slope stability problem in the Columbia River Valley, a problem which was threatening an important American rail link. Instability of the slope above the railway had occurred as a result of seepage from the adjacent Pend Oreille Reservoir, created by the Waneta Dam near the international boundary. As a remedial measure, Terzaghi had recommended the construction of a drainage curtain into the hillside in order to intercept the seepage. This was a complex construction job calling for the building of drainage tunnels, one above the other in soil overburden, then backfilling the tunnels with gravel. The work was very much behind schedule.

Terzaghi was visiting the job site on one occasion, and Cominco advised the cookhouse that Terzaghi would be in after the regular dinner hour, and that they were to take special care of this important person. So the chief cook stayed on. After his field inspection, Terzaghi came into the cookhouse late that evening, reportedly "hungry as a bear," and the cook himself served the great man. When concentrating, Terzaghi often walked with his head leaning forward and down, and while sitting alone eating his dinner, Terzaghi was still looking down in his very concentrated manner. Seeing this, the cook, a rather breezy fellow, approached him and said, "You look worried." Terzaghi looked up and admitted that he was. The fellow offered to help in any way he could. Terzaghi, no doubt somewhat taken aback, had the rare insight to realize that perhaps this man could indeed help somehow. They chatted, and Terzaghi confided that his problem was that, in constructing the drainage tunnels, he was working with hardrock miners, men who knew little about tunnelling in earth. The cook returned that he had done some work sinking shafts in earth. He had mined for gold at Wells (near Barkerville), where there are all kinds of tunnels and shafts constructed in overburden. Terzaghi quizzed him about what he'd done and what he knew, and finally he asked the fellow point-blank whether he could construct the tunnels properly. The cook, now enthused, replied that he wasn't certain that he could but that he was more than willing to give it a try. Terzaghi responded by saying that the man would start the following day.

Next morning, Terzaghi talked to the contractor, a large and reputable firm. The cook proved to have experience; he was made foreman, and the tunnels were successfully completed under his supervision.[9]

In 1959, when Cominco's Engineering Division first contacted Ripley and Associates, the operation appeared to Cyril Leonoff to be somewhat insular and self-contained. The engineering offices were located in outlying Trail where the company's smelter was located. But Cominco was embarking on some major developments, and its engineers were astute enough to recognize that they needed the advice of a well-versed soil mechanics consultant. Leonoff quickly developed a good working relationship with Cominco's structural people—A. C. Ridgers, the chief design engineer, and his assistant, Gwylim Hughes. The first job was on the foundation for the company's new iron smelter near the Sullivan Mine in Kimberley, B.C.[10]

In the summer of 1962, Ripley, Klohn & Leonoff Ltd. was commissioned by Cominco as foundation consultant on the construction of a concentrating mill at Pine Point Mines. This lead-zinc mine was located on the south shore of Great Slave Lake, between Hay River and Fort Resolution, in the Northwest Territories. The site was isolated and remote, having no road or rail connection of any kind.[11] Leonoff recalls the long, six-hour flight from Edmonton, down the Mackenzie Valley, on the slow but sturdy propeller-driven DC6-B, eventually landing in Yellowknife, on the north shore of the lake. While the era of the bush pilot was just about over, Leonoff remembers vividly the one-hour flight the next morning back across that vast lake on a CP Airlines single-engine wheeled aircraft:

"There was absolutely no sign of civilization in sight. Certainly your fate depended on the sound mechanical operation of that one engine. We finally landed on a dirt runway that had only recently been bulldozed, creating a huge dust-cloud behind us. Scrambling out of the aircraft that summer morning, we were a welcome breakfast for the fiercest colony of mosquitoes and black flies that I have ever experienced. During the entire site inspection we were trying, unsuccessfully, to run away from those flies. Lars Anderson very stalwartly supervised the drilling investigation there."

Soil conditions at Pine Point were novel to the company and a challenge to the foundation engineer. The region is a northern extension of the interior plains of Canada, and the ground, which rises gently on a plain south of Great Slave Lake, is heavily wooded and poorly drained, covered with many small lakes and muskeg bogs. The bedrock at the site is mantled with glacial till averaging 15 feet in thickness but, in places, the bedrock outcrops or is near ground surface. The land surface features a series of closely spaced, long but narrow, sub-parallel raised ridges that are clearly strand lines from previous, higher levels of a glacial lake. (The ridge at the mine site itself is over a mile long and 700 feet wide.) The ridges are composed of clean granular materials formed by earlier beach action at the glacial lake, which had washed and sorted the till, thereby removing a large portion of "the fines." Muskeg covers the land between the ridges and has formed because the surface drainage is cut off by the surrounding ridges, while downward drainage is stopped by the impervious glacial till below. The muskeg is composed of silt and fine sand washed out of the ridges, combined with organic matter and sphagnum mosses growing in the bogs—a treacherous foundation material.[12]

Compounding the foundation problem was the fact that the site was near the southern edge of the permafrost belt, where intermittent pockets of ice could cause hazardous, differential settlement of the mill. Frost conditions in the subsoil were measured by a thermocouple-type gauge. A visually readable frost gauge was also devised for the drill holes, whereby a polyethylene tube filled with methylene-blue solution was inserted into the drill hole. The tube could be pulled out at any time for observation. Frozen zones were indicated by a change in colour of the liquid, from blue to colourless.

Because of the variable nature of the surface soils, the mill was founded largely on bedrock. But the sedimentary bedrocks at the site are composed of limestone, dolomite, gypsum, and shale, and these are fractured, containing many vugs and solution cavities, and some of these joints have filled with soft material produced by a chemical weathering process. So the foundations had to be carefully inspected and the footings conservatively designed at more moderate pressures than would be conventionally used for hard rock.[13]

About this time, RKL also consulted on the construction of a new East Tower for the Kootenay Lake transmission line, after the old tower had been dynamited by Doukhobors.

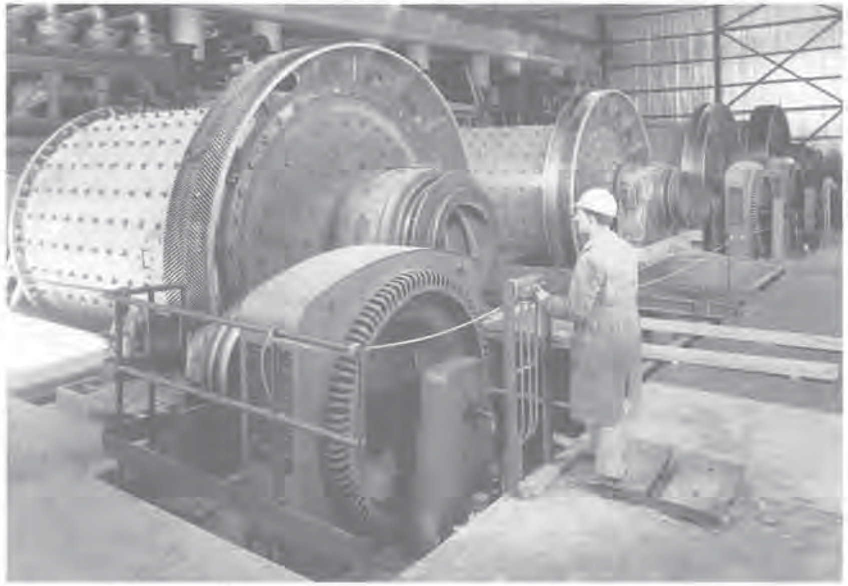
While it may have been lead-zinc that was viable in even so remote a place as Great Slave Lake, in British Columbia in the 1960s it was copper that was finally becoming economically feasible to mine. A number of belts of copper ore had been known of in the province for many years, but the ore was low grade, containing only between 0.5 to 2 percent copper. However, with post-war, world-wide urban and industrial development came a demand and rising prices for copper for such uses as water pipes in buildings and long power lines transmitting electricity from remote hydroelectric sites. The principal copper mine sites developed in British Columbia during the 1960s (Craigmont, Bethlehem, Highmont, and Lornex) were in the Highland Valley region, a mineralized plateau, the perimeter of which was a triangle formed by Ashcroft, Merritt, and Kamloops. Other B.C. copper mines were located in Strathcona Park near Campbell River, Vancouver Island (Western Mines or Westmin); in the south-central area near Williams Lake (Gibraltar); in the north-central region near Babine Lake (Bell Copper and Granisle); and in the Okanagan (Brenda). Eventually Ripley, Klohn & Leonoff Ltd. would work on all of these properties.

The geotechnical problems related to the construction of these mine sites are threefold. The first concerns the concentrating mill foundations. These mills consist of heavy vibrating machinery—primary and secondary crushers and grinding mills—which break up the rocks into smaller and smaller sizes, eventually down to a fine rock dust, such that the copper can then be extracted by a chemical process. Second is the problem posed by the huge open pits used to mine the rock ore, pits which create high, steep slopes whose stability assessment comes within the purview of rock mechanics. And the third problem is the disposal of the tailings—the waste rock, heavy metals, reagents, and sludge—that are left once the ore has been extracted. The vast amount of material being taken out of the earth, either by open pit or mining, is mostly (perhaps 98 percent) waste rock. Therefore, if the mill runs through 100,000 tons a day, 98,000 tons of tailings must be stored. Since water is the means of conveyance within the mill, this material leaves the operation in a fluid form which, according to environmental laws, must be stored in a stable manner forever, under conditions as severe as those caused by a major earthquake. Thus a dam of compacted, stable materials must be deposited downstream in order to form a barrier behind which the waste materials are safely stored. These "tailings dams" (built of sand recovered from the tailings) may be as high as 550 feet—some of the largest man-made structures on earth.

To prevent contamination of groundwater supplies, rivers, or lakes, the water used as the conveyor in the milling, separation, and disposal processes must be circulated in a completely closed circuit and reused in the mill. Positive seepage cut-offs are designed into the system, but any seepage water that escapes must be picked up downstream and recirculated to the tailings pond.[14] Finally, when the mine is abandoned, contemporary environmental standards require re-vegetation of the waste pile.

While a number of small copper properties had been in production before this time, in 1961 Craigmont Mines, with a 4,000-ton-per-day copper mill located near the town of Merritt, was the first major copper mine to come into operation in British Columbia for many years.[15] The mill was designed by Wright Engineers Ltd., a company led by the brothers Harold and Leonard Wright. While this was their first major mill, they were later to become the foremost mine mill designers in British Columbia and later yet to successfully market their services world-wide. Leonoff has no doubt that he was fortunate to be engaged by the Wrights as foundation consultant on the Craigmont mill. "It was a new experience for us," explains Leonoff, "Paul Cook had done some preliminary work on the site, but when Wright got involved in the fall of 1960, they engaged Ripley and Associates because of our reputation in industrial foundations."

"Craigmont was a landmark job for us," adds Leonoff.



Craigmont Mines, Merritt, B.C. – rod and ball mills.
Photo: Otto Landauer, Leonard Frank Photos

The plant site was situated on a cut bench above the Nicola River and Guichon Creek valleys. There was no rock present, so the mill was founded on glacial materials of ablation moraine origin, that is the soil had had no external loading during or since deposition, as compared to the more commonly found till which had been previously compressed by glacial ice. The soil at the Craigmont site also had appreciable silt and clay content and was therefore sensitive to disturbance and softening when wet and worked upon by construction equipment. And indeed, when excavated, the site was found to be moderately wet from seepage out of the hillside. Ripley and Associates' detailed investigation and reports, filed in October and November 1960, concluded that the site was stable overall, and that the soils were suitable to support the mill at moderate footing pressures, provided that drains were installed and particular care taken during construction to prevent softening of the foundation soil.[16]

RKL had no further participation on the Craigmont job until the end of July 1961, when Cyril Leonoff received an emergency call. By this time the mill had begun operations, with four grinding mills—two rod and two ball mills—located in a row. But when the mills were started up, in particular the rod mills were found to be rocking on their bases. And these machines had sensitive gear drives that could tolerate virtually no movement. Leonoff immediately travelled to the site, looked at the problem, and said, "Well, let's dig a hole." When the workers broke through the concrete floor they discovered water. The next thing Leonoff said was, "You've got to drain the water out." At this point, according to Leonoff, the Dominion Engineering man [the company who built the mills] refused to take any responsibility and simply "punched the button," shutting down the entire operation. And the mills continued to sit idle, with 180 tons of rods, balls, and ore waiting, for six weeks while crews supervised by RKL worked beneath the mill floor, digging down and installing filtered drains.

Given these circumstances, Leonoff was under intense pressure:

"More important than the drainage, my analysis showed that rocking occurs when the dimensions of the mill base are insufficient to provide the general stability needed by the foundation block under the machine thrust. I had no prior experience in designing such machine foundations but searched all the literature I could find. It was quickly apparent that these bases were under-designed for the soil conditions at the site. While there were no universally accepted rules for predetermining what the mass and dimensions should be under any given conditions, I recommended a redesign calling for an increase in the mass and dimensions of the footings and a tying together of the four machine bases structurally by dowels and concrete, so as to form an integral slab.[17] Everything rested on the results of this redesign, but I had confidence that the problem could be resolved."

In the wake of the complete shut-down of the mills, there was a "difficult meeting" convened at the site, attended by representatives of the mine owners, Wright Engineers, and Cyril Leonoff:

"The president of the mining company, O. J. Simpson, was a hard-bitten mining man feared by everyone. But I called a spade a spade and told him honestly what had to be done to remedy the situation. And he accepted our recommendations. We insisted on full-time inspection of the foundation treatment and drainage and sent up Mark Olsen, our most experienced and meticulous man, to look after the reconstruction."

Olsen recalls as clearly as Leonoff the pressures of the assignment:

"It was really a crash job, working three shifts around the clock, to get those mills going.[18] Because that was when they had three years of tax-free incentive, to make mining attractive, and they were probably highgrading up at the mine just to get as much copper out as they could during the tax-free period. And everything was hung up because the grinding mills weren't working properly. Ross Duthie [the mine manager] thanked me at the end and enquired, 'Did you get any sleep, because people say they saw you at every shift?' Well, I just catnapped."

Cyril Leonoff travelled back to the site on the "critical day" when the mills were restarted. To his great satisfaction, "they just purred beautifully." Adds Leonoff, "To my knowledge, they had no more trouble with them in the sixteen or so years that the mine operated. Harold Wright thanked me many times over for 'saving their bacon' on that job."

Only a month after Craigmont Mines restarted, in the fall of 1961, Leonoff and Olsen drove up to the Highland Valley to work again for Wright Engineers, this time on the Bethlehem Copper Corporation mill—the first porphyry-copper producer in Canada. Accessible only by a dirt road winding through lonely range land, the solitary sign of civilization, recalls Mark, was "a primitive hunting lodge run by a 'Jack Spratt and his wife' sort of couple." The Bethlehem site had better foundation conditions than that at Craigmont, and the mill was built, without problems, on rock. Bethlehem was the pioneer mine in the valley, brought into production through the dogged determination of the legendary Herman Hagerman "Spud" Huestis.

Huestis has been described by his biographer as "the dreamer always seeking the Golden Fleece." A prospector, he was a "loner spending days or months trudging through mountains and valleys, content with the company of a horse." At Highland Valley he identified millions of tons of copper ore disseminated through the rock below the surface of the valley. Convinced that this low-grade copper could be profitably mined on a vast scale, he persuaded two British Columbia businessmen-entrepreneurs to help finance and manage the venture.[19] Thus Leonoff and Olsen were on hand on February 1, 1963 to celebrate not only the opening of the mine but the "Horatio Alger/local boy makes good" story of Spud Huestis.[20] Bethlehem was the precursor of a number of major mines in the Highland Valley, and today the once undisturbed area has been churned up by a beehive of mines and tailings piles.

Says Leonoff: "I was foundation consultant to the Wright brothers on all of their early mines, including Western Mines (Westmin) and the Kennedy Lake iron mine on Vancouver Island, as well as a gold mine at Wenatchee, Washington. Most of these sites had complex geology, and on each of them I called on the advice of the most experienced local engineering geologists—Dr. William H. Mathews, the UBC Pleistocene geologist for Pine Point and Craigmont, and Dr. Victor Dolmage for Bethlehem, Westmin, and Kennedy Lake."

Westmin was brought into production in 1967. This site was of particular interest, not because of its foundations, but because it precipitated one of the early industry-versus-the-environment issues that are now so common in the province. The mine was located in the provincial Strathcona Park at Myra Creek, the headwaters of Buttle Lake, a picturesque body of water surrounded by towering mountains. While an access road was built along the lake and some tailings were dumped into its waters, rigid controls exercised by the provincial government allayed some of the concerns of environmentalists about this development.[21]

Leonoff's work on mining mill foundations was eventually to be superseded by others from the company:

"By the latter half of the 1960s, I was phasing out of engineering work. In my day we thought Craigmont, at 4,000 tons, was a big mill. Today our people are working on copper mines such as Valley Copper in British Columbia and Kennecott in the United States, of 120,000- to 140,000-tons capacity per day. And, as the mills have gotten larger, tailings disposal has become the major problem. Earle Klohn, Bob Maartman, Robert Lo, Peter Lighthall, and other staff members have become world experts in that field."

Tailings dams were indeed to become the company's "big-ticket" item at the end of the sixties and the beginning of the seventies, and they have continued to be a staple engineering product for Klohn Leonoff Ltd. ever since. Charlie Ripley first became acquainted with these structures during a trip to California:

"I made a trip to San Francisco, looking for work with potential clients and making sure that we were known to the large engineering companies there—Bechtel and International Engineering. At IECO I had a nice visit with Ed Smith, who was one of their chief geotechnical people. In talking about the kind of work in which he was engaged, Smith mentioned doing a lot of work on tailings dams. And, at the time, we didn't even know what the definition of a tailings dam was. At Bechtel, I also talked to a relatively young fellow of my age, and they were involved in tailings dams too. My gosh, I thought, with the large open-pit mines that were just coming into vogue in British Columbia, there's a potential area of work for us. I was located in Winnipeg at the time, but I talked to Earle Klohn about this. My recollection is that the introduction of Earle to tailings dams occurred during this period. He made a trip down through the United States examining the technology of existing tailings dams. With Klohn's ability to concentrate, to acquaint himself with a new subject, and to quickly become authoritative, the obvious result was his involvement in a major way with such dams. That was the lead into

Bethlehem Copper mill, Highland Valley, B.C., February 1, 1963.
Photo: George Allen Aerial Photos

Brenda Mines, Peachland, B.C.

Starter dam, June 13, 1970.
Photo: Cyril Leonoff

Tailings dam, 1980.
Photo: Brenda Mines

such project engineering for the company."

In 1966–67 a feasibility study was under way for development of Brenda Mines, a copper-molybdenum property at an elevation of 5,000 feet on the edge of the interior plateau twelve miles west of Lake Okanagan. The ore body contained 125 million tons, the extraction of which would involve an open-pit mine operating for twenty years. In order to supply water to the mill, the project called for the construction of an 85-foot-high, impervious-core earthfill dam at Peachland Lake. A more significant engineering challenge was safe storage of the massive amount of waste material (tailings) derived from the milling process, thereby preventing any environmental damage to Lake Okanagan. The basic design involved construction of a rockfill toe dam, a sand tailings dam to an ultimate height of 500 feet, an underdrainage system to keep the sand dry and prevent liquefaction, and a water-reclamation dam downstream to collect and recycle seepage water. Noranda, a major shareholder, had management control of the development. Earle Klohn was appointed design consultant for the dams.

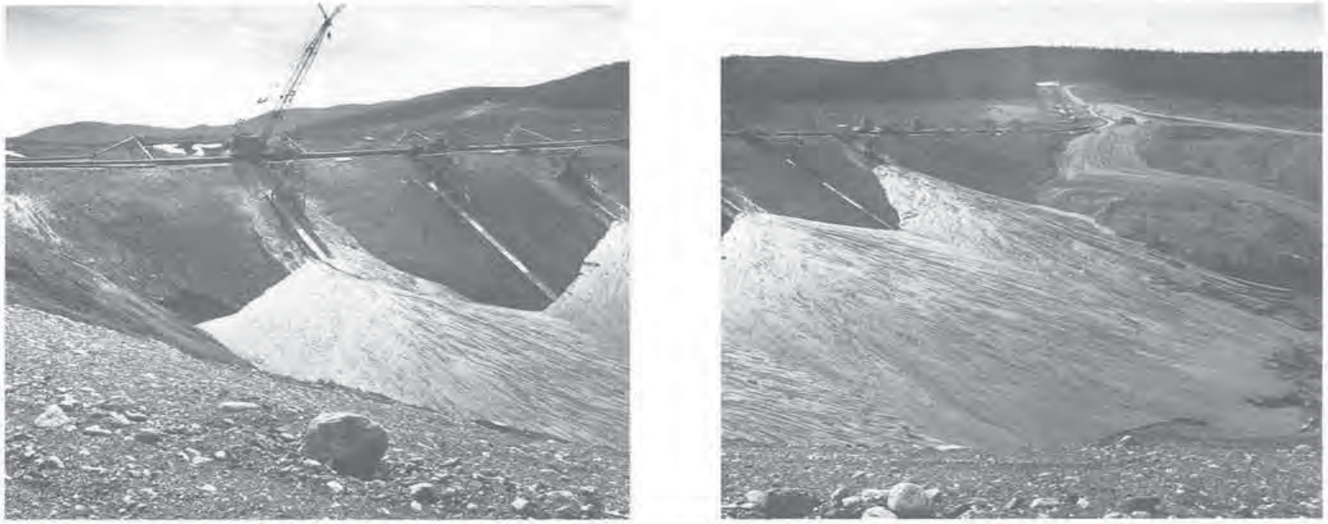
Recalls Klohn: "A group of four of us [Klohn, Keith Douglass, Manager of Engineering Services for Brenda, and two other Noranda people], at Brenda's expense, spent a couple of weeks touring tailings dams all through the U.S., studying what they looked like, how they were built, and how they performed. So we had a good exposure to tailings dams, some of them very large." But the dams Klohn studied were all built "into the pond." None of them was constructed by downstream methods, that is by reclaiming sand from the downstream tailings and depositing it to form a dam, behind which the main body of the tailings would then be stored.[22] This was the type of design Klohn wished to follow at Brenda Mines, a design he described this way: "Build a pile of sand, placed on reasonably flat slopes, and then drain the sand so that it is kept dry." Under such conditions, the dam is stable and cannot fail through liquefaction if hit by an earthquake. Reiterates Klohn, "My design criteria were as simple as that."[23]

Following his trip and the completion of his design work, Klohn met with the Noranda people in their Vancouver headquarters to discuss construction of the dam at Brenda Mines. He presented his design sections and discussed the proposal—"what the concerns were, what the design rationale was, and why."[24] Continues Klohn, "Here I was a relatively young person, telling them to build a dam without precedent—500 feet high, using dry sand. That's not the way dams were normally built." Nevertheless, the president of Noranda was persuaded by Klohn's presentation, and announced at the meeting that the company would be proceeding with Klohn's design.[25] "That was the decision," remembers Earle, "and there was no more discussion. Needless to say, I spent many months worrying about this big decision I had recommended."

Brenda Dam has probably seen more visitors from afar than has any other mine site in the world. And it remains the model for tailings dams under construction or completed all over the world. Brenda Mines officially opened in 1970,[26] and twenty years later, without there having ever been any suggestion of instability of the dam, the project is winding down, as the ore-body has finally been depleted. (The mine officially closed in June 1990).[27] The site is being reclaimed, in conformance with current environmental standards.

Following Brenda Dam, the next sand dam designed by RKL was located thirty-five miles north of Williams Lake, B.C. A project of Placer Developments Ltd. of Vancouver, it was called Gibraltar Mines and was constructed in 1969–70.[28] This dam was to be 300 feet in height and 1.5 miles in length, impounding 400 million cubic yards of tailings.[29] Using different methods than Brenda, this centreline-constructed dam was raised by cycloning sand from the riverbed.[30]

Engineers have a reputation, often exaggerated, for their hard-driving, hard-drinking habits. The opening of Gibral-



Gibraltar Mines, first sand cycloning after starter dam completed, May 1972.
Photo: Earle Klohn

Hydrocyclones, Highland Valley, B.C.
Photo: Earle Klohn

tar Mines was cause for one such celebration, and Bob Maartman, one of the designers, tells this self-deprecating story:

"This was when they had finished the starter dam for the tailings at Gibraltar, and Earle Klohn and I were up to have a look at the finished product. Tom Harper was our representative on the site. Anyway, the contractor brought in a couple of cases of booze to celebrate the completion of the job, and after we had finished work on the site, we visited him and had a few drinks. Then we went to Tom Harper's place [at the mine site town of McLeese Lake] for supper and had a few more."

They were to catch a plane to Vancouver later that evening, departing from Williams Lake, thirty miles to the south:

"So we had a fair drive to get to the airport, and I had a little difficulty gathering everybody together to return to Williams Lake. I had the U-Drive and the rest of the guys were just passengers. But everyone was pretty high by this time, including me, and when we made it to the airport and walked in to check in, I guess I was talking a little louder than normal. [Bob is noted for his booming voice.] The Pacific Western Airlines representative wouldn't give me a boarding pass. He tells me I'm too drunk to go on the plane. Actually I was the soberest one of the bunch, but nevertheless I was the one he singled out. I still had the keys to the U-Drive so I thought, okay, I'm driving to Vancouver. This bothered Earle a little bit; he didn't like the idea of me driving all the way to Vancouver. So he worked on the representative and persuaded him to let me on the plane, and we finally got on, but it was a bit of a hairy do. The thing that made me mad was that the guy who was trying to smooth things over for me was in worse shape than I was."

Today, two decades later and with attitudes much changed, one might hope that even the drive to Williams Lake might have been foregone in favour of a taxi.

Klohn Leonoff received "Honourable Mention" in the 1977 Canadian Consulting Engineer Design Awards for its work on Gibraltar Mines Tailings Dam,[31] and, following the pioneer work at Brenda and Gibraltar, the company has been involved in a long series of tailings dams in Canada, the United States, and overseas.

Earle Klohn has been a long-time member of the International Commission on Large Dams (ICOLD), an organization dedicated to the advancement, design, construction, maintenance, and operation of large dams, and president from 1989 to 1991 of the Canadian National Committee of ICOLD (CANCOLD).[32] In 1972 Klohn was awarded the Engineering Institute of Canada Leonard Medal in mining for his paper "Design and Construction of Tailings Dams."[33] A fellow of the Canadian Institute of Mining and Metallurgy (CIM), Klohn received the ultimate recognition of his peers in the mining industry when he was awarded the Donald J. McParland Memorial Medal, given "in recognition of his pioneering work in the economic and technically sound design and construction of large tailings dams."[34]

Chapter Eight

EXPANSION TO THE PRAIRIES

Following the death of Karl Terzaghi in 1963, and with the B.C. economy continuing at a very low ebb throughout the early sixties, Ripley, Klohn & Leonoff began to experience financial constrictions which it had not previously been obliged to face. The company had, at this stage, as competent and experienced a group of soil mechanics engineers as anyone in Canada, but, prior to this time, the firm had done very little selling or promotion and had developed no long-range plans for expansion of offices or increasing the scope of services offered. Work had always simply come to the company, with little or no initiative necessary on its own behalf. In the meantime, competitors had sprung up on all sides, and these companies were busy selling and promoting themselves. As Earle Klohn stated in his 1972 company retrospective:

"When Karl Terzaghi passed out of the picture, RKL assumed that, since the company had the respect of the international soil mechanics fraternity, and since it had worked for most major clients in B.C. as Terzaghi's 'technical arm,' Ripley, Klohn & Leonoff Ltd. was the natural heir to major consulting assignments with these clients. This was to prove to be a major misjudgment. In reality, most large clients had no appreciation of the major input that had been made by RKL on the Terzaghi work; rather they considered the firm as little more than field supervisors and soil testers who had done as directed by Terzaghi. In the ensuing years, RKL attempted to operate its consulting business employing the same general approach that Terzaghi had in handling engineering and client problems. That is, the firm attempted to take the same 'my way or no way' approach that Terzaghi or Casagrande had tended to adopt. This did not prove particularly effective and in fact annoyed many clients. There was only one Terzaghi, and people had to put up with him if they wanted his advice. Those clients did not feel that RKL had the same uniqueness. The result was that, although there is no question that RKL benefited greatly through its association with Karl Terzaghi over the years 1951–1963, following his death, the company found itself 'holding a troublesome bag.'

"Because we had all been too busy doing engineering during those first ten years to worry about our image, nobody, outside of a few local clients, had any knowledge of either our technical competence or our wide experience. Moreover, we still seemed to believe that eventually clients would realize that we were the experienced, competent, well-established, responsible consultants in this field and would come to us for advice and help."[1]

While the essence of Klohn's near-harangue undoubtedly contained much truth, in order to make his points the message also contained some exaggeration. Certainly, for instance, some of the major clients, such as Simons, Alcan, and the Greater Vancouver Water, Sewerage and Drainage Districts, appreciated the company's services and have remained good clients to this day.

In his review, Klohn went on to describe some of the decisions that were made in the early sixties in order to expand the company's base and to attempt to even out the effects of the cyclical peaks and troughs that were endemic to British Columbia's resource-based economy. There were "differences of opinion" amongst the principals as to what should be done to improve the company's position, but one conclusion that was unanimously reached was that RKL should expand its base by opening an office in Winnipeg.[2]

Conditions in the Prairie provinces were not new to the company, since engineers such as Ripley, Klohn, and Morrison had their initial training and work experience there. And the company had also done some small-scale work for Associated Engineering Services in Alberta on military barracks, water reservoirs, and small dams. Earle Klohn's first experience with earth dams was in consulting for Associated on modest but interesting 25- to 30-foot-high water supply dams for the Alberta towns of Leduc and Tofield. But the company's first major project in the Prairies was the Squaw Rapids hydroelectric development of the Saskatchewan Power Corporation, near the town of Nipawin in northeast Saskatchewan, constructed in the period 1960–1963. G. E. Crippen and Associates of Vancouver were the design and construction engineers.

The project consisted of an earthfill dam, a concrete spillway, a large power canal, and a powerhouse. The unique feature was that all structures, including the 100-foot-high concrete spillway section, were founded on soil. At the time, this was to be the highest concrete structure ever built upon earth, and consequently its construction posed several foundation problems. These included developing adequate resistance to sliding, ensuring sufficient flexibility to absorb differential settlements, and controlling seepage and uplift pressures.

When Charles Ripley first reviewed the Squaw Rapids site, he recognized the complex problems to be faced and insisted with Glenn Crippen on the need for not only soil mechanics input on the design, but also for full-time, resident inspection on the geotechnical aspects of the construction. With some initial reluctance, Crippen accepted these recommendations. Jim Libby, an experienced dam engineer, was Crippen's project engineer in charge of the overall design; and Earle Klohn, the person from RKL Ltd. responsible for the soil mechanics aspects of the project, found the alliance amenable:

"We worked on [Squaw Rapids] for years—did all the geotechnical design—I was the guy who worried about the drains and the foundation support—went to all the meetings of Crippen's structural people, and it was a very good relationship."

When asked whether the design and engineering of dams is something that can be learned at school or only through practical experience, Klohn has replied:

"Basically, in my opinion, to become a dam designer one has to have a thorough grounding in theoretical soil mechanics, because you have to understand the theoretical principles involved. Beyond that, it's a matter of being interested, spending a lot of time reading, going out to dams under construction, seeing the kinds of problems that develop. In the case of Charlie and myself, we had a real advantage in that we used to tour with Terzaghi looking at the various ongoing jobs, and he was always full of stories about dams and what problems to look out for. So we had a very thorough grounding in what you should be aware of and what can go wrong—the most important part."[3]

Over the three-year construction period, Klohn and Robert Peterson of PFRA were the review consultants on the Squaw Rapids project. Says Klohn of this affiliation: "Peterson was accepted as the great dam expert by everyone in Saskatchewan. He was 'Mr. Dam.' So Bob and I went out there two or three times a year. That was a good relationship. I got along very well with Bob, and we had no difficulty working together."

Ripley, Klohn & Leonoff's field engineer on site was "Don" Davison, then only twenty-seven years of age, and Don spent the entire construction period on the project. He was Crippen's sole geotechnical advisor on the site and so had no choice but to assume great responsibility for ensuring the quality of the work done. And there were problems from the very outset in maintaining specifications.

"The project manager came from a contractor-engineering background," explains Don, "so he always felt that you could give a little and the contractor would give a bit, but, in this case, the contractor was taking everything. There was evidence of inadequate stripping of foundations. The worst problem was to force the contractor to do a sufficient washing job to remove the fines from the filter material. Finally I had to give written, as well as verbal recommendations, which may not be the best way to achieve co-operation on a site. But we persevered, having

Squaw Rapids Dam, Nipawin, Saskatchewan.

Under construction, October 25, 1962.
Photo: Len Hilliard

Placement of compacted earthfill.
Photo: Donald Davison

good backup support from my own office and from both Libby and Peterson."

The Squaw Rapids Dam was built of homogeneous glacial-till construction, with a central drain. Nevertheless, according to Davison, there seemed to be "a little bit of everything" on the project from a geotechnical point of view:

"There was the generation of high pore pressures in the till materials if we placed them slightly wet of optimum. The concrete spillway structure, which was founded on glacial till, was a concern. There were high artesian pressures in the soils located in the valley bottom. We had frost heave under a couple of very heavy structures, which indicated to me the extreme pressures that this phenomenon can exert. And there were some landslides in lacustrine, highly plastic clay."

For the time, there was a good deal of instrumentation placed in the dam and in the various structures, and it was also Don's job to supervise the monitoring, keep the records, and inform everyone involved as to what was transpiring.

Earle Klohn wrote a paper on the project, presented at the Nineteenth Canadian Soil Mechanics Conference in October 1966, that was a landmark case history for its time.[4]

When asked if dam building is an art or a science or both, Davison has said:

"I call it an art, but I'm old-fashioned. Modern people would call it a science. It's really both. I think it has evolved from an art to a science, as long as they don't lose the art part of it, which I call the judgment part. If you rely strictly on analysis, you are going to have problems, because soil conditions are so variable that you really can't predict them. You have got to use that judgment factor, that built-in safety factor that you put into it when you are designing the dam."

Donald Morse Davison's family traces its roots to the early days of Nova Scotia. Don's mother was of Scandinavian descent; her family settled in the Chipman area of Alberta, near the CNR line, northeast of Edmonton. Don's father worked on the CPR in eastern Canada before being transferred west to the railway's southern route through the Coquihalla watershed in British Columbia. Then he worked as a telegrapher-station agent at Enderby, Salmon Arm, Penticton, and Agassiz. As the station agent Don's father did "all the chores at all hours"—sending telegrams, selling tickets, handling freight, and whatever else might be passing through the station. Don, who was born in August of 1933, graduated from Agassiz High School in 1951 at the age of seventeen. During high school he had become interested in geology, and he planned to study this science at university.

In order to earn some money before entering university, Davison spent a year working on an oil rig nearing the end of its production in the Leduc oil field south of Edmonton. But in the summer of 1952 R. M. Hardy was looking for someone to go to Kitimat for Hardy-Ripley on the initial fill placement for the Alcan smelter. Says Davison: "I was interviewed by Bob Hardy out at the university. He offered me a job; it sounded great, so I jumped at it and immediately went up to Kitimat." That winter he enrolled at the University of British Columbia. The next summer he was back at Kitimat working for Alcan as a concrete technician. The following summer he worked there again, this time under Cyril Leonoff on the asphalt paving then under way.

Following discussions with Cyril Leonoff and Charlie Ripley, Don Davison decided to study civil rather than geological engineering. In subsequent summers he gained a great deal of earthwork construction experience working for the company on the Prince George reservoir, the Imperial Oil Burnaby Marketing Terminal, and at the Cheakamus Dam, following Mark Olsen's departure to work on the Mission Dam. Davison recalls a visit by Terzaghi to the Cheakamus site:

"We were having a devil of a time with the contractor—he was not a very good contractor. Dr. Terzaghi came to the job. I was on night shift. Terzaghi came into the field office, and he wasn't at all happy with the quality of the construction that was ongoing. He wrote his report right there. I always admired the way he could turn a word; he called it 'glorified dirt.' Anyway, he straightened out that contractor."

After graduation from UBC in 1958, with business and field work slowing, Davison and the company made the decision that he should go directly into post-graduate studies in soil mechanics at Massachusetts Institute of Technology. At that school, Davison received excellent training under T. William Lambe, head of the department, Robert V. Whitman, and Charles C. Ladd, as well as the visiting lecturer Laurits Bjerrum of the Norwegian Geotechnical Institute. He also took some courses at Harvard—a seepage course from Arthur Casagrande and a geology course from Ruth Terzaghi. Don graduated from MIT with a master's degree in 1959.

After his return from university, Davison worked as an inspector at the Seymour Falls Dam. Then, in mid-winter, he was sent to a dam site on the upper Fraser River northeast of Prince George. Don describes an experience indicative of what working conditions were like in that part of British Columbia during the winter months:

"I [parked my truck and] walked into the site and had supper with our engineer there, Bill Jubien. The following day I was to start drilling investigations for another saddle dam. Time passed, and it was dark by the time I headed back to the truck, and I got lost. I had a flashlight, but the light died on me. It had been snowing during the day, and I couldn't find the trail. Finally I took a round-about trip to get back to the road and eventually found the truck. But it was an old heap, and I went off the road on the way back to Aleza Lake. I found a logging camp and was about to go to bed there when the grader operator, who was clearing the road, came by. He said he would pull me out of the ditch, which he did. I got back to Aleza Lake about 3:00 A.M., and was up early that morning to start off the drilling. You had to pack everything in and everything out of the site—including the soil samples—on the packboard, using snowshoes. But I was young in those days and could do rugged work."

Don was sent to the Squaw Rapids site in Saskatchewan the following spring, and upon completion of the work at Squaw Rapids,[5] in the winter of 1963–64, Davison was seconded to Crippen and Associates for feasibility studies on three dams—Kettle Rapids, Long Spruce, and Limestone Rapids—on the Nelson River in northern Manitoba. Says Don in describing those sites: "Access was difficult. I was up there for four months that winter. It was really my first introduction to classifying permafrost, which was good experience for me."

In retrospect, what are Don's feelings about field work under such trying conditions?

"I was not making much money, but I was going for experience. That experience has been invaluable over the years. I was off in the bush for several months at a time, and you never came out during that time. Nowadays of course you have a difficult time getting the young students or new graduates to go out on field jobs; they want to be in the city. I looked forward to field work and thought that it was an opportunity to learn."

The result of that attitude was that, by his early thirties, Don Davison was an experienced earthwork and dam engineer.

The decision taken by the principals of Ripley, Klohn & Leonoff Ltd. to expand operations into the Prairie provinces was as a result of a number of considerations, not the least of which was the downturn in British Columbia's economy during the early 1960s. In the opinion of Charlie Ripley: "We had the strongest group of geotechnical people in Canada at that time. And we wanted to keep the core of well-trained, experienced staff that we had built up." The Prairie provinces seemed to be the logical area into which the company could expand, since the majority of its personnel had originated from that region and were familiar with the soil, climatic, and social conditions. Such was the assessment at the time, and it was not an unreasonable one.

Manitoba

The first definitive move was made in January 1964, when the company sent Don Davison to open up an office in Winnipeg.[6] However, if the company was to seriously compete on a high level of engineering, the principals felt that one of them should also be resident in the province. Charles Ripley agreed to go and took up residence in Winnipeg on September 1, 1964.[7] In the next five years, offices were opened in Calgary, Edmonton, and Regina, ultimately providing coverage of the entire Prairie region. Some offices were successful, others less so.

Don Davison's move to Winnipeg was a prime example of the type of opportunity that expansion offered to some of the company's younger engineers: "Up until then, I had been primarily in the field doing construction control. Winnipeg was the first city in which I actually lived. I welcomed the change and the opportunity to become manager of an office." When the office first opened and until Charlie Ripley arrived later that year, Don was by himself operating as "chief cook and bottle washer," doing field investigations and then writing his reports out of a back room. As the company became established in Winnipeg, Don inherited the problems of managing the staff, initiating and reviewing projects, and ensuring that work was completed on time. "In many cases," adds Don, "I was completely on my own. I would get Charlie to review major jobs. When he got interested in a job, he was extremely thorough."

Don remembers in particular a case when the company was called upon to do its first investigation of an overpass in Winnipeg:

"As part of this work, we looked at all the bridge structures in the city. This was during the winter, and the expansion plates should have been opened in the cold—but they were all jammed shut. Charlie felt that this was the result of creep that was occurring in the foundation soils. Accordingly, our report recommended allowance for more opening in the plates. This discovery was accepted by our client, Les Wardrop, the city's consulting structural engineer, but the report was then reviewed by the Manitoba bridge engineer, and at the review meeting he was very unkind—reamed us out, saying, 'This is untrue—couldn't happen—you cannot leave that amount of opening—and anyway we don't have creep in our soils.' Charlie kept his cool. Subsequently they decided, over the years, that they were indeed getting creep. So this was a pioneer discovery in the Winnipeg area."

St. James and Assiniboia overpass, Perimeter Highway crossing Portage Avenue West, Winnipeg, Manitoba.
Photo: Glen Robinson

During the last half of the 1960s, Manitoba was in a period of economic expansion, and the company worked on a number of significant projects—the International Nickel Company (INCO) was completing a major expansion at Thompson, where permafrost was present; Churchill Forest Industries were building a pulp mill at The Pas; a major rock breakwater was designed by RKL and built in Lake Winnipeg; and Winnipeg was experiencing a building boom. That construction boom included the Richardson Centre, located in Lombard Place at the famous corner of Portage Avenue and Main Street. In its foundation design for the building, RKL "broke new ground" by calling for the support of the building by caissons 3 to 8.5 feet in diameter, excavated through clay and socketed into limestone bedrock 90 feet below grade, carrying loads up to 3,200 tons.

On major jobs, the new offices relied heavily on the experience of the Vancouver office. Mark Olsen, who was resident engineer for the company on both the INCO and Richardson jobs, found his time at Thompson to be nearly tumultuous:

"I was on my own and just ran scared. I went there to do two specific jobs and ended up doing eighteen different assignments. Towards the end, I called up Don Davison and Charlie Ripley and said, 'I'm coming back [to Winnipeg] next weekend with all my stuff to go over the decisions I've made, and I want you to tell me objectively how I've been making out.' That was a real eye-opener for them; I guess they must have thought that I was just about ready to crack up. Because they both met me at the airport, took me off to a good hotel, and poured a couple of drinks into me—it was all a very light evening. The next morning we got to work, and I had Charlie's undivided attention for Saturday and Sunday."

Don Davison was only too glad to have Mark Olsen supervising the Richardson Centre construction. On the project, Olsen was also assisted by John Odermatt, a technician from Vancouver who remained in the Winnipeg office and later moved to the Calgary office, becoming a valuable staff member of the Prairie operations. Odermatt also assisted with the caisson work for the Richardson Centre:

Richardson Centre, Lombard Place, Portage Avenue and Main Street, Winnipeg, Manitoba.

Caisson rigs at start of construction, summer 1967.
Photo: Hugh Allan, Winnipeg Tribune

Richardson Tower, construction nearing completion.
Photo: Ralf Lilje-Gren

"There were sixty-four of these very large-diameter caissons—large enough that you could have a dance on the bottom floor of these things. They were drilled with a rotary-type drill, using augers, through 35 feet of clay. Below this was a layer of glacial till, to 10 feet thick, with a water-bearing sand layer between the clay and the till. Then the surface of the limestone bedrock would be soft and weathered, so that the caissons had to be socketed 15 to 20 feet into sound limestone. In excavating the bottom of the hole, they used these big star bits with eight points made of sheet steel, dropping them with cranes to chop out a vertical hole. Then this would all be mucked out and cleaned, the walls would be washed off, and Mark and I would go down and inspect them. Because the foundations depended on both wall friction and end bearing for support, we would have to inspect both the walls and the socket. To accomplish this we were lowered by crane into the hole, sitting on a bosun chair—we didn't have a cage. We would just sit on the chair, with a safety harness wrapped around us and a couple of husky men at the top holding the end of the rope. Descending rapidly, the crane's cable would twist, and we could bounce off the walls."

At least sixty-four times John and Mark enacted such a hellish descent. And other caisson jobs followed, such as the University of Winnipeg's "Expansion 70" and the construction of Winnipeg's Misericordia General Hospital.

Ripley, Klohn & Leonoff Ltd. also did the foundation work on the structures built for the 1967 Pan-American Games held in Winnipeg, including the swimming pool and the velodrome. The Pan-Am Pool was an Olympic-class structure founded on 341 precast, prestressed concrete piles driven through expansive clays to refusal in glacial till. But, in general, foundation engineering in Winnipeg was less sophisticated than that necessary around Vancouver. The bulk of the Winnipeg work was done for architects and structural engineers. The local soil profile was relatively uniform, and so foundation investigations for most structures were fairly routine—often just the drilling of auger holes to discover where bedrock was located.

About the time of the company's arrival in Winnipeg, the River Protection Authority was instituted. Thereafter, anyone wishing to develop a site along the Red and Assiniboine rivers had to obtain a report evaluating the condition of the riverbank, the stabilization that would be required, and the building setback (from the river) that would be advisable. RKL became prominent in this work.[8]

In February 1966, Kenneth A. Millions joined the Winnipeg office as chief engineer. Millions had a master's degree from the University of Alberta, where he had received soil mechanics training; prior to joining the firm, he also had fourteen years of experience on building, road, and floodway projects throughout western Canada. He had held the positions of Soils Engineer, Manitoba Water Control and Conservation Branch, and Supervisor at the Canada Public Works Testing Laboratories in Banff, Alberta.[9] In September of 1968, two years after Millions's hiring, he assumed the position being relinquished by Don Davison as branch manager of the Winnipeg office. The quip that went around the office was that RKL acquired "Millions for thousands." He was an excellent engineer, who added an important dimension to the Winnipeg operation, but, concluding that his temperament was not suited to the consulting field, "Ken" resigned in July 1969 to become a teacher of civil engineering technology in Edmonton.[10]

Winnipeg is of course notorious for its cold weather. A further addition to the RKL Winnipeg staff arrived in the dead of winter in 1967; never having seen snow he was quick to comment on the harsh climatic conditions. He was a technician from Africa, in Canada under the auspices of a foreign exchange program. When he asked how best to dress for the cold and also why people wore strange coverings on their ears (earmuffs), a staff member jokingly informed him that people sometimes slip on icy

Rock-socketed caisson installation, University of Winnipeg, 1970.
Photo: John Odermatt

Pan-American Pool, Winnipeg, Manitoba.
Photo: Cyril Leonoff

sidewalks, are knocked unconscious, and before such a person comes to or is rescued, he freezes his ears, which subsequently fall off. RKL's new colleague arrived at work the following day wearing winter gear which included a leather helmet with ear flaps. Earmuffs covered the flaps, and over both helmet and earmuffs he had wrapped a scarf. "I won't lose my ears!" he exclaimed.

In August 1969, James Hunter, a Glasgow University graduate in civil engineering, joined the firm as manager of the Winnipeg office. Prior to emigration to Canada, Hunter held various engineering positions in Scotland over a fifteen-year period. While residing in Canada for three years, he had been deputy chief engineer of an Ontario consulting firm.[11] Also in 1969, Richard J. Jewell, an experienced engineer from Australia who had worked in the Vancouver office, became chief engineer in the Winnipeg office.[12] But within a short time Jewell returned to his home country to teach. Then, on June 30, 1970, Charles Ripley gave up residency in Winnipeg to return to British Columbia.

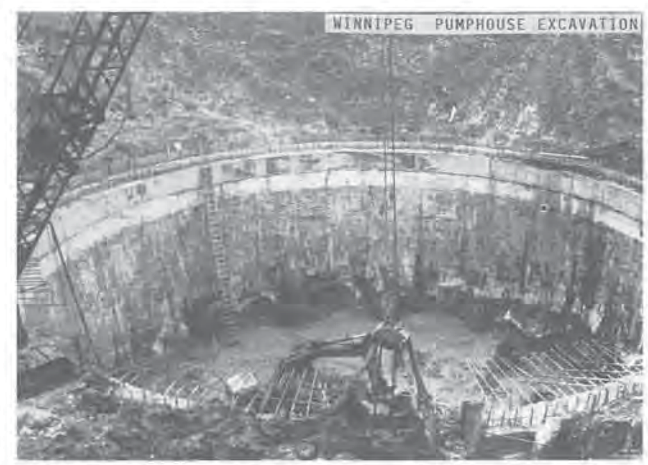
An unusually sophisticated foundation design job in 1972 was the excavation of the Pump and Grit Building at the South End Water Control Center for the city of Winnipeg and the designers W. L. Wardrop & Associates. The structure is 50 feet by 70 feet in plan, with the floor level 54 feet below ground surface, excavated through 48 feet of clay into glacial till. The diaphragm wall involved excavating a trench held open with a slurry of bentonite mud. The reinforcement steel was lowered into the trench, and the slurry was replaced with concrete. This produced a permanent circular concrete wall which did not require tie-back support. The soil contained within the walls was then excavated. A ring of grout holes was installed to seal and control the water pressure in a gravel and sand aquifer located beneath the building.[13]

In July 1976, Klohn Leonoff received a noteworthy, two-thirds-page newspaper spread under the headline, "Engineers Have Remedies for Crumbling Winnipeg Riverbanks." The story covered the firm's year-long riverbank restoration study for the city of Winnipeg, an investigation which described the condition of thirty-six city-owned sites along the Red River and identified sections in critical need of repair. In his report, James Hunter recommended a number of possible methods of bank stabilization: replacement of clay at the toe of the slope with sands and gravels; placement of a riprap blanket of large limestone rocks between the summer water level and the winter ice level; installation of a pile retaining wall; and flattening of the riverbank slope.[14] These assorted treatments proved variously applicable to the different riverbank sites.

At its maximum the Winnipeg office employed a dozen people. Its geographic range of business extended from Manitoba to Saskatchewan, northern Ontario, and the Lakehead. Other people who served the office well over its years of operation included engineers Alex Kuluk, Paul Janzen, Adrian Wightman, and Steve Ahlfield, technician Ed Nyczai, and secretaries-bookkeepers Chris Andrusiak and Elsie Leknes. Upon Jim Hunter's resignation, after fifteen years of operation, the office closed on October 31, 1979.[15]

Looking back on the Winnipeg operation, Don Davison can see that the firm had, at best, a limited opportunity in Manitoba:

"It was a big move for the company in those days, and our first experience in opening up a branch office. At the beginning we had some major industrial projects and some large buildings. But Manitoba goes through periods where there is little or no development occurring in the province. After Charlie and I departed, most of the work seemed to be just routine foundation investigations. That type of business does not fit the quality of engineering that our company offers, and it's difficult to keep engineers interested in the work. And, to make money, you have to have a reasonable-sized operation. We made a few dollars when we had significant projects happening in the North, but thereafter it was marginal."



Pump and Grit Building, South End Water Control Center, city of Winnipeg, 1972.

Red River bank stabilization, Winnipeg, Manitoba.
Photos: John Odermatt

Eroded bank before stabilization, April 1976.

After remediation, October 1977.

Alberta

Following its expansion into Manitoba, the company next looked towards Alberta for further business opportunities. Alberta was the neighbouring province and, second only to British Columbia, its resource base offered the best prospects in western Canada for soil mechanics work. As well, both Calgary and Edmonton were experiencing accelerating urban expansions that were rapidly making them the leading Prairie cities.

However, the move was not to be accomplished so easily as it first may have seemed. Whereas the move to Winnipeg filled an immediate consulting void in the soil mechanics field in Manitoba, in Alberta there was considerable established competition. Foremost was the firm of Hardy and Associates, headquartered in Edmonton. But there were also a number of other small, resident materials and soils testing firms, as well as several companies based outside the province, already offering their services in Alberta.

The choice of Calgary rather than Edmonton for the site of the new office was predicated in most part on the upcoming construction of the city's new freeway system (which would call for a large volume of soil, asphalt, and concrete testing), proposed irrigation dam projects in the southern dry-belt, and oil and gas pipeline explorations ongoing in the North (an industry by and large based in Calgary). The office was opened on July 15, 1966, and, as with the move to Winnipeg, the company looked within, to its Vancouver staff, in order to find the logical management team. David Bruce Campbell was appointed manager and A. Bruce Hamilton, chief engineer.[16]

Campbell, a graduate of the University of Alberta, had joined the Vancouver office in the mid-1950s, obtaining considerable experience with the company on foundations, as well as in the construction of earth dams. Sponsored by the company, in 1958–59 he had completed a master's degree in soil mechanics at the University of Illinois, under Dr. Ralph Peck. After returning from his post-graduate studies, Campbell rose to the position of chief engineer of the Vancouver office.

Bruce Hamilton had graduated in civil engineering from the University of Manitoba, then gone on to complete a master's degree, specializing in soil mechanics, at the University of Alberta. Prior to joining the company's Vancouver office in April 1966, he had eight years of experience with road and building projects across western Canada and the Northwest Territories, first as a highway research engineer with the Alberta Research Council, and then for six years as supervisor of the Canada Public Works testing laboratories at Banff, Alberta.

Establishing a business in a new region is always difficult, and, not unexpectedly, the Calgary office struggled initially. One significant assignment that boosted the office work load was the Consolidated Mining and Smelting Company's (COMINCO) new iron mine at Pine Point, Northwest Territories, on the south shore of Great Slave Lake. This job had originated in the Vancouver office, where Cyril Leonoff operated as the foundation consultant to COMINCO in their Kootenay (and other) developments (Chapter 7). The project was farmed out to the Calgary office in order to boost Calgary's work load and because of that office's closer geographic proximity to the work site. As well, back in Vancouver, Leonoff was becoming increasingly involved in management duties.

Both Campbell and Hamilton were good engineers. However, as time went on, they found that the realities of establishing, promoting, and managing a new consulting engineering office were not entirely to their liking. Consequently, in 1967, Hamilton resigned from the company to take a faculty position with the then newly opened University of Calgary.

Early in 1968, the company was presented with a new opportunity to increase the scope, geographic area, and volume of work needed to make it's Alberta operation more viable. Dr. Elmer W. Brooker, a soil mechanics engineer who had spent some time on the civil engineering staff of the University of Alberta, in 1966 had opened a consulting practice in Edmonton under the name of Whitmore and Associates.[17] The potential benefits of a merger of the two operations seemed evident. With offices in the two principal Alberta cities, a new company would be better positioned to challenge established competitors like the Hardy organization. As well, the addition of Brooker would provide the firm with a man of considerable engineering training and a native Edmontonian whose energy and extroverted personality would add considerable business development skill to RKL's stagnating Alberta operation. In turn, Ripley, Klohn & Leonoff would offer Brooker the opportunity to employ his abilities in an established engineering organization of greater scope.

The result was that Leonoff and Brooker negotiated the formation of Ripley, Klohn, Leonoff & Brooker Ltd. (RKLB)[18] "to provide soil mechanics and foundation engineering services throughout the province of Alberta, commencing May 1, 1968."[19] This company was owned on a fifty-fifty basis by Whitmore & Associates Ltd. and Ripley, Klohn & Leonoff International Ltd., then RKL's operating company. Elmer W. Brooker was elected president, David B. Campbell vice-president, and Cyril E. Leonoff secretary-treasurer of RKLB.[20] On August 12 of that same year, Contec Construction Technology Ltd. (CONTEC) was incorporated in Alberta[21] as an associated company of RKLB in order to carry out routine materials testing functions separate from the consulting engineering practice. Since CONTEC's competitors also offered concrete testing services, an affiliation was arranged with Gordon W. Spratt and Leslie W. Russell of Spratt Russell Laboratories Ltd., concrete specialists in Vancouver, to provide consulting expertise in this field.[22] Members of their firm also sat on the board of CONTEC.

Almost from the beginning, the marriage of Ripley, Klohn, Leonoff, and Brooker proved to be a misfit. Brooker valued his independence too much to be satisfied with the constraints imposed upon him by his new associates. On the other hand, Ripley, Klohn & Leonoff required a team player to fit in well with the overall planning of their operations. Additionally, frictions developed between Brooker running the Edmonton office and Campbell in charge of the Calgary office. Consequently, on October 30, 1968, David Campbell resigned as an officer, director, and employee of RKLB.[23] (Campbell went on to continue his substantive engineering career in the Vancouver office of a national Canadian geotechnical firm.)[24] And, effective December 31, 1968, a severance agreement and separation of assets was worked out with E. W. Brooker,[25] who, effective January 15, 1969, resigned as president and director of RKLB and CONTEC.[26]

These severances necessitated a complete reorganization of the company's operations in Alberta. The name RKLB was changed to Ripley, Klohn & Leonoff Alberta Ltd.[27] In January 1972, RKLA and CONTEC were dissolved and the assets sold to Ripley, Klohn & Leonoff International Ltd., who registered in Alberta.[28] The name of CONTEC was retained as a division of RKLI.

Taichi "Jack" Fujino, a Japanese-Canadian, had been hired by CONTEC Ltd. in September 1968 to take charge of the company's materials testing facilities in Calgary. He came with experience from another testing company located in Calgary. In the severance agreement with his previous employer, he had also acquired concrete testing equipment, and, at the time of his hiring, this equipment valued at $8,000 was acquired by CONTEC in a lease-purchase agreement.[29] Fujino and his technician Terry Haigh competently handled the testing work of CONTEC until Fujino's resignation in October 1972.[30]

In the meantime, Don Davison had left Winnipeg to work in Vancouver on the implementation of a new accounting-invoicing system. With the problems arising in Alberta and with his previous management experience, he seemed the obvious choice for assignment to the Calgary office. But Davison was reluctant, initially saying no—one of the few times he was ever to refuse a company request. But the company's Vancouver principals continued to press him, matters only got worse in Alberta, and eventually Don agreed to go on a temporary basis. He arrived in Calgary in early December of 1968.[31] Don's temporary assignment became permanent in January 1969, and he was to remain as head of the Alberta operations for twenty-one years until his retirement in 1990.

Nevertheless, Davison remembers his initial experience in Calgary as "extremely trying":

"It was becoming very obvious to everyone that we couldn't operate with Elmer Brooker. He was attempting to virtually run the Alberta operation, 'calling all the shots.' I think I was sent there in order to make sure that he was not taking over. Maybe he had succeeded [in doing so] with Dave, but he didn't with me. Then the decision was made to split up. He took the Edmonton office and we retained the Calgary office, which is what we had originally.

"The office was in one of the old buildings downtown. At that time, we had very little business—the business was virtually gone. CONTEC had the materials testing equipment in a credit union building on Fifteenth Street. In order to cut costs, we moved the office out to the same place. There were five of us—myself and Ken Gillespie, Jack Fujino and Terry Haigh of CONTEC, and one girl. I came there in the worst winter they had for quite some time. I remember that because we nearly froze to death. They kept saying that there were going to be chinooks, but there never were. We were in an old shed area. There was practically no heating, and I recall placing our feet up on boxes to keep them off the concrete floor. We got out of there fairly fast." On March 1, 1969, 3,800 square feet of office space were leased at 140 First Avenue S.W. in downtown Calgary, near the Centre Street Bridge.

Two other men who came to the company during this transition period were, like Don Davison, to make a lasting impression on the company. The first was "Ken" Gillespie, who was acquainted with Bruce Hamilton and who started work in the Calgary office in March 1967. Ken recalls that, during his early years with RKL Alberta Ltd., there were "a lot of small foundation jobs—that seemed to be the norm." At times, in his first year with the firm, Ken "wasn't that busy" and "wasn't in Calgary that much." Instead he spent the summer working for Mark Olsen at Brenda Mines in the Okanagan and later worked on several bridges on the Alaska Highway for Charlie Ripley.

Kenneth Gillespie

Kenneth R. Gillespie's family history, and his civil engineering background in particular, are rather colourful, if not downright adventurous. The Gillespie family came to settle in the Moncton region of New Brunswick as part of the large Irish immigration in the mid-nineteenth century. Ken's grandmother went to school together, on the same horse, with R. B. Bennett, and the story is told that she correctly predicted that he would be prime minister of Canada. After finishing high school, Ken's father worked on the railway, but, at the height of the Great Depression, became a civil servant with the Federal Penitentiary Service at Dorchester, New Brunswick, where he remained for twenty years. Ken, the oldest of eight children, recalls Dorchester as "a small town, maybe 1,000 people, about thirty miles from Moncton, at the head of the Bay of Fundy." While it was small, the town was not without a long history:

"It was a very old town and I can always remember, as a kid, these great big timber houses that we lived in—three or four storeys with about twenty rooms. The rents were something like ten or fifteen dollars a month. It had been quite a seafaring and boat construction area, so all of these old homes were built 100 or 150 years ago by the sea captains and shipbuilders who built wooden ships down the river."

Ken finished high school in 1943, in the middle of the Second World War, and upon graduation found that "there wasn't much to do." So he joined the army at the age of eighteen, discovering that "the only people they were looking for were foot soldiers for the infantry corps." But instead of getting the action he desired, Ken spent the next two years as an infantry instructor in the Maritime provinces. After the war he took three years of pre-engineering studies at St. Francis Xavier University in Antigonish, Nova Scotia. Ken freely admits that he had "no burning desire to be an engineer" at the time but, when he entered the university, he "happened to know one of the professors who taught engineering." Ken went to visit this professor, who immediately impressed upon him the fact that Canada was going to need engineers in the coming decades. "So I considered it," adds Ken, "and went into engineering." Two of his younger brothers followed him into engineering careers, and thus the Gillespie family did their part in filling the post-war engineering demand anticipated by the professor. Ken completed his engineering degree by spending two years at Nova Scotia Technical College in Halifax:

"I can't remember any course work in soils or compaction or anything like that. It was essentially structural. There was something on road and highway design, but there was never any mention of what you used to build the roads. So my basic education in geotechnical was pretty limited."

After graduation in 1950, Gillespie was to resume his military career, spending eight varied and interesting years in the Corps of Royal Canadian Engineers (RCE):

"I felt that I'd been in the army during the war for two years and never really seen much of the country. At that time the Korean War was on, and they were recruiting around the universities. So I joined the army and promptly came out to the Royal Canadian School of Military Engineering at Chilliwack, B.C. and never did get to Korea."

Gillespie trained at the Chilliwack engineering base for a year, then was "shipped up" to Whitehorse for a two-year stint serving in what was called the No. 1 Road Maintenance Company, RCE, comprised of about one hundred soldiers. This company was maintaining the Alaska Highway at the time, and Ken first worked as troop commander in the northern Yukon on the construction of a highway bridge composed of eight 200-foot steel spans. After completion of this bridge, he was stationed in Whitehorse as the Corps' bridge engineer: "We used to inspect and maintain all the hundreds of bridges on the Alaska Highway, from little short timber bridges to large metal structures."

Following his Yukon posting, Gillespie was sent to take the Long Survey Course in the British School of Military Survey:

"I had not expressed any particular desire about the course. It came up and the fellow who was supposed to go was injured in an accident. They looked for somebody else and said, 'Gillespie you can go; you're single.' So I said, 'Sure I'll go to England for a year.' "

It was an intensive course in map-making, consisting of geodetic surveying, production of stereo maps, as well as the study of air photography, and Ken was the only Canadian in a class of twenty students.

After completing this course, Gillespie was posted for three years to the Army Survey Establishment in Ottawa, working with the Department of Mines and Technical Surveys on the preparation of maps. His first summer there was spent mapping in the Mackenzie Valley in the Arctic, heading up a helicopter party that was supported by a light float plane. The next summer he did similar work around Kapuskasing in northern Ontario. Then the Suez-Sinai War between Egypt and Israel (joined by Britain and France) erupted in November 1956, and a United Nations Emergency Force (UNEF) was dispatched to the Middle East. The force was commanded by the Canadian Lieutenant-General E. L. M. Burns, with headquarters in the Gaza Strip. Burns had directed the Mapping Branch in Ottawa, and he wanted a survey officer to mark the Armistice Demarcation Line in the Gaza Strip.[32] Gillespie arrived in February 1957 to take on this task for fifteen months. While Ken didn't deal directly with Burns, he reported to him periodically, "so he'd have first-hand information about what went on there."

As Gillespie tells the story, surveying the boundary line was no mean feat:

"The boundary consisted of a ditch that was dug two feet deep into the ground. Whereas it was supposed to be a straight line, it had a habit of meandering laterally back and forth. One day it would be around this particular geographic feature that the Palestinian army controlled; the next night it would be around one that the Israeli army controlled. We'd do all the traversing during the day, then we'd go out at night and make star shots to try and fix the points. We'd bury a great big barrel—a forty-five-gallon oil drum—in the sand and put a flag on it. That was supposed to be the border marker. But these things would have the habit of suddenly disappearing—one day it would be there; the next day it would be gone. So it was a pretty futile effort.

"And it wasn't much fun. We would get shot at the odd time, particularly when we started doing the survey down in the Sinai Desert, which is quite isolated. We would tell the Israelis we were going to be there, and they would always be on hand with a platoon of soldiers, which was comforting. The Arabs, on the other hand, wouldn't have a clue about what we were doing. The minute anybody got near the border, they would start shooting at them, regardless of what uniform they wore. There were also a lot of mines in the area, and at the time, the Egyptian army's method of clearing a mine field was to use camels and women. The women would drive the camels through the mine field and, hopefully, that would detonate the mines. Females in that part of the world didn't hold much value, and unfortunately this method sacrificed a lot of women and children."

Gillespie returned to Canada and, since he was "getting a bit tired running around the country," retired in December 1958, with the rank of captain. In retrospect, how does Ken regard his army career? "To make a career of the army you have to be totally committed. I didn't feel that I wanted to be a full-time soldier, so this was why I got out. But it gave me an appreciation for the services and an opportunity to see a bit of the world. At the time, I knew everything that could be known about surveying. But I wanted to do something more along civil engineering lines."

Gillespie next went to work for the Canada Public Works Department at Banff, on a section of park highway near the Columbia Ice Fields: "We did the design and construction of about forty miles of highway. This ranged from the basic survey and route location to the eventual construction of the road. It was difficult construction country—steep terrain, rock, lots of water and ice."

Afterwards he spent six months with the department inspecting piles for a forest research lab in Victoria, B.C. This job piqued Ken's interest in foundations, and so in 1964 he enrolled in the master's program at the University of Alberta, specializing in soil mechanics and highway engineering. When he returned to the department, the work in Banff park was winding down. Looking elsewhere for work, in 1967 Gillespie obtained employment with a consulting firm headed by Reg Thurber, supervising the geotechnical work on 100 miles of the Alberta Resources Railway in the Grande Prairie region. However, Thurber was killed in a plane crash in January 1968 and the work ended. After this job Gillespie came to work for Ripley, Klohn & Leonoff where he was to spend the remainder of his career, retiring in 1990.

Over those years with the company, Ken Gillespie proved to be a model engineer who, with his extensive civil engineering experience, became a reliable and valuable asset to the company's Alberta operations. Ken himself has succinctly summed up his particular value to the company in saying that, "I don't consider myself an engineer who really knows a whole lot of the theoretical aspects of geotechnical. I consider myself to be more practical, and I have always really enjoyed getting out doing the work rather than sitting in the office writing reports."

Following the separation with Brooker, RKL began an active search for a candidate who could manage an Edmonton office, and the problem was resolved by a chance airport conversation between Charlie Ripley and Scipio ("Skip") Merler, a well-known materials engineer. Merler suggested that Earl Speer, then living in Edmonton, might be a suitable candidate. Speer was duly interviewed in Calgary and Vancouver. An extant memorandum from C. E. Leonoff indicates the favourable impression that Speer was able to make in those interviews: "Earl Speer phoned me today [saying] that he will join our staff. . . . This is good news."[33] Thus Leonoff presciently commented on the man who was to be a key factor in the progress of the company and would eventually succeed him as executive vice-president. Earl Wesley Speer joined the Alberta company in May 1969. In June 1969, an Edmonton office of Ripley, Klohn & Leonoff Alberta Ltd. was opened, and Speer became its manager in August.[34]

Sea-Captain William Speer arrived in Montreal in the year 1765, from Letterkenny, Donegal County, Ireland. Following his arrival, he took up a homestead near Lindsay, Ontario. Land in Ontario became scarce for succeeding generations, so many of the settlers' offspring looked to western Canada, where vast farmlands were being opened up for settlement in the last three decades of the nineteenth century. In the 1870s, the CPR transcontinental railway had not yet been built, so members of the Speer family departed for the Prairies in a covered wagon, travelling through the United States, then north down the Red River to Fort Garry. They took up homesteads in the Birds Hill-Moose Nose region, northeast of Winnipeg. Unfortunately, for these farm folk, the large gravel ridge they settled on was too stony to farm properly. In fact the property was to become the site of the principal gravel pits supplying construction materials for the Winnipeg area, much to the family's later chagrin. There were no geotechnical engineers in the family at that time, and, as Earl describes the scenario:

"My family owned all those gravel pits. But, being farmers, they said, 'That land is no good for anything.' So the CPR land man came along and bought the whole ridge for five hundred dollars. Millions and millions of dollars worth of materials have been taken out of there since. My aunt has told me that I should have been born with a silver spoon in my mouth; however I certainly wasn't."

On his mother's side, the Huguenot Folliotts came over to England during the Protestant Reformation in order to escape persecution in France. According to Speer:

"My great-grandfather William Folliott was quite a famous artist and weaver and, indeed, had designed gowns for Queen Victoria. He won many awards for tapestries and wall hangings. Some of these still hang in Windsor Castle[35]. In our house, we have some watercolour and oil paintings of flowers that he made. My grandfather Thomas Folliott came to Canada when the Riel Rebellion was under way and was recruited to fight in the rebellion. He stayed in Manitoba to homestead and ended up nearby Oakbank, where my mother and father met."

Earl Speer's parents lived on the homestead until 1943. In fact, Earl was born in the same house in which his father was born. Like Ian Morrison, Earl attended the legendary one-room country schoolhouse. When he was thirteen, the family moved to Agassiz, British Columbia, where Thomas Wesley Speer took a position in the Agronomy Section of the Dominion Experimental Farm, staying there for twenty-three years until his retirement. He had some university training in agronomy, and, being an experienced farmer, he grew various varieties of wheat and other grains for the experimental farm.

In moving to British Columbia as a boy and coming straight off an isolated farm, Earl discovered a world rather foreign to his background. Even the small town of Agassiz was a new experience. Earl and his older brother were never really accepted "into the crowd," and, almost immediately, the brothers sought out directions separate from their father's agricultural profession. "As kids," explains Earl, "of course we were required to do work on the farm—milk cows and shovel this and that. I had had enough of that and wanted to stay as far away from cows and growing things as possible." The brothers got involved in flying, and Earl started his lessons at the age of seventeen. Perhaps the brothers were influenced by the memory of an uncle, a pilot who was killed in the First World War. Earl's brother went on to become a commercial airlines pilot, flying for Air Canada.

Like Ken Gillespie, Speer remembers no "burning desire" to be an engineer. According to Earl, "it just sort of happened." More precisely, the reason he went into engineering was because, in 1949–50, with the return of so many war-time pilots to Canada, experienced flyers were "a dime a dozen."

"I was going for my commercial license," recalls Earl, "and my instructor in Chilliwack said, 'Why don't you take a year of engineering and then come back?' And once I had an investment in engineering I decided to continue on. I don't regret that, mind you. But I flew quite a bit after that—just for fun. The last time I personally flew was in Edmonton when we opened the office. Following that I had enough of flying in the Arctic."

Speer enrolled at UBC in 1949, taking a year of Arts, the equivalent of grade thirteen, which was required for acceptance into engineering. Then he took a year off in order to earn some money. Initially, Earl had planned to go into mining engineering, but after working underground in a mine during his year off, when he returned to university, Earl switched to civil. He married while at university, then took another year off between third and fourth years' engineering, again in order to earn enough money to continue. Coming from a farm family who had suffered through the Depression, Earl had little in the way of family financial resources to draw upon:

"We didn't have a whole lot of money behind us, that's for sure. I had no assistance from my parents, other than maybe a few muffins once in a while, and so I borrowed money [for my education], like a lot of other people did. We figured it took us ten years to pay back the government loans. Instead of buying furniture and refrigerators, we were always paying off the loans."

Speer spent his second year-long sabbatical, along with his wife, Evelyn, in the Yukon, working on improvements to the Northwest Highway System—straightening the road, rerouting, stabilizing slides, and bridges. Most of this was geotechnical work under Stan Thompson and Bob Hardy of the University of Alberta, and it amounted to Speer's first exposure to soil mechanics problems. (Soil mechanics courses were just being initiated at UBC at the time, under Bob Spence.)

After his graduation from UBC in 1956, Speer went to work for two years with Ontario Hydro on the St. Lawrence Power Project, engaged on the construction aspects of a concrete gravity dam. On the project, he was involved in lift drawings—construction drawings showing the embedded parts, such as the water stops, built into the structure. Thirty years later, when Klohn Leonoff engineered the Ok Menga hydroelectric project in Papua New Guinea, the client asked for lift drawings. Says Speer, "Not many people in the office knew what a lift drawing is—at least I knew. The point is that you can often draw on experience from a long time back, experience that you never thought you would ever use again."

Following the St. Lawrence project, Speer spent six years with the PFRA on the South Saskatchewan River dam project, working mostly on concrete construction and on sulphate problems with Dr. Thorbergun Thorbaldson of the University of Saskatchewan. During this period, he also took post-graduate courses in soil mechanics at the university, working on his studies at nights and on weekends. But he couldn't afford to take time off from work to complete a thesis. Eventually, Earl had to make a decision faced by many engineers on their career path—to work either in design, construction, or management:

"When I look back now, sometimes I wonder whether it would have been better to stay with the technical side. But I'm not an intense and detailed enough person like, for example, Ian Morrison. I really enjoyed construction, because you could see things built, and I do have a handle on that sort of thing. As well, with both Ontario Hydro and PFRA, I realized that I didn't fit into the civil service mentality. And I could see on construction that we were driven by the private sector—by the contractor. So I consciously went out to find [work within a] private enterprise. I had some notion that the management route would get you to the top faster, and I was ambitious to get into such a position. I was not trained and had no experience whatsoever in management. But I was able to get into the role essentially by default, because there weren't many engineers around with any management experience."

Speer obtained employment managing the Alberta operations of Warnock Hersey International Limited, a huge Montreal-based materials testing company having two to three thousand employees. Part of this time, Earl worked as manager of engineering in their Coast-Eldridge Division in Vancouver, under Scipio Merler, the man Charlie Ripley had happened to meet in the airport in 1969. The Coast-Eldridge office, at the time, was doing extensive work on the Portage Mountain Dam project and had 400 employees. As it turned out, Earl's transition from Warnock Hersey to RKL was indeed timely: "Skip was a good friend and was looking out for me. I wasn't looking for a new job when he recommended me to Charlie, but their [Warnock Hersey's] management was very bad, and they were starting to falter. It turned out that, three months after I departed, the whole thing went down the drain. So it was an opportune time to leave, but of course I didn't know that was going to happen."

Saskatchewan

Following the opening of Ripley, Klohn & Leonoff Ltd.'s Winnipeg office, the company obtained the occasional job in both Regina and Saskatoon. Ben Torchinsky, a master's graduate of the University of Alberta who in 1949 became an assistant professor at the University of Saskatchewan, was the only soil mechanics consultant active in Saskatchewan, but he became involved in various other enterprises which diverted his attention away from consulting engineering.[36] Paul Kozicki was managing Torchinsky's Regina office, and RKL was familiar with the Kozicki family because Paul's twin brother, Peter, had worked for a time in RKL's Vancouver office. (The twin brothers are native sons of Saskatchewan where the family has large farm holdings near Kindersley.) But Peter had left RKL to manage Torchinsky's pile-driving company in Toronto. Then, in 1969, Torchinsky closed his Regina office and Paul Kozicki found himself out of a job. Consequently, Paul approached RKL to enquire if they would be interested in opening a Saskatchewan office.

The rationale was that Saskatchewan had embarked on a major highway expansion program of the "farm to market" grid roads throughout the province. The Saskatchewan Highways Department had a small but competent soil mechanics section (headed by Barry Mickleborough), whose administrators were appreciative of the soil and stability problems indigenous to Saskatchewan, and they were letting out consulting contracts to specialists. Dr. E. Karl Sauer, a highway specialist at the University of Saskatchewan, with a background in soil mechanics and aerial photographic interpretation, was one of their principal consultants on slope stability and bridge approaches—particular problems in Saskatchewan. And Sauer required a soil mechanics organization to work with him on these projects.

As a result, in the fall of 1969, RKL opened a small office in Regina, managed by Paul Kozicki, with Karl Sauer and Del G. Fredlund, soil mechanics professor at the University of Saskatchewan, acting as consultants. A number of highway projects were carried out by this office, as well as several other small foundation jobs. But, in 1971, following the election of an NDP government, the highway program was greatly curtailed. Thereafter there was not enough work to justify maintaining the Regina office, and it was closed at the end of 1971.[37] Kozicki continued to practice on his own under the name of Ground Engineering. A lease-purchase arrangement was worked out with him on the office and laboratory equipment, and a liaison was maintained with Kozicki until May 1973.[38]

With the benefit of hindsight, Earle Klohn now sees the company's expansion binge in the Prairies as somewhat misguided:

"All the engineering companies were opening offices in these little towns, and everyone thought that was great. It was the thing to do in those days. I probably promoted it as strongly as anybody. The problem was that we had no co-ordination. We had managers in Vancouver, Calgary, Edmonton, Regina, and Winnipeg, but as I recall none of these people really got together and co-ordinated their efforts. There would be telephone calls and screams for help when they needed staff for something. I never knew what Winnipeg was doing, and I suppose Winnipeg had a very loose arrangement of management of those various offices. My conclusion was then, and still is, that you are far better off to have one, possibly two, major offices, like the airlines are doing, at the central hub of the wheel. Having things spread out all over hell just doesn't work worth a darn."

Chapter Nine

A NEW REGIME

In 1968 Ripley Klohn & Leonoff convened the first of a series of five annual meetings that were to change the face of the company. Attending were RKL's key personnel—the managers and chief engineers from each office. This was a critical gathering designed to provide the first co-ordinated management, develop operating policies, and define new directions that the company would pursue over the next two decades. These meetings would also witness a change in leadership.

The first annual meeting, attended by nine persons, was held as a getaway at the Harrison Hot Springs Hotel from February 8 through 10, 1968. The agenda and minutes show that a total of five sessions were held over two and a half days, each chaired by a different person, and that these sessions included a comprehensive review and group discussion on all facets of the company's operation. The last half day, on Saturday, was devoted to a general discussion by everyone and a wrap-up by the president.[1]

In retrospect it's apparent that this first of what has grown into a routine plethora of annual general, directors', corporate, management, and committee meetings was a chance for everyone to express their personal frustrations—to air the problems of a company growing in volume of work, number of staff, and geographical territory. Many problems were raised and few ready answers were forthcoming. However, it should have been expected that many meetings would be required to provide solutions to nagging problems and to formulate the firm policies needed to direct a mature company.

Most significantly the meeting brought to the table a simmering dichotomy among the principals that would have to be resolved if the company was to have a viable future. Earle Klohn, in his assessment, saw new directions as something imperative for the firm:

"It was a meeting to try to assess where we were, where we were going, and how we were going to get there. People got up and expressed strong opinions on what they thought; I had a whole bunch of opportunities that I thought we should be pursuing, but nothing really got settled. Everybody was confused, the meeting was kind of chaotic, and I certainly came away frustrated. It was the first time that we ever had an open forum with everybody around, where Charlie expressed his opinions, and I expressed mine. It was pretty obvious that the two of us weren't on the same route, and this probably added to the confusion."

Charles Ripley, on the other hand, felt that the company should be hesitant in abandoning what had been its chief route to success thus far:

"We brought in the manager and the chief engineer from each office. It was a very democratic procedure, and everybody aired his view of the problems that we had and contributed ideas as to the direction to go. And I recall at that meeting that Earle did raise the point there that he felt that a significant change in direction was needed from the point of view of going after project work rather than being continually subconsultants. And I had some serious reservations about that.

"The philosophy that I had in starting out and carried through until I left the firm in 1970, was to provide specialist service in the geotechnical field in a subconsultant position to the project engineers. And in that period, while we had various good times and hard times, I think we were reasonably successful in doing that. We understood very well the disadvantages of being a subconsultant, and it bothered us on some of the larger projects that, while we were involved in the most difficult phase, our work was nevertheless controlled by other companies.

"But [at that time] I was in the Prairie region, following a period of serious economic downturn, in order to spread out the base from which we could derive work. This was almost like starting over again, to develop the confidence of clients, as I had when I first came out to Vancouver. And we were reasonably successful for a period of years in getting work in the Prairie region. In the branch offices in the Prairies most of our clients were project engineering companies. And if out of Vancouver we suddenly appeared


Annual Meeting, Banff Springs Hotel, Alberta, January 16, 1970; from left: front, Donald Davison, Earle Klohn, James Hunter; back, Mark Olsen, Paul Kozicki, Earl Speer.
Photo: Cyril Leonoff


Directors' Meeting, Richmond, B.C., January 22, 1977; from left: front, Donald Davison, Raymond Benson, Earle Klohn, Ian Morrison; back, Robert Melling, Earl Speer, James Hunter, Cyril Leonoff, Mark Olsen.
Photo: Bob Dibble, Croton Studios


Board of Directors, Vancouver, B.C., September 24, 1991, from left: Earl Speer, John Burrows, Douglas Watts, Earle Klohn, Raymond Benson, Cyril Leonoff.
Photo: Stephn L. Manzi, Ad-Vision Graphics

the late 1980s: "The reason I did that was out of a sense of obligation to the clients because I felt that it was important that my knowledge still be available to them."

The stamp of an organization comes from the top down. And, despite all the changes, the growth pattern that was set for the firm in its early years continues today. One of the aspects of this evolution that has pleased Charlie, since his retirement, is the continued emphasis on the hiring of "people with a very high calibre of technical capacity." Adds Charlie, "While I don't have firm facts, my guess is that the company has the highest percentage of engineers with graduate degrees of any of the civil consulting firms in Canada." Other aspects of the permanent legacy that Charles Ripley left to Klohn Leonoff Ltd. are generally agreed to be dedication, integrity, technical excellence, and unpretentiousness. Earle Klohn, in summing up Charles's contribution to the company, has recognized both strength and weakness:

"He was an excellent engineer. Perhaps he was too concerned about details, but he was theoretically correct and very perceptive. His prime interest was engineering. He was less interested in management. The delegation of final decisions to others upset him."

"Yet," responds Leonoff, "he did delegate the work to Klohn and myself and saw to it that we were his natural heirs in the company. Certainly whatever I learned about practical engineering and the running of a consulting practice originated with him. And the transition from his regime to ours was remarkably smooth. Basically Charlie was a modest person, but in his work he could be arrogant and would suffer no fools. And he was demanding. Sure we worked too hard and long—spending sixty to seventy hours, seven days a week, at the sacrifice of our personal lives and our families. I am still occasionally reminded of that at home. Yet I valued the relationship with Charlie and still do. We were a good team."

Bill Richards found that "Charlie was always so enthusiastic and interested and very, very intense." And Dick Read recalls in particular Charlie's idealism and modesty: "Well, I liked working for Ripley, Klohn & Leonoff. I wanted to work for a company that was really idealistic. Times were hard for my wife and myself. But I said to her, 'Look, the principals work like dogs trying to keep this firm going. They all live very modestly and don't put on a big show of being principals of a consulting engineering company.' "

As it is with most people, Charlie's greatest asset sometimes led to his greatest liability. His profound interest in integrity and quality contributed to what some employees believe was a certain lack of business acumen. "In retrospect," comments Dick Read, "maybe we didn't have enough entrepreneurship." Don Davison concurs, in part: "Charlie's attitude was that if you were king, then the work should come to you because you are so good. And I really think he got disturbed that that wasn't the way the world was." Lars Anderson has a more positive conclusion: "The thing that impressed me and has always remained with me was the integrity of the company. I do know that the reports and opinions of the company were not always popular with our clients. But the company would never back down from these opinions. There was never any cheapskating—the quality was the ultimate you could obtain."

Bob Maartman when speaking of Charlie confirms that, "He was very forthright—he would tell it the way it was. Of course Charlie was a student of Terzaghi, and Terzaghi was that way too."

When Charles Ripley left his company, he was looking for "something out in the world beyond what [he] was doing." And beginning in 1971, through to 1976, he did not take on any engineering assignments and did not intend to become involved in engineering ever again. He took courses in accounting and economics at the University of Victoria. And he guided the management of the family farm in Saskatchewan through a time of great changes in farming practice.

But then, in August of 1976, Ripley received a telephone call from the Controller of Water Rights office in British Columbia, asking him to review the stability of the Downie Slide in the wall of the proposed Revelstoke reservoir. (The Revelstoke power project on the Columbia River is comprised of a 500-foot-high concrete spillway and earth dam, on which Ray Benson and Earle Klohn were specialist consultants—Ray on the rock and Earle on the soil.) Charlie was intrigued:

"I would have automatically said no, except this slide triggered my imagination because of its monumental size—one of the largest landslides known—so I accepted the assignment. And I carried on work with them from 1976 to the end of 1985 as a reviewer of major projects in B.C. with regards to safety. It opened up a new phase in my life. I spent a lot of time visiting projects and going to conferences, re-acquainting myself with practices relating to the dams that I was reviewing. And having the time to think and study to a degree that I had not ever had before was very enjoyable. I really did my best work in those ten years."

Once again, in 1985, Ripley had to make a difficult decision between continuing work and retiring from active practice. The work available to him was "perhaps more fascinating than anything in the previous ten years" and related to the rehabilitation of dams in the province to meet current standards of earthquake design. After considerable pondering, however, Charlie decided that, "There were many other things that I wanted to do in whatever time I have left, so I decided that I would retire from engineering completely, and I have lived up to that since." Well, almost. In April 1989, Charlie was asked to undertake a Cross Canada Lecture Tour for the Canadian Geotechnical Society (CGS)[3]:

"I was delighted to do that because I felt that I had a message that needed to be given [related to seepage and filters in dams]. That was a pretty rigorous trip physically, involving ten cities with two lectures in each city, in a very short period. But it was a wonderful opportunity to travel across the country to meet old friends and make new friends."

In October of 1987, in recognition by his peers of his "achievements and contributions to the geotechnical field in Canada," Charles F. Ripley was given the R. F. Legget Award of the CGS.[4] Says Charlie, reinforcing the perception that has held him in such high regard for so many years: "It's a nice gesture by the society. But you probably know that I don't place much emphasis on these kinds of things."

As of January 1970, Ripley, Klohn & Leonoff International Ltd. had sixty employees in six separate offices (including CONTEC) scattered across western Canada (Appendix II). That month the following memorandum was issued, to the attention of all those staff members:

"The following announcement, which will appear in the press next week,[5] is for your prior information:

"Ripley, Klohn and Leonoff International Ltd., Soil Mechanics and Foundation Engineers, announces the following corporate changes, which became effective on January 1, 1970.

"Earle J. Klohn is the new President of the company, Cyril E. Leonoff is Executive Vice-President, and Charles F. Ripley is Senior Consultant.

"In his new capacity, Mr. Ripley will provide specialist engineering services exclusively to all offices of the company in Canada and abroad. . . .

"Our new President Earle Klohn brings to this office twenty years of widespread engineering and administrative experience, keen enthusiasm, an optimistic outlook, and unbounded energy. I am certain that as president he will serve our company well in its expanding operations in Canada and abroad.

"Mr. Klohn's duties will involve him fully as chief officer of the corporate organization. Mark Olsen, Manager, is in charge of the Vancouver office. Ian Morrison is Chief Engineer and Bob Maartman is Executive Engineer.

C. E. Leonoff, P.Eng.,
Executive Vice-President"[6]

In a share purchase agreement dated January 1, 1970, Earle Klohn and Cyril Leonoff agreed to purchase equally all of Charles Ripley's shares in the companies over a five-year period for a total purchase price of $50,000. And Ripley resigned as a director and officer.[7]

On January 14, 1970, the Second Annual Directors'/Managers' Meeting was convened at the Banff Springs Hotel, with E. J. Klohn sitting as chairman. New participants at this meeting included Earl Speer from Edmonton, Paul Kozicki from Regina, and James Hunter from Winnipeg. While at the three-day meeting, Klohn received this telegram:

"Best wishes for increasing success to you in your new responsibilities as president, and to RKL under your capable leadership. I look back with considerable satisfaction on past accomplishments of the company, high quality of work done, increasing competence of technical staff, improved management capability, and new horizons created by recent expansions. My thanks to you and to Cyril Leonoff and to all staff for their extra efforts in past accomplishments and for loyal support to my leadership.

"The orderly change to new leadership gives me great satisfaction, particularly for the new opportunities it creates throughout the company. Much remains to be done to realize these opportunities and to consolidate past objectives. I have full confidence in the leadership that you and Cyril will give, and am sure that you will receive the same loyal support that you and the entire staff gave to me.

"I pledge my support and look forward to a continuing relationship with the company as its senior consultant. . . .

Charles F. Ripley"[8]

On his return to British Columbia, on July 1, 1970, a one-year retainer was arranged with Ripley for him to act as a consultant to the firm.[9]

From the mid-1960s to the early 1970s, the engineering staff at RKL, although continuing to be largely geotechnical, began to take on a more international flavour. Additions to the staff over this time included: G. Grant Cherrington of the Universities of Toronto and Purdue;[10] Dr. Milton Hsu of Queen's University, Belfast;[11] Hari K. Mittal from India and British Columbia; Stuart T. Wharton and Adrian Wightman of the University of Manchester; Kerry McManus and Arthur Love from Australia; and Thomas G. Harper from New Zealand. In 1969, Walter Shukin, a former UBC student, was hired, and was to go on to become a highly valuable "meat and potatoes" engineer for the company until his death in 1986. (In his memory, Klohn Leonoff Ltd. established the Walter Shukin Memorial Scholarship, awarded annually to the top geotechnical student in third-year engineering at UBC.) Technicians on the Vancouver staff at the time included Tom J. Flynn, John Redmond, Art Risdahl, Bjorne Carlson, and Dennis Diggle; and in the Prairies, John Odermatt, Allen Warsing, and James Zabachenski. Eric Pharey joined the staff in 1968 and rose to the position of chief drafter. On the secretarial staff during this period were Joyce Clarkson, Cathy Carr, Sharon McNeill, Dianne Collis, Pam Hollier, Sandra Skopyk, Terry Garrett, and Leah Tevyaw. Christine McGrath was the first part-time library technician, and Rosalind Turner the first print shop operator.

Early in his presidency Earle Klohn proceeded with the task of realigning the company, that is he set out to hire additional personnel. He wanted people with a broad range of engineering experience, people who would have a direct

Leah Tevyaw, executive secretary, ca. 1969.

Staff members at their workplace, January, 1973.
Photos: Ian Morrison

Walter Shukin

Terry Garrett

Thomas Harper

Yves Bajard

Kenneth Gillespie

Robert Tape

impact upon the scope of the company's work.

C. H. "Bob" Maartman joined the company in November 1969.[12] Of Norwegian-English ancestry, Bob was born in 1920 on a homestead near Eyebrow in the Qu'Appelle Valley of Saskatchewan. After stints in Alberta, Los Angeles, and Seattle, where Bob went to school, the family settled on a farm near Chilliwack, B.C.

Maartman trained as an automotive and diesel mechanic at the Vancouver Technical School. He had always "monkeyed around" with machines, "tractors and everything else," and when he joined the air force in 1940, it was first as an aero engine mechanic. But before the war was over, Bob was flying as a member of an air crew.

Upon demobilization Maartman enrolled at UBC as a beneficiary of the veterans' program. He was planning to be an engineering physicist, but was, at the time, working on construction projects as a member of the Carpenters' Union, so he chose civil engineering. A brilliant student, Bob headed the civil class, graduating with honours in 1950. "I have always had an easy time with any kind of learning," states Bob, "I'm lucky. I just have the sort of mind where I can read something and hang on to it." That summer he worked on a model of the Fraser River, studying under Professor Ted Pretious and analyzing the training of the Fraser River estuary.

In 1950 Maartman was fortunate to become involved with the great hydroelectric projects that were then just under way in the province. B.C. International Engineering Company (IECO) had the engineering contract for the Alcan Kemano power plant and, according to Maartman, "They didn't have anybody in Vancouver at the time who knew anything about hydro projects, so they came in [from the United States], set up an office, and hired a bunch of rookies like me." Thus Maartman received his basic training in this field from experienced Americans—Bill Huber, Norm Lane, Karl Kangas, and Glenn Crippen—whose backgrounds were on heavy civil engineering projects in the United States. Bob describes these men as "good engineers [who] worked hard," and so Maartman learned quickly.

While Maartman's first job with B.C. IECO was rather elementary, it did serve to quickly establish his repute as a design engineer. Told by his manager to design a wharf to accommodate the coastal ships that would be landing at Kemano, Bob protested that he knew nothing about wharf

C.H. "Bob" Maartman
Photo: Cyril Leonoff

design. Consequently, he was instructed to go out and look at some existing wharves to determine how they were built. Because in those days timber on the northwest coast was large, plentiful, and cheap, the wharves were invariably built of wood. And Bob knew that these deep-water wharves, with their long piles, would be subject to high lateral loads when hit broadside by ships during storms and tide rips. Indeed the sea captains relied on the pliancy of the wharves to protect their ships from damage, but in turn damage to the timber wharves was endemic. Maartman was unimpressed with the "rule-of-thumb" design and the scant bracing that he saw. Applying his knowledge of structural forces, the Kemano wharf was built with batter piles and heavy cross-bracing at each bent. When the first ship landing at Maartman's wharf hit with a bang, to the chagrin of the captain, it was the steel hull that gave way, not the wooden wharf.

Thereafter Maartman moved on to more sophisticated designs. He worked on Kenney Dam, did all the hydroelectric calculations for the Kemano tunnel, and headed a team doing the structural design for the service bay section of the Kemano powerhouse.

And with B.C. IECO, Maartman was also involved with the B.C. Electric Company developments at Wahleach, Seton Creek, Clowhom Falls, and Cheakamus. In 1954 B.C. Electric bought B.C. IECO and formed B.C. Engineering Company, with Thomas Ingledow as president. Bob Maartman worked for these companies on "a whole bunch" of proposed dam site and river diversion projects for the International Joint Commission (of the Canadian and U.S. governments) under Canadian General A.G.L. McNaughton, and also on the initial power studies of the Peace River.

But after August 1961, when the provincial government expropriated the B.C. Electric and Peace River Power Development Companies, International Power and Engineering Consultants Ltd. was formed and became the engineering arm of the British Columbia Hydro and Power Authority. "Tom" Ingledow then formed his own private consulting firm, and Maartman went to work for this company. With Ingledow's firm he became involved in international hydroelectric projects—on the Kundah project in Madras State, India and on other projects in Ceylon and in South America. Then Maartman worked for H. G. Acres of Niagara Falls on the downstream projects for the Churchill Falls, Labrador development and on miscellaneous projects in southern Ontario.

After the Churchill Falls project wound down, in 1966–67 Maartman became assistant chief engineer to Glenn Crippen (formerly with B.C. IECO), who had formed a consulting engineering company in Vancouver. While with Crippen, Maartman was on the Review Board for the Kettle Falls generating plant in Manitoba and for the Mica Dam project in British Columbia. During this period he also became acquainted with Ripley, Klohn & Leonoff Ltd., working with Earle Klohn and Charlie Ripley on the South Saskatchewan power plant. Then, in the fall of 1969, after working on his own for a few years on mining and other projects, Bob Maartman was invited to join Ripley, Klohn & Leonoff, and he has been with the company ever since. (He presently serves as a senior consultant on a regular, part-time basis.) Bob has been described as "the best civil engineer in the company," and after seventy years of life experience and forty years of engineering, Maartman's views are invariably respected. In a conversation with Cyril Leonoff, Maartman described his work with the company, the company's policies, his love of engineering, and his views on the new generation of engineers:

"When it gets down to handling people I get very exasperated. That's really what got to me at Crippen. I was a manager there—almost pure and simple. And I wasn't allowed to get my teeth into the engineering. When I came to work for you I didn't want to manage things—I wanted to stick to engineering.

"I liked Charlie, Earle, yourself, and Mark Olsen. These guys were held in high esteem all over. You really had a good working team and I came because of that. You were saying that you kept getting into hydraulic things, and you had nobody to provide that part of it. But once I got here, I found myself running flat out at times trying to learn geotechnical subjects because there wasn't enough hydraulic work to keep me busy. So I had to do gas stations, and dykes, and work on the drills. But it was good fun."

In coming to RKL from Crippen, and spending less of his time on hydraulics, Bob Maartman was obliged to contend with the more empirical nature of geotechnical engineering:

"Hydraulics is mathematically demonstrable. In soils engineering you can't write down a series of formulae and say that is the way it is for sure. There is some kind of mystique that makes a good geotechnical engineer—more judgment. That's getting less and less though, because we have some absolute brains around here—smart young people that the company has recruited who are beginning to nail a lot of things down. But you still can't get away from this heterogeneous material that we are dealing with."

In his geotechnical career Bob Maartman was one of the first to consider the effect of an earthquake in the design of dykes, embankments, and dams—long before it became fashionable:

"I got interested in liquefaction with all these dykes up and down the Fraser Valley. I think that we just suddenly stumbled onto the fact that here were these nice dykes, built on this loose sand deposit, and they were in an earthquake zone. Maybe an earthquake would knock them flat. So I got interested in liquefaction and I guess, over the years, I have become a bit of an authority on this subject.

"First it was the dykes. Then we got into the tailings dams—originally Brenda and Gibraltar. I have been monkeying around with tailings dams ever since. We began to realize that we were building tailings dams of relatively loose sand, and that it was going to be saturated. We knew

Drilling investigation and piezometer installation, Vedder Canal dykes, Fraser Valley, B.C., April 2, 1970.
Photo: Cyril Leonoff

that if the sand is fairly dense and is dry it won't liquefy. But if it's loose and gets saturated, it will liquefy. So the procedure was to make clean sand, try to place it at a fairly decent density and put drains under it so that it will drain well. My invention was writing a computer program called SEISLOP, which was set up for Brenda Dam, so that we could calculate the possibilities of pore pressure increase in an earthquake. The object was to try to get a measure of how much abuse the dam could take before it would develop a big flow slide. These downstream or centre-line constructed dams—like Brenda and Gibraltar—with good drainage and moderate density, should survive all right [under an earthquake]."

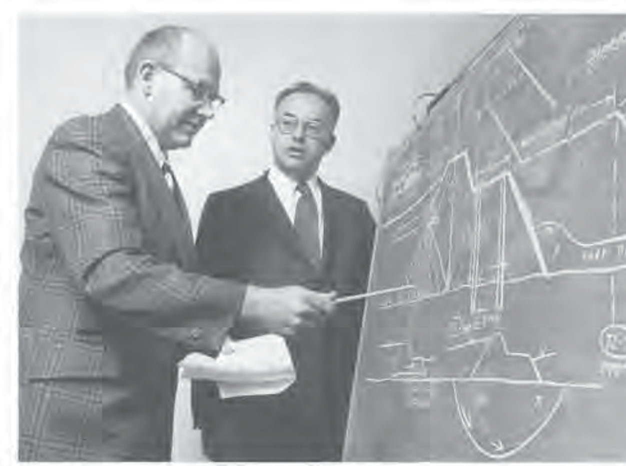
With his practical approach to the profession, and his reluctance to involve himself too deeply in management problems, Bob Maartman has found in hands-on engineering a career-fulfilling love: "I think the fun in engineering is in solving problems. When you come up with a good solution, that's satisfaction in an engineering job for me. My biggest worry now is that I may have to stop some day. But I don't intend to for as long as I can keep thinking."

As much as anyone, Maartman is able to articulate why he and his peers at the core of engineering in the company have come together as such a solid team:

"Of course we're not the same. Mark Olsen is more of an artist than I am. He does most of his engineering by intuition. But he's a real good detail man too when it's necessary. Ian Morrison is another absolutely brilliant man. He loves the theory—gets deeply involved in theory. I respect theory, but I am more pragmatic than theoretical. Earle Klohn is absolute tops—best guy I have ever worked with. I don't know how he does it, but Earle gets a lot of respect because he keeps on top of engineering—keeps well read—as well as being involved in management. He is still regarded as the last word on any number of things."

Unlike many of his younger cohorts within the company, Maartman does not have a doctoral degree. But this fact seems not to have hindered his career, nor caused him any regret:

"It doesn't bother me. I sit in judgment on Ph.Ds. In the areas that matter, I probably have accumulated as much or more information than they have in their formal training. But you do it the hard way—you pick it up along the way. These guys all come out of the university trained on computers—and they are programmers. I had to fight to learn all that stuff. To me, the average engineer today is a baby—he has to have everything laid out for him. There are so many things that he won't do. When we started with the Kemano project, we didn't have any draftsmen. Every engineer drew his own stuff. If you designed something you drew it. Now a job gets held up because the drafting section



Ian Morrison, left, and Mark Olsen analyzing Granisle Tailings Dam, 1972.
Photo: Ralph Wallis - Henry Tregillas

is busy. By the time you have a draftsman do things over and over again, the thing becomes like a rag—it's been erased so often. I'm not sure that is efficient. However things have changed. They do CAD [computer assisted drafting] now and never get on a drafting board."

Maartman concludes the discussion about KL in his own brusque but definitive way: "I am not sure whether we have much more to talk about, have we? I think it is a heck of a good company. I've stuck with it longer than I have with any other. I have enjoyed working with the people, and I have never had a day that I regretted becoming involved with them."

During 1971 other staff were added to broaden the technical capacity of RKL. In May of that year, Keith Douglass joined the company as executive assistant to the president.[13] An honours graduate in civil engineering from UBC, he brought to the firm thirty years of experience in feasibility studies, planning, design, and project management. Just prior to joining RKL, Keith had been on the staff of Brenda Mines, assisting in the development of mining and other resource properties and in reconciling that development with sound ecological management practices. He remained with Ripley, Klohn, & Leonoff for most of the decade.

At the same time—1971—Dr. Arvind Phukan joined the staff as a specialist in rock and soil mechanics,[14] working principally with the design of dams, waste disposal piles, and impoundments. He had taken a degree in civil engineering from Banaras Hindu University and both D.I.C. and Ph.D. degrees in soil and rock mechanics from Imperial College, London in 1968.[15] Unfortunately, Phukan remained with the company for only a short time. In August of that year, Dr. Yves Bajard joined the company as an executive engineer. A graduate in applied geology and water management from the University of Grenoble, France, Bajard had working experience both in Europe and Africa. At RKL he was responsible for engineering geology, hydrology, and surface and groundwater management.[16] Another senior staff appointment at this time was Robert P. Richards, who had received a graduate diploma from Delft, Holland in hydraulics and river engineering.[17]

Keith Douglass

Robert Lo

A significant addition to the technical capacity of the firm was the hiring in 1972 of Dr. Robert C. Lo.[18] Lo had obtained his Bachelor of Science in civil engineering from the National Taiwan University in 1962. A Ph.D. from Harvard followed in 1969, and then Robert Lo was personally recommended to RKL (as a brilliant theoretician) by Dr. Arthur Casagrande. As head of the engineering analysis section of the company, Dr. Lo's specialty is the application of mathematical analyses and computer techniques to a variety of problems in civil, dam, earthquake, geotechnical, mining, and permafrost engineering. And he has authoured numerous technical papers on these subjects. In recent years Dr. Lo has carried out state-of-the-art evaluations of seismic stability for rehabilitation of older dams, such as the Cleveland and Seymour Falls dams.[19]

On January 3, 1971, Ripley, Klohn & Leonoff officially quit its old premises and Vancouver home for eighteen years, at 1930 West Broadway. At this time the company was restructured, with Klohn, Leonoff, and the Accounting Department segregated into a "corporate division" serving all the various offices. The main Vancouver engineering office moved across the street to a concrete building located at 1847 West Broadway, near the corner of Burrard Street, formerly the Allstate Insurance Building but then owned by Orr's Stores (Bill and Bob Orr, whose family, by coincidence, had homesteaded near Klohn's family in Manitoba). This office was managed by Mark Olsen, with Ian Morrison as chief engineer. For a time auxiliary laboratory-field equipment space was rented around the corner at 2401 Burrard Street. Klohn and Leonoff personally purchased a 50-foot frontage commercial property at 1912–16 West First Avenue containing two old houses. One of the houses was adapted to accommodate the executive and corporate accounting offices on the main floor, occupied by Leonoff and Melling, and the soils laboratory was established in the basement, managed by Peter Wiens.[20] The hope was that eventually this site would be utilized to build a permanent office building for the company. As there was insufficient space in the corporate building, Klohn and his secretary were located on a separate floor of the Orr building. These physical separations which the company endured through five years were hardly efficient to the overall operation.

The Third Annual Managers' Meeting was held at the Grosvenor Hotel in Vancouver from January 28 to 30, 1971, following a year in which the company had shown a small loss. This meeting marked the first anniversary of Klohn's presidency, and in his introductory address Klohn stressed that 1970 had been "the first year of reorganization, a year of consolidation, and strengthening [of] the main offices." The major themes of the conference were organizational—corporate responsibilities and methods of achieving better communications among offices and members of the company. The working sessions were devoted to these subjects, as well as to consideration of various policies and administrative controls.[21] It was apparent that in the previous year the company had achieved its first, if elementary restructuring, as evidenced by the issuance of a "Management Chart" (Appendix I).[22]

These annual meetings were mostly work, but there was also some fun. The conference ended on Saturday evening with the "Managers' Ball," to which staff and their companions were invited.

The Fourth Annual Managers' Meeting took place at the Harrison Hot Springs Hotel from March 19 to 22, 1972. For the first time, wives were invited, and at this pleasant resort set up their own "ladies program." By now the new management team had had two years in which to restructure and consolidate the organization. New staff, with training and experience in different disciplines, had been added, expanding the range of the company's engineering capability. Therefore this was the key planning meeting in which the future course of the company, over the next decade and beyond, was to be clearly enunciated. At the outset of the meeting Klohn gave a succinct and frank outline of the company's history to date:

"In 1951 soil mechanics and foundation engineering was a relatively new field . . . and there were only a handful of qualified soil mechanics engineers in all of Canada. Charlie Ripley was one of these and the firm he founded was one of the first consulting practices set up in Canada to exclusively carry out soil mechanics and foundation engineering work.

"In the early years, a large part of our effort and money was spent on selling people the need for soil mechanics, and attempting to explain to them what we did. In many people's minds we were some kind of soil testing technicians, not to be confused with civil engineers, who as everyone knew, actually did the designing and building of dams, canals, etc. This is an impression that is still shared by many people.

"As the early years passed, the company became well established in Vancouver. It developed the reputation of being a highly competent soil mechanics firm, which, if anything, was too well versed theoretically and perhaps lacking wide, practical experience. On the negative side, we became labelled as an organization that was difficult to deal with, because we tended to dig in our heels and refuse to compromise whenever differences of opinion came up between us and our clients. The firm's philosophy appeared to be, 'We are the experts and know what is best for you, even if you don't know it yourself.' Understandably this created a few enemies, as no one likes to be lectured to and proved wrong, especially when he is wrong."

Klohn went on, in his report, to describe some of the problems that had developed for the company in the wake of Karl Terzaghi's death, and with the onset of an economic slump in the early 1960s. During this period, despite the competence and experience of the staff at RKL, with the rise of competition for the firm and with the lack of any focus on promotion or advertising, the company found itself contemplating an overall financial loss for the first time since its inception in 1951. Expansion was decided upon as a remedial action—the opening of a new office. As Klohn noted:

"Toronto had been our first choice, but we had reservations. At that time, Toronto was a bit of 'a club' and you had to have connections to do business there. That is changed now. Besides, Charlie was not interested in going to Toronto."

"So Winnipeg," continued Klohn, "became the second choice because it was the next largest English-speaking city in Canada. Charlie Ripley agreed to move to Winnipeg to open and run this office. And about that time, Leonoff agreed to move from an engineering function . . . and take over the management chore.

"Our expansion kick continued, with offices being opened in Calgary, Edmonton, and Regina. It soon became evident that managing such an operation was extremely difficult, as well as being very expensive. Moreover, differences in opinion developed concerning how the company should operate and what services it should sell. These various opinions were greatly influenced by local conditions and many of them did not accurately reflect what was good for the overall company. As we approached the end of the sixties, it became evident that to survive and become successful, it would be necessary to completely reshape our entire thinking concerning all aspects of operating the company: reorganization of management, revamping of accounting, establishment of sound public relations and promotion programs, increasing technical competence of staff, and a complete review of the services being offered to clients. . . .

"These changes bothered Charlie Ripley, who, while on the one hand realized they were needed, on the other hand did not want to become involved in their implementation. He indicated to Leonoff and Klohn that he did not want to be in a position where most of his time and energy was required for administering a large organization, and that he wished to sell out his interest to Leonoff and Klohn. Agreement on this matter was reached and Klohn took over the presidency of the firm in January 1970."[23]

The meeting of March 1972 essentially confirmed actions that were already under way, and hammered out a range of company policies that were to be implemented forthwith.[24]

The company was to operate out of three offices: Vancouver, Calgary, and Winnipeg. Statistics showed that, from the time of opening the first Prairie office (1964) to date (1971), Vancouver had shown a profit seven out of eight years. But during this same time all Prairie offices had shown net losses. Winnipeg had two profitable years and one break-even year out of eight, Alberta (with CONTEC) one profitable year out of seven, and Regina three non-profit years. The Vancouver office was carrying the company. In aggregate, the Prairie operations had reduced the overall profit by 32 percent. Consolidation was in order.[25]

In March 1971, the Edmonton office was closed, and Earl Speer was relocated to Calgary as manager of the Alberta operation.[26] At the end of that year the Regina office was closed, although a working arrangement was maintained with Paul Kozicki, Del Fredlund, and Karl Sauer. By January 15, 1972, RKL Alberta and CONTEC were discontinued and the assets acquired by RKL International, although the trademark CONTEC was retained for a time (Chapter 8). Thus all the offices were now operating under one company, RKLI. Vancouver, where the largest base-load of work and broadest range of expertise existed, was designated as the head office.

In keeping with the ownership policy originally established by Charles Ripley, on January 15, 1972 Mark Olsen and Don Davison purchased common shares of the company from Klohn and Leonoff.[27] Both were appointed directors, Olsen responsible for the British Columbia Region and Davison for the Prairie Region. Commencing June 1972, a Management Committee composed of these four persons (Klohn, Leonoff, Olsen, and Davison) was set up to run the company and hold monthly or bi-monthly meetings.[28] Managers Hunter of Winnipeg and Speer of Calgary were appointed advisors to this board.

All managing, accounting, and invoicing functions were revised and improved. The computer program was operating satisfactorily, and reasonably accurate cost controls were in place. The regional office managers were to be

Excerpt from company brochure, 1972.

responsible to Leonoff on all administrative and financial matters.

Olsen in British Columbia and Davison in the Prairies were responsible to Klohn on all engineering matters. With the addition of such people as Maartman, Douglass, Bajard, Phukan, and outside consultants, the technical base of the company had been broadened from pure soil mechanics. The branch offices were expected to sell and utilize their services locally, as required.[29]

Sales and public relations programs were to be launched both in Canada and internationally. The image of the firm was to be that of "Consulting Engineers" offering a complete range of geotechnical services that encompassed all aspects of the physical behaviour of "Soil, Rock, and Water." The objective was to sell a complete project engineering service in this field. This company image was to be portrayed in a new brochure which was published in October 1972.

In what has been described as "1,154 Controversial Days,"[30] the socialist New Democratic Party government under Premier David Barrett held office in British Columbia from August 30, 1972 to December 11, 1975. New taxation, royalty, and ministerial discretion policies enacted by the NDP government caused an immediate decline in private sector developments, particularly in the forest and mining industries which formed the backbone of RKL's engineering work. A mid-year business survey of 1974 confirmed that, "A mood of pessimism grips the business community in British Columbia. . . . The uncertainty over the impact of new royalties is the chief reason why there is no significant capital being invested either in forestry or mining." Indeed, the survey noted "a marked swing in mining companies to become active elsewhere in Canada and overseas."[31] As well, the provincial government was unfairly blamed by some members of the media and public for circumstances beyond its control—inflation within Canada and the United States, declining overseas markets for B.C. lumber, and a severe world-wide recession. Nevertheless, in the retrospective view of a present-day historian, "For growing numbers of British Columbians, the NDP's actions seemed designed to destroy the province's economic base in resource exploitation."[32]

A measure of the drop-off in the company's work is evident in the president's report to the Fifth Annual Managers' Meeting, held at the Blue Horizon Hotel in Vancouver from March 8 to 10, 1973:

"During the past three years RKL has put much effort, time, and money towards developing a well-organized, competent, and efficient geotechnical team. I believe that . . . we have finally achieved these objectives. The major problem now facing us is the development of sufficient work to keep this high-priced, highly talented, well-oiled machine operating at a high enough capacity to meet our current expenses, and to develop some much needed profits for expansion and development.

"On the one hand we have increased our sales and promotion efforts, have [reorganized] our management team, and appear to finally be making headway in selling foreign work. . . . On the other hand our total volume of work has dropped off by more than twenty percent. Moreover the outlook for major resource projects in B.C. during the next few years is very poor. Unless the policies of the present . . . government change markedly, we expect a further drop in our volume of work in B.C. [A] major problem is to pick up the slack that decreased activity in B.C. has created and will continue to create in our organization. . . ."[33]

For the first time the benefit of RKL's new-found geographic diversity was realized when "the slack" was taken up by the company's Alberta operations, then busily engaged in route and materials surveys for northern oil and gas pipelines. As well, new projects relating to the firm's expertise in mine tailings disposal were arising in domestic regions new to the company, such as the province of Quebec and the state of Minnesota. And the company's venture into foreign work was beginning to bear fruit, specifically in a major materials survey for the state of Kuwait.

RKL's Alberta operations had started modestly when a two-man office was opened in Calgary in mid-1966. The Alberta division had then floundered through two and a half years of growing pains, staff, and corporate changes (Chapter 8). But by March 1, 1969 a viable office was operating in downtown Calgary under the direction of Don Davison, along with the CONTEC materials testing division under the supervision of Jack Fujino. "We started out in foundation engineering," recalls Don, "and in the early seventies Alberta was in the midst of a great population and building boom that resulted in a good many foundation jobs for the company." Perhaps the most newsworthy contract concerned the Lethbridge University building, designed by Arthur Erickson. Constructed in 1970, the university is situated in the incised valley of the Oldman River in south-

University of Lethbridge, Alberta.
Photo: Cyril Leonoff

Glenmore Trail, Calgary, Alberta.

General view.

Concrete testing.
Photo: Mathieson Photo Service

ern Alberta. The concept was to tuck the main building into the natural setting of a coulee, but, because the soils at the site are susceptible to swelling, it was necessary to found the building on caissons drilled deep into stable ground.[34] Davison recalls the work as less attractive than it might seem:

"The architectural work was highly competitive, the fees low, and the liability high, so this was not necessarily a sector which the company wished to actively pursue. However, the network of Calgary city freeways was being built—with a large number of bridges and overpasses—and this gave RKL a firm work load in soils, asphalt, and concrete testing."

Throughout the 1960s oil prospectors had roamed the North American continent's North Slope, moving across Alaska, Yukon, and the Northwest Territories. Expensive test holes were drilled, costing up to $1 million each, but the initial holes were all dry. Then, in 1968, drillers working near Prudhoe Bay, Alaska struck a field with resources estimated in the billions of barrels. The oil rush to the Arctic was on. Later, oil and gas discoveries were also made in the Beaufort Sea, off the mouth of the Mackenzie River.

Mackenzie Valley Pipe Line Research Limited (MVPL) was formed early in 1969 to study the technological and economic feasibility of constructing a 48-inch-diameter crude oil pipeline from Alaska through the Yukon and Northwest Territories to Edmonton, Alberta. At Edmonton the pipeline would connect with the Trans Mountain and Interprovincial Pipeline systems for distribution to eastern Canada and the United States. Nearly 1,700 miles long, the line would traverse terrain that is underlain with continuous or intermittent permafrost. In July 1969, MVPL retained Canadian Bechtel Limited to conduct a field test program that would lead to completion of the major portion of the study.[35]

When Earl Speer had opened an Edmonton office for RKL in mid-year 1969, as luck would have it, he had a former schoolmate who was in charge of the pipeline work for Bechtel. Carl Hunter of RKL-Vancouver also pursued Bechtel to do work on this project. Their combined efforts proved successful, and RKL's first assignment was an $18,000 reconnaissance by Earl and technician Jim Zabachenski of the pipeline routing from Prudhoe Bay, along the North Slope of Alaska-Yukon-Northwest Territories then up the Mackenzie River right through to Edmonton. On this initial survey Speer felt like something of an explorer:

"We were sort of pioneers—the first company to go into the Arctic on pipelines. At the beginning, when we went up to Inuvik, we knew nothing about permafrost. And we sure learned that we knew nothing about it. We were all learning as we were going. But we became leaders in this field and still are."

From 1969 through to 1973, Ripley, Klohn & Leonoff Alberta Ltd. was retained by Bechtel to carry out a series of field investigations, air photo analyses, and engineering studies along the pipeline route from Prudhoe Bay to the Northwest Territories-Alberta border. Terrain evaluation, surface and airborne drilling, sampling, and testing programs were conducted along alternate routes and at river crossings. Preparation of air photograph mosaics showing surficial geology and bedrock features were subcontracted to J. C. Sproule and Associates of Calgary, and J. D. Mollard of Regina.[36]

Oil originating from deep in the ground is naturally heated, and retention of that heat in the pipeline is required for fluidity during transport. In building a pipeline or any heated structure on permafrost, loss of heat into the ground will melt the ice lenses, resulting in large settlement. Therefore northern construction is conventionally based on the premise that the permafrost must be preserved. Conventional methods employed to achieve this goal had included insulation of the pipe and its support on berms or trestles above the ground. Farther south, in the intermittent permafrost zone, the heat balance is even more tenuous, and the ground even more sensitive to thawing. In this region design may involve excavation and replacement of the frozen ground or the installation of piles to carry the load below the frozen zone.

In order to determine the effect that the hot oil passing through the pipeline would have on the permafrost, analyses were made by RKL Alberta of permafrost degradation, thaw settlement, and thaw bulb stability. As well, slope stability, drainage and erosion, thermal erosion, and seismicity were studied. These soils investigations, probably the most extensive ever undertaken on permafrost, provided the basis for the selection of a pipeline support system (on, below, or above ground), insulating materials, and the type of foundation for the pipeline.[37] Charlie Ripley, Earle Klohn, and Don Davison were involved in the engineering studies, with Davison being in overall charge. Staff for the drilling investigations were recruited from all offices.

Access by construction equipment to the sparsely populated northern regions of the North American continent is limited. There are few permanent roads and relatively few airstrips. Conventionally, helicopter programs are conducted in the summer months when days are long and the weather is suitable. Conversely, overland operations are usually carried out on frozen "winter roads" traversed by tracked vehicles.

The first field investigation undertaken by RKL in 1969 used track-mounted equipment based in Fort McPherson, drilling and sampling across the Yukon North Slope to the Alaska border. Subsequently, the company became more conscious of permanent disturbance to the environment caused by tracked vehicles and changed to helicopter programs, whereby all equipment and supplies were flown in.

In 1970 a huge terrain evaluation program—drilling, sampling, and testing—was conducted to "ground truth," that is to confirm that ground conditions were as indicated by aerial photographs. The lengthy route traversed was from Prudhoe Bay, Alaska over the Brooks Range, through the Old Crow area in the Yukon, across the Peel Plain to Sans Sault Rapids, then up both the east and west sides of the Mackenzie River to Fort Simpson and on to the 60th parallel. The drills were flown in and the fuel was deployed along the route by helicopter. The logistics of moving men and equipment in and accommodating people in these isolated sites proved to be a more difficult exercise than solving the engineering problems.[38]

Mackenzie Valley Oil Pipe Line terrain evaluation – Drilling in massive ice lens with rotary drill, using air.
Photo: Thomas Harper

The 1972 field program was a land operation of drilling and sampling, from Norman Wells to Tuktoyaktuk at the mouth of the Mackenzie River.[39] This work, starting in February, was carried out in the dead of winter, often at temperatures of thirty or forty degrees below zero. The route, located on photographs, followed the old "telephone trail." Ken Gillespie, who was supervising the drilling investigation, recalls a caravan reminiscent of the fabled wagon trains of America's Wild West:

"There were forty or fifty men in the party—drillers, helpers, surveyors, technicians, and engineers. We went along this route using two drills mounted on Nodwell carriers, working twenty-four hours a day and drilling holes every half mile or so. We had a cat train which followed behind the drills, pulling six or seven trailers to accommodate all of the people."

Even the most hardy souls find working during the cold, dark months of a northern winter a severe challenge. Quoted in a business magazine interview in 1977, Earle Klohn set the scene:

"They work on a cat train in complete isolation. The crew is together working seven days a week, and they really get cabin fever. They're working and trying to sleep in cramped quarters, and it's dark and cold. Since the train sometimes moves at night to different locations, the workers strap themselves into their bunks to avoid rolling out during the move. It's a completely self-contained unit, including . . . a cook and assistant . . . all provisions [and] sanitary facilities. . . . They work two or three weeks then come out for a week, then go back. It's very hard."[40]

This was to be the last large-scale field program on the Mackenzie Valley oil pipeline. In the end the Canadian route

Mackenzie Valley Oil Pipe Line terrain evaluation: Soil sampling on North Slope of Alaska using heli-drill, August 1970.
Photo: Donald Davison

Bell 205 helicopter setting up heli-drill, Peel River crossing, Fort McPherson, Northwest Territories, 1970.
Photo: Donald Davison

Cat train en route from Norman Wells to Inuvik, Northwest Territories, March–April 1972.
Photo: Thomas Harper

Drilling in permafrost with Nodwell carrier and Failing drill rig, Inuvik and Tuktoyaktuk, Northwest Territories, April 1972.
Photo: Thomas Harper

was not selected, regardless of the fact that it would have been of most benefit to the Midwest and East where the energy crunch was by far the most acute. As well, it may have been environmentally advantageous to a trans-Alaska route since it would avoid earthquake zones and the need for tankers, which inevitably spill oil on the Canadian and U.S. West Coast. Instead the Alyeska Pipeline Service Co., a consortium of seven oil companies with rights to exploit Alaska's North Slope oil, opted to build a $3 billion 789-mile pipeline from Prudhoe Bay to the port of Valdez on the Pacific Ocean.[41] From Valdez the Alaska oil is shipped down the West Coast by tanker. The Canadian Beaufort oil has never been taken out.

In 1973 a CN/CP Joint Committee, sponsored by the Canadian government as an alternative to the pipeline transport of oil, investigated the possibility of constructing an Arctic railway from the Prudhoe Bay field across the North Slope of Alaska and the Yukon, thence up the Mackenzie Valley to the 60th parallel, and southeast to Edmonton. RKL was commissioned to design 800 miles of the railway and to co-ordinate the work of three other consulting firms on the remainder of the route. Design involved consideration of soils, topography, permafrost, drainage, construction materials, and bridge crossings.[42] "Al" Edgeworth of the Calgary office was responsible for the field work on this project. As with the Mackenzie Valley pipeline, the railway was not built.

In conjunction with the pipeline work, RKL was engaged by the federal Department of Indian Affairs and Northern Development (DIAND) to explore for natural gravel deposits in the Mackenzie Delta and Hay River regions of the Northwest Territories for use in construction of the pipeline, airstrips, or other community public works. The studies were conducted to evaluate the quality and quantity of construction materials, access and modes of transport, the best materials handling and processing methods, and environmental and pit restoration requirements. The methodology consisted of air photo studies and field reconnaissance, followed by drilling, sampling, and testing of the most promising deposits.[43] Some of the reports on this work are still being utilized today.

Another precedent-setting project begun in 1971 was the 3.4-mile-long Aishihik power canal in the Yukon for the Northern Canada Power Commission. RKL was engaged to carry out site investigations, route selection, design, and construction supervision for this "cut and fill" operation. Investigations showed that permafrost was prevalent throughout the route, but with widely varying ice contents in the silty soil. The canal water, a source of heat, would lead to thawing of the permafrost and eventual readjustment of the dyke foundations. The time required for thawing

Tuktoyaktuk, Northwest Territories – whitefish drying.
Photo: Robert Lorimer

would be dependent upon the permeability of the foundation material, and calculations showed that in some areas thawing would not be complete for fifty years.[44] RKL's resident engineer on investigation and construction of the canal would be "Tom" Harper.

Thomas George Harper, born the day before Christmas 1943 in New Zealand, was raised and educated in his native country. Two generations before, his grandparents, Scottish Highlanders, had emigrated to seek better economic opportunities as pioneers in the frontier lands of the British colonies and, as free thinkers, to escape from the domination of the church. Tom's father was an industrial engineer in New Zealand; therefore his son had always been interested in engineering, which to him "just seemed like a natural thing to do." In 1965 Tom Harper graduated with a degree in civil engineering from the University of Auckland. Comparing his education with the equivalent given in North American universities, Tom offers this partial contrast:

Aishihik Power Canal, Yukon

Drilling investigation, 1971.
Photo: Thomas Harper

In operation, August 1977.

"At that time the degree in civil engineering in New Zealand, at either one of the two engineering schools, was quite a bit broader than the Canadian education and distinctly broader than the U.S. . . . I think that [education] has set me up nicely for a career which has spanned several different areas, some of them not in engineering. . . . One of the benefits . . . is that New Zealanders have not felt constrained by any specialization."

Nevertheless the civil engineering curriculum at Auckland did include a two-year combined soil mechanics-geology course, and upon graduation, Harper served his apprenticeship by working as a project engineer for Tonkin and Taylor, an Auckland engineering firm whose work was equally divided between civil and geotechnical: "So I immediately got into the dirt business. And one of the interesting things that I've never forgotten was Don Taylor . . . telling me that in this business you can't be a geotechnical engineer and keep clean fingernails. I didn't appreciate it much at that time, but it's a very good piece of advice."

Harper worked for the New Zealand firm into 1969. At that point, as Tom puts it, his choice was either to "settle down, get a mortgage and stay there forever, or do some travelling." Forty percent of his graduating class had come to Canada, which was perceived as a land of opportunity, so Harper and his wife chose that route. Vancouver was the first stop on what they anticipated was their way around the world. Embarking from the boat on a Saturday, the next week, in an interview with Olsen, Morrison, and Leonoff, Harper was asked where his expertise lay, and he advised that he had done a lot of work on "stop banks." The term was utterly unknown to the three assembled interviewers. RKL was then heavily engaged in the civil and geotechnical works on the Fraser River flood protection dyking, and when it was finally determined that stop banks and dykes were the same thing, Harper was hired on the spot. He worked on the Fraser River dykes periodically from 1969 to 1977.

Unlike many of their compatriots from "down under," the Harpers remained on this continent, where Tom would go on to make significant contributions to engineering projects in many regions of Canada and the United States. In 1971 he became the company's resident engineer on the Gibraltar tailings dam and thereafter became engaged on many other mining projects. He was also involved on route investigations in northern Canada for the hot-oil pipeline. He remembers his experience on the Aishihik Canal as something of an adventure:

"The investigation amounted to spending a winter up there with a drill rig at temperatures down to minus sixty, which was a new experience for a New Zealander like me. I kept buying more and more clothes as the fall wore on, till finally I had a complete set of Canadian north winter gear. We dealt with people who were living in the Indian village of Aishihik. In fact I took a trip in there once with the district nurse who went in periodically. It was a seasonal village. In the late fall they'd come out of there with bags full of mukluks for sale. I still have a couple of pairs of very nice, smelly moose hide mukluks at home.

"My family and I went up and lived there for nine months in 1974 while construction of the canal was under way. By then there was a camp set up and we lived in a trailer. For a time we were the only family in the camp. It was fun for our little boys, who would stand on the side of the road, thumbing a ride with the garbage truck. He took them out to the dump so that they could see the black bears and grizzly bears. Great fishing of course. Just a very interesting place to live."

Piezometers and thermistors were installed along the canal after construction to allow continuous monitoring of the pore pressures and melting rate in the foundations and dyke. As expected, thaw settlement has occurred in areas where the foundation was pervious. However, the dyke has continued to perform satisfactorily over the years, with only minimal maintenance required.[45]

Donald Davison, left, and Earl Speer, Calgary office, ca. 1973.

At the outset of the northern pipeline job, RKL Alberta was working out of two offices, Calgary and Edmonton. The pipeline work required close liaison of staff and operations between the two offices, and it soon became apparent that for reasons of co-ordination, efficiency, and economy, it would be better to operate out of one office. Calgary, which was the older and better-established office, was chosen. So, early in 1971, Earl Speer joined Don Davison in the Calgary office, becoming manager of the Alberta operations, responsible for managing the work in northern Canada and Alaska. Davison was designated as head of the Prairie Region, where he continued to be responsible for the engineering work of the company both on the Prairies and in the North.

Fortunately, in 1973, just as the oil pipeline work was winding down, as a result of their experience in the northern terrain and gravel searches, RKL's Alberta office (along with J. C. Sproule) was able to land a major contract on a materials investigation for the state of Kuwait. The major field program for this investigation was carried out in 1974 (Chapter 11). According to Speer, this assignment followed logically upon the heels of the pipeline work:

"In Kuwait we applied the same approach to the 'hot desert' as we had applied to the 'cold desert,' because the logistics in the desert environment weren't unlike the Arctic. So having that experience in the Arctic really paid off for us."

As it turned out the lull in the Arctic work was only temporary. Just as the Kuwait report was being completed, in January 1975, Ken Gillespie was making the first reconnaissance for a proposed natural gas pipeline along the Mackenzie Valley:

"We took a helicopter from Hay River on January 3 and flew up to Inuvik. It took us a month to look over all the route. In retrospect, it really wasn't a very good trip, and I wonder what use it was. Because it was forty or fifty degrees below zero and we only had three or four hours of light each day."

While the 1972 ground program (for the oil pipeline) by "cat caravan" down the Mackenzie was self-sufficient and had purposely bypassed the Indian communities, the 1975 program involved contact:

"We stopped at all the Indian villages for gas, food, and shelter. We flew the helicopter maybe a hundred miles a day and stayed in these little communities at night. Nobody thought to say, 'Look we are going to build a pipeline behind us, and what do you think of it?' The Indians knew something was afoot but they had no clue as to how they would be affected. Some of them were a bit apprehensive about what we were doing."

In the early 1970s, Canadian Arctic Gas Pipeline Limited (Arctic Gas), dominated by a consortium of American-owned and controlled firms, was actively studying a plan to transport natural gas from the Prudhoe Bay field to the "energy-starved Lower 48" American states. The route selected for a proposed $10 billion 48-inch-diameter chilled-gas pipeline was to be across the Alaska-Yukon North Slope to the Mackenzie Valley, then south to the Alberta-Saskatchewan border. Coincidentally the grandiose National Energy Policy (NEP) was being fleshed out by the Trudeau administration, and by 1973 it was apparent that the objectives of both government and industry favoured the removal of regulatory barriers to allow early construction of a natural gas pipeline up the Mackenzie Valley.

Construction of the pipeline required the approval of two federal statutes, the NEP Act and the Territorial Lands Act, the latter under the jurisdiction of DIAND and its minister, Jean Chrétien. Both acts required the provision of information and opportunity for questions at public hearings. At first, to avoid costly delays, Chrétien favoured an in-house assessment by government specialists. But as pressure mounted from groups representing aboriginal peoples and environmental concerns, the government was obliged to take a second look. Questions raised by these groups concerned the novel experiment of building thousands of kilometres of pipeline over fragile Arctic terrain, title to the land, the socio-economic impact that the construction would have on Canada's last frontier, and indeed whether the pipeline was needed at all. As well, there was political concern about relinquishing government control over northern development by vesting so much power, without competition, in Arctic Gas. Finally, in January 1974, cabinet resolved that DIAND would order an inquiry pursuant to the

Peace River Oil Pipeline crossing Smoky River, Alberta.
Photo: Matthews Photo Lab

Territorial Lands Act. The intent was not to kill the pipeline but to find an acceptable route. The commissioner chosen in March 1974 to head the Mackenzie Valley Pipeline Inquiry was Thomas R. Berger, a westerner, lawyer, politician, and future judge, who was "driven by a strong social conscience and a sense of justice." Berger entered the picture just as Arctic Gas was making its official application for the crown land right-of-way that would allow for construction of the pipeline, and a long period of delay began. "Tom" Berger explained this delay some time later in saying that, "The risk is in Canada. The urgency in the U.S."[46]

Prior to this time, RKL had been shut out of the engineering studies for the gas pipeline because of the firm's work for the rival oil pipeline. Therefore competitors had gained a stranglehold on the Arctic Gas studies. But suddenly an interloper entered the pipeline game, and, from then on, chortles Speer, "We were the company on the winning team." The new player was Foothills Pipe Lines Limited, a partnership of western utility companies under chief executive officer Robert Blair of Nova Corporation (the principal participant), a man journalists described as "a colourful nationalist." It was Foothills who in January 1975 hurriedly hired Klohn Leonoff to investigate their proposed "all-Canadian" Mackenzie Valley route (astutely named the Maple Leaf Pipeline), which would carry only Canadian gas to Canadian users, at an estimated cost of $4 billion.[47]

But it soon became apparent to the shrewd Blair that environmental and native opposition would ultimately veto the Mackenzie Valley route.[48] So Foothills looked for new, less controversial routes. One from Prudhoe Bay would follow the Alaska Highway down through Whitehorse, then cross northeast British Columbia near Fort St. John, continue through Alberta and eventually branch either south to California or east to the eastern states. Another proposed branch to tap the Beaufort gas would come through Inuvik, then down the Dempster Highway to link with the Alaska line at Whitehorse. Klohn Leonoff was geotechnical consultant for Foothills at this point, and so became heavily involved in investigating and studying these routes. Foothills put forward their "Alcan proposal" on the grounds that there would be less potential environmental damage by following existing highway routes, and the company was subsequently invited to join the Berger inquiry's community hearings. In this way, Foothills became the main intervenor against the Arctic Gas application, which, after five years of study and a $150 million expenditure, seemed committed to the Mackenzie Valley route.

The formal hearings were held in Yellowknife, but wanting to know what "ordinary people" were thinking, Berger took the fact-finding stage of the commission into thirty-five northern communities, the homeland of Indians, Inuit, Métis, and whites whose way of life would forever be changed by the pipeline.[49]

Don Davison was an expert witness for Foothills at the Berger community hearings and before the National Energy Board (NEB), which was holding simultaneous hearings in Ottawa.[50] Davison describes his participation as:

"Fun days. We were doing a lot of reviewing of the Arctic Gas proposal and identifying the weaknesses in their work. It's great when you're cross-examining someone else. Foothills had a tremendous lawyer, Reg Gibbs [later a judge], whom I really came to admire. He had the ability to listen to a whole bunch of engineers, digest and sort the pertinent facts in his mind, then work for hours questioning these people. I remember on one occasion he was examining a senior civil engineer with Arctic Gas. It had to do with building ice roads across Richards Island in wintertime. He got this fellow talking about all the trucks and equipment that would be needed, nose to nose, on this road in order to meet the schedule. Finally he posed the question, 'Isn't this going to be difficult to do and very costly?' The poor fellow blurted out, 'Well, if we can put a man on the moon, we can do this.' Gibbs retorted, 'Yes, but won't it cost an awful lot of money?' At the end, of course, we were also cross-examined on the Foothills proposal."

After 283 days of testimony given, 1,700 witnesses heard, and 40,000 pages of transcripts typed, the hearings concluded. The report of the Mackenzie Valley Pipeline Inquiry was tabled in the House of Commons on May 9, 1977 and became the best-selling document ever published by the Canadian government.[51] Pro-native and pro-environment, it effectively killed the Arctic Gas proposal. The National Energy Board, the official regulatory agency, had the final authority to choose which, if any, pipeline should be built, but by now the public and political consensus of the nation had shifted. Two months after the Berger Report, the NEB report came down, recommending that the Arctic Gas proposal be rejected and that preference be given to Bob Blair's Foothills Pipe Lines, following the Alcan route through the southern Yukon and northern British Columbia.

Helicopter work, such as that undertaken by RKL along the pipeline routes, is always a dangerous occupation, but especially so in a northern climate with enveloping darkness and a mountainous terrain. When questioned on this subject Gillespie remarked:

"The big problem is the weather. Everybody seems to think that when the weather is bad, you can fly with helicop-

Molikpaq, Beaufort Sea.
Photo: Gulf Canada Resources Inc.

ters anyway because you're so close to the ground. But that isn't true. In our type of work, using helicopters, we were doing drilling, slinging heavy equipment, cutting paths. So I would say it's dangerous. But I don't think anybody ever really thought about it that way."

Earl Speer believes that he logged at least 4,000 miles of helicopter work on the pipeline projects—"enough to last a lifetime". Considering the thousands of miles flown, the heavy equipment moved, and the variable weather, RKL's safety record on the pipelines was very good. However, tragically, in October 1976, while supervising a field drilling program in the Yukon, one young engineer, Victor Olacke, and three crew men were killed in a helicopter crash caused by mechanical failure of the main tail rotor.[52]

An interesting corollary to the Arctic work is the development, for Gulf Canada Resources, of Klohn Leonoff's "analytical icequake liquefaction model," an important step in the safe design of offshore drilling structures for use in the Beaufort Sea.

As vividly demonstrated by the 1989 oil tanker spill near Valdez, Alaska,[53] the sensitivity and remoteness of marine Arctic environments demand that drilling and transportation systems be designed to prevent every conceivable accident. Such are the demands placed upon the "artificial islands" used in oil and gas exploration in the Arctic Ocean, structures which are without precedent in civil engineering. From 1972 to 1987 thirty-six of these temporary caisson-retained islands (CRI) were constructed for exploration in the Beaufort Sea. Various designs were developed, including the state-of-the-art Molikpaq system of Gulf, first deployed in 1984. The Molikpaq island is a huge steel caisson, 29 metres high and 110 metres square, that is floated into place and set down on a prepared sand berm. Ballast sand is hydraulically placed in the core of the caisson and provides the primary strength in resisting external loads.

The largest loads that a CRI must resist are from ice-sheet impacts, which in the Beaufort Sea are among the greatest encountered by man. The magnitude and duration of dynamic ice-loading can be sufficient to initiate liquefaction of the sand in the supporting berm and caisson core if the sand is not dense enough. These ice loadings are referred to as icequakes because they can cause vibrations in the same manner as do earthquakes.

The solution to the problem is densification of both core

Densification test, 1981, of loose sand deposits by vibro-flotation for Dome Petroleum, used in constructing artificial islands for oil exploration in the Beaufort Sea.
Photo: Adrian Wightman

and berm sands by stages of blasting. The analytical model, when verified by field performance, permits a method of ascertaining the density required to resist the ice loading. Thus specifications can then be set to give Arctic operators more confidence in development and maintenance of safe oil-production systems. In 1989 Klohn Leonoff was given a Canadian Consulting Engineer Award of Merit for development of this technique.[54]

The Arctic gas lines have never been built. Some so-called pre-built sections, taking Alberta gas to the United States, have been constructed, but neither Canadian nor American financing has ever materialized to convey the gas of the Prudhoe and Beaufort fields south. But, no doubt, with increasing demand and rising prices for gas, the economics will eventually be right, and the Arctic pipeline issue will arise again. In the interim, drilling explorations and technological studies have continued.

The Berger Report was a precedent-setting document in terms of its sensitivity to native concerns. And, with over half-a-dozen years living and working among the northern native peoples, before most other white men had contact, the observations of Klohn Leonoff's field staff seem to coincide with many of the views stated in the report.

Earl Speer was among those first on the ground for the oil pipeline, and he soon gained a clear impression of the northern native people and how a pipeline might impact upon their lives:

"In the routing from Prudhoe Bay over the Brooks Range in Alaska, we lived with the natives in Arctic villages. They provided the accommodation and they cooked for us. When we were doing drilling we employed them on the cat trains. We were able to use them, basically, for menial sort of tasks because obviously they had no training.

"Later, when we were in Fort McPherson and Fort Simpson we were always involved with the natives. Got to know them very well and to appreciate these people. I can remember sitting on the banks of the Mackenzie and talking to the chief of the tribe and some other people. We talked about all kinds of things—how they felt about the white people coming, how they felt they were discriminated against—which they really were of course. And I developed a real sympathy for their cause, just through the contacts we had with them."

Don Davison was with Earl Speer on those initial forays into the North, and he remembers the crew moving into the native community of Old Crow, just east of the Alaska-Yukon border. In doing so they unknowingly offended the inhabitants of this isolated locale:

"The move was made with our helicopters, a big '205' and a smaller one that we used for reconnaissance. And we landed in the first open place we saw, which turned out to be right next to the church—a bit of stupidity on our part. We were working seven days a week and this happened to be a Sunday. We had no problem at the time, but we found out later that we had disturbed their church service. I don't know whether we started it, but Old Crow became very opposed to pipelines, westerners, and everything else. There were a couple of other communities that were also quite radical, and we learned that we had to be very careful around them.

"We made camp in one of the unused log cabins at Old Crow, a cabin that was absolutely falling apart, and worked out of there. But it was summertime and the accommodation wasn't a concern. Most of the helicopter programs were flown in the summertime because in winter darkness was a problem. Old Crow was certainly very primitive. Fort McPherson was reasonable. The northern communities in those days were small—maybe a hundred people—and remote. The people were living off the land, mostly by trapping."

Ken Gillespie was a third member of RKL's exploratory party, and he remembers in particular the Mackenzie Valley communities of Wrigley, Fort Norman, and Fort Good Hope:

"We stopped at all of them along the way. They would give us a cabin to stay in and we would get some of the local people to cook for us. Some parts of the community would have a bit of electricity, but there was no plumbing. We actually stayed in cabins with only lamps. In most of the communities there was a Bay store, a school, usually a health nurse, and probably a telephone or a signals detachment. There was always an airstrip but air transportation was scarce. They were pretty isolated communities during the winter."

These northern communities were indeed isolated, and, according to Don Davison, they often wished to remain that way:

"At that time they really wanted to shut out western civilization or the southern influence. They did not want a white man around because he brought disease, he brought drinking. The outside influence was minimal. The odd white woman might have been living with a native person. The minister was often white and sometimes Métis. A lot of these communities revolved around the church and the school. Usually our contacts were with the minister or the local merchant to arrange some place to stay. At that time the leaders were strictly the church officials. They had a real archaic approach and were against any development because it was going to bring bad western things. They just didn't want anything.

"I always remember Fort Good Hope, where Arctic Gas had problems getting in. We had an Irishman in the crew—a real haywire fellow. But he got on well with the priest, so it was great for us. We learned from this and other places. Don't bring your western ideas or your city ideas. If you can get a staff member who knows how to deal with the locals, can adapt to local needs, then it's easy."

Earl Speer believes that the native people were initially against the pipeline because they were being provided with information by people who had an entirely different agenda: "I guess they were confused by the whole thing. It was an intrusion, of course, on their lands. And they felt that their people would suffer because of the construction crews coming in, influencing their young people, then leaving problems behind."

And soon environmental concerns entered the picture. Don Davison was among the earliest to note the problem: "In our very first investigation we were using tracked vehicles. Even though we were doing the work in late fall or winter, I'm sure that you could still see these tracks up there today. Of course construction of the pipeline would have done a tremendous amount more damage than that. So a lot of research was carried on about the thawing of the ground and the crossing of rivers in permafrost terrain. Much was learned that will prevent excessive environmental damage in the long run."

Davison concludes that the cancellation of the pipeline was, at the time, in the best interests of the native people:

"In retrospect I believe that the pipeline then would have done damage to the native communities. When we arrived in the early seventies, band councils, if they had them, were very weak and primitive. Since then they have gradually become accustomed to dealing with white people. They have learned to manage their own affairs. Their leaders are now native people. They are much better organized, have their own co-operatives, and their own municipal government. What's happened is that they have become business people and entrepreneurs. And now of course the natives favour development of the pipeline and the business and jobs that it will bring."

Several staff members contributed significantly to the challenging and demanding work load of the Calgary office during the first half of the 1970s. Among these were Allan L. Edgeworth, B.A.Sc. in geological engineering, University of British Columbia; Geoffrey A. Evans, M.Sc. in transportation engineering, University of Saskatchewan; Frederic B. Claridge, M.Sc. in soil mechanics and foundation engineering, University of Illinois; Jacques Roy, B.Sc. in civil engineering, University of Sherbrooke, Quebec and M.Eng. in soil mechanics, UBC, who had experience in highways and tunnelling methods for subway construction with Regie des Transport Parsiens, France; and A. James Zabachenski, a certified engineering technologist who had worked with Earl Speer on the South Saskatchewan River dam project.

Following the work in Saskatchewan, Zabachenski was employed with Warnock Hersey International Ltd. in the testing of soils, asphalt, and concrete, and in the training of local technicians, for various public works construction in Jamaica. "Jim" joined RKL upon his return from abroad in 1969, and immediately joined Earl Speer in some of the earliest explorations of the Mackenzie Valley oil pipeline route. A reliable and loyal employee, Jim remained with Klohn Leonoff as a senior field and laboratory technician until his sudden death of a heart attack at the wheel of his car in November 1989, after twenty years of service with the company.

Other key employees in the Alberta office during the boom years of the 1970s were supervising technician Allen S. Warsing, and Daniel G. Wasylyk, B.Sc. geology, University of British Columbia, who did geological studies and mapping for the northern gas pipelines and for the water resource projects in the Red Deer River Basin. In the mid-1970s, Robert J. Rennie, M.Sc. in soil mechanics and

James Zabachenski, June 1972.

foundation engineering, University of Alberta, was seconded from the Winnipeg office and played a critical role in the Kuwait materials investigation and report.

The year 1971 was profitable for Ripley, Klohn & Leonoff, with fees approaching the $1 million level. A stagnant period for the Vancouver office began in 1972–73,[55] but, thanks to the northern pipeline work, the company as a whole was able to maintain a modest profitability. In 1973 a new office for the Winnipeg operation was opened at 1288 Pembina Highway.

In August of 1973, Cyril Leonoff attended the Eighth International Conference on Soil Mechanics and Foundation Engineering held in Moscow. A post-conference tour was made to the Ukraine (Kiev and Yalta) by a party including three delegates who had Russian-Ukrainian roots: Gregory P. Tschebotarioff, Professor of Civil Engineering, Princeton University;[56] John L. Seychuk of H. Q. Golder & Associates, a Toronto-headquartered geotechnical firm; and Cyril Leonoff. On the tour each of the three delegates was accompanied by his wife, and Mrs. Seychuk had relatives living in the Ukraine, with whom the party met. And it had been exactly seventy years since the Leonoff family had departed from the Ukraine. Reminisces Leonoff, "They seemed to make a special point of treating these three couples very well—gave us the best hotel suites."

In December of 1973, in recognition of his contribution to the northern work, Earl Speer was appointed as a director of the company, bringing board membership to five directors.[57] Henceforth, in order to provide firm direction, formal meetings of the board were established on a regular, semi-annual basis.

A turnaround in the economic cycle began in 1974. That year revenue increased by 69 percent and profits by 80 percent. The upward trend would continue, with minor exceptions, through to the end of the decade.[58] (By 1980 the company was doing $6.5 million worth of business, a sevenfold increase over yearly totals at the beginning of the decade.) In other ways, too, 1974 was a breakthrough year that within a short time would change the face of the firm.

At the annual managers' meeting in May of that year, Klohn's keynote address set the stage, stressing that in future it was critically important that the firm present itself as a firm of "CONSULTING ENGINEERS" able to provide any required extent of services, from review and consulting services by specialists to complete project engineering. Furthermore, asserted Klohn, the company must project an international image, that of a company "willing and able to work anywhere in the world." And this must be accomplished, added Klohn, without ever sacrificing the company's reputation for dedication and integrity. While the prime concerns must always remain "the welfare of the project and the client," at all times the ethical behavior of the firm must remain beyond question.[59]

In June of 1974, the company name was shortened to Klohn Leonoff Consultants Ltd., "Civil and Geotechnical Engineers," reflecting the fact that Charlie Ripley was no longer active with the firm.[60]

Early in the year the field program for the first major foreign job, a materials inventory for the State of Kuwait, was launched (Chapter 11). As well, by the mid-1970s, the company had gained recognition from the American mining industry as a result of Klohn's work as a consultant and expert witness on the Reserve Mining Company tailings facility in Minnesota, a significant assignment that was to be the forerunner for the opening of a permanent United States office (Chapter 12).

In order to handle the greater work load, sophistication, and geographical diversity of the company's projects, during the mid-seventies staff were recruited from all over the continent, as well as from abroad. These new staff members had trained in some of the best geotechnical schools in the world, and included: Dr. Neil H. Wade from the University of New Brunswick, Imperial College and the University of London, England, a man who had served as a senior geotechnical engineer with B.C. Hydro; Adrian P. Joseph, also from Imperial College and the University of London, who had been employed with Peto MacCallum consulting engineers in Toronto; Vincent G. Fournier from Laval and the University of California, Berkeley, who had been a staff engineer with Dames & Moore in Chicago;[61] Chaim Perach, from the Technion, Israel, who had been with H. G. Acres, Niagara Falls; and Raul Lopez, an engineering geologist from the University of Cordoba, Argentina, who was fluent in both Spanish and Portuguese.

While none of these people were to become long-term employees, they effectively handled the challenging jobs of the period and left their mark in contributing to the increasing growth and expanded outlook of the company.

One of the engineers who came in 1969 and did stay to make a sizable contribution to the company's expertise in foundation engineering is Adrian Wightman. Wightman describes himself as a "Brit"—born in Derby in the Midlands of England. His father was a self-employed craftsman—a cabinet-maker and joiner. Adrian received a conventional education in a state system—primary and grammar school—"that had been around for about four hundred years and had a good reputation."

"I feel I had a very good education," says Wightman, "perhaps a little narrow. We did our Latin and Greek and all that kind of traditional stuff." Wightman excelled in the sciences—physics, chemistry, and mathematics—and thought of becoming a physicist. But he soon discovered that university placement in a physics course was "rather difficult." Explains Wightman:

"In Britain in the sixties, if you were bright enough, there was no real financial barrier to entering university. There were government grants to assist you. But the real barrier was in terms of the limited number of available university spaces. You had to be in the top five percent scholastically; otherwise there was just no room."

The senior Wightman was in a construction-oriented business and Adrian had seen some brochures showing engineers peering through the telescopes of transits and levels and "it all looked very attractive." Wightman decided upon an attempt at civil engineering, and such was the beginning of his career—"more through ignorance than anything else." Adrian was accepted into the University of Manchester, where Peter W. Rowe, one of Great Britain's leading soil mechanics engineers, was on the faculty. Rowe inspired Wightman to pursue soil mechanics, and Adrian completed his master's degree in February 1967.

As it happened, Dr. Rowe was an external consultant to W. A. Trow & Associates, soil mechanics consulting engineers in Ontario. And, since engineers were not very well compensated in Britain, Wightman reasoned that he would "go over to Canada for a couple of years, see the world and get a job at an inflated salary," then return home. Charter flights were available at a reduced fare (approximately £60) through a British Universities North America Club, and thus

Wightman found himself in the employ of Bill Trow. He was never to return to live in Britain.

Wightman spent two years with Trow, then got "itchy feet," wishing to see the West Coast. He remembered that Stuart Wharton, a fellow student at Manchester two or three years ahead of him, had gone to work for a company called Ripley, Klohn & Leonoff in British Columbia. Locating a B.C. phone book, Adrian discovered that, indeed, the firm existed. It seems almost astonishing, from the vantage point of higher technology and expanded bureaucracy, that the following sequence of events could then transpire as quickly as it did, evidenced by the correspondence:

May 20, 1969, a letter from Wightman in Hamilton to RKL in Vancouver suggested, somewhat timidly: "If you have a vacancy in the immediate or near future, I should be pleased if you would consider this application."

May 22, the letter was received at RKL, having taken just two days to cross the country by ordinary mail, at a cost of six cents' postage.

May 23, a letter was sent by Cyril Leonoff to Wightman: "I am enclosing an application form. If you will fill out the form and return it to us, we will be pleased to give consideration to your application."

On June 2, the application form was filled out and returned by Wightman.

June 4, in a telegram from Leonoff to Wightman: "Offer employment at $850 per month starting July 1 out of Vancouver office. Moving allowance $300. Advise acceptance." Recollects Wightman: "[Leonoff] didn't offer me the salary I'd asked for, but I must have thought it was good enough."

June 5, a telephone call was placed by Wightman to Leonoff. Adrian accepted the offer, but advised that he would have to give thirty days' notice to Trow.

July 14, Wightman reported for work in Vancouver.

There was, however, one catch. Attached to the application form that Wightman had completed was an addendum which read: "What are your personal limitations, if any, as regards field work, both short and long term, at locations beyond easy commuting distance from the metropolitan Vancouver area?" Then followed the explanation that "the nature of the work done by this company is such that much of our work is in the field at various locations. . . ."

Wightman, who was then only twenty-five years of age and single, studied this addendum carefully, hoping to assess all of its implications:

"I don't know if [Leonoff] remembers this form, but [he] must have designed it. Obviously there was a great emphasis on whether or not a guy was willing to go out in the field. It was clear that if you said no to all this rigmarole you weren't going to get hired. So I thought I'll play along a little bit. And it said further, 'Would you, if requested, be prepared to work in Calgary?' And I said, 'Yes.' 'Winnipeg?' 'No.' 'Any other location?' 'Possibly.' I hedged my bet a bit, and of course the first thing that bloody well happened was I got sent to Winnipeg, where I said I wouldn't go. So I got finessed."


Adrian Wightman

Late in that year, when winter was exerting its fierce grip on the Prairies and Wightman could tolerate it no longer, Leonoff happened to be visiting the Winnipeg office. Because there was then a heavy work load in British Columbia, Wightman was able to negotiate with him a transfer to Vancouver, effective January 1, 1970. Wightman recalls driving across the snowbound country in "an old Rover 2000," finally arriving in Vancouver during the first week of January.

Adrian Wightman was married in Vancouver on September 1, 1972. Two days earlier the new NDP government of B.C. had been sworn into office. Upon return from his honeymoon the effects were already being felt, and Wightman was requested to move to the Calgary office on "a trial basis." He remained in Calgary until the spring of 1974, by which time Calgary was "losing its attraction." Finally, by threat of resignation, on April 29 Wightman was transferred permanently to the Vancouver office where he has remained ever since.

Beginning with relatively simple gas station and Safeway store footings, Wightman soon graduated to heavy industrial foundations in the pulp and paper and mining industries, and, with minor variations, he has stayed with this calling. His experience includes a range of earthquake engineering applications, including seismic hazard evaluation, liquefaction assessment, ground response, and soil-structure interaction:

"I don't know that you're ever an expert in this field because it keeps changing so fast. I've made an effort to try and keep up to date with developments in foundation dynamics. Some of the things we used to do in the old days you just can't get away with anymore because there's a lot more sophisticated engineering that goes into, say, a paper machine foundation than was the case in the seventies. We made sure that we had a fairly heavy and stiff foundation, and the dynamics sort of took care of itself. There weren't the analytical tools to solve these problems, and the problems themselves didn't arise because the machines were slower in those days. Every generation of paper machine is faster than the previous one. So we do a lot more testing. Now it's an explicit design requirement to look at the deflections of the foundations and to worry about frequency response in order to make sure that the machine won't shake itself to pieces."

From the mid- to late-1970s, through experienced foundation engineers like Mark Olsen, Ian Morrison, and Adrian Wightman, Klohn Leonoff pioneered in British Columbia the application of "ground improvement" techniques, using dynamic consolidation processes such as vibro-flotation, vibro-replacement, and dynamic compaction. The objective of these techniques is to improve foundation soils so that bearing capacity is increased and settlement reduced. These processes are particularly germane in coastal tidewater and river estuary sites where the soils are generally heterogeneous loose sand-silt deposits that are incapable of supporting heavy structures without some form of remedial treatment. Ground improvement can in fact obviate the need for placement of deep foundations such as piles.

In 1975 one of KL's earliest applications of the vibroflotation process was used by Mark Olsen in preparing the foundations for the Central Maintenance Facility for the MacMillan Bloedel mill at their Powell River Division.[62] This method of *in-situ* densification of the soil deposit is achieved by using a vibrating, pokerlike probe suspended from a crane. The probe has water jets at the nose, and is thus able to penetrate the ground on a regular grid pattern to the required depth.

The tidewater site for the building was the former location of an old sawmill, and the beach was covered over with a loosely dumped fill of silty sand, gravel, and debris. The vibro-flotation method to be employed in densifying the foundation soils would be, without a doubt, a dirty, noisy job. Olsen, through the local Canada Manpower office, interviewed four candidates for the position of field inspector on this work. One of these happened to be a young woman. During the interview she asked Mark point-blank, "If I don't get the job, is it because I'm a woman?" Olsen, with many years of experience in rough field conditions, was admittedly somewhat skeptical of the proposition. Nevertheless, she was hired, and she was hired because, in Mark's mind, she was quite simply the best candidate for the job.

Mark was not to be disappointed. She handled the assignment with aplomb, in one instance observing that the survey stakes set by the contractor were out of line. The contractor couldn't believe this and bet the young woman that the stakes were in fact correctly aligned. A re-survey confirmed that she was correct. Observes Olsen, chuckling, "The contractor was seen sheepishly presenting her with a bottle of the best." Mark Olsen's young hiree had won the respect of the contractor and the engineer and no doubt made her own path slightly easier to follow for other women.

When the vibro-flotation method is augmented by the addition of graded stone aggregate pushed down the probe holes, then forced out laterally into the foundation soils to create stone columns, the improved process is called vibro-replacement. This latter method, along with piles, was used by Morrison and Wightman for the No. 11 Newsprint Machine at Powell River. According to Wightman: "That's the first application of vibro-replacement I know of for a sensitive paper machine foundation, and it's worked out very well." In 1978 the same process was used to stabilize loose sandy soils along the foreshore of a Saskatchewan Wheat Pool elevator in Vancouver's Burrard Inlet.

In 1979 Doman Industries Limited was building a large sawmill complex at the Duke Point Industrial Park near Nanaimo on Vancouver Island. The site had been created by quarrying bedrock material from two nearby ridges, then placing it as fill to form a reclaimed platform extending into

Dynamic compaction of rockfill with a 20-tonne weight, Duke Point, Vancouver Island, 1979.

Northumberland Channel. The site to be occupied by the mill buildings was underlain by coarse, end-dumped rockfill up to 15 metres thick. In studying the design Adrian Wightman was struggling with the problem of how to counteract the potential settlement of the loose rock. The solution he arrived at is called dynamic compaction, and he was the first engineer on the West Coast to try the process. With this method, the mechanical characteristics of the ground are improved to a considerable depth by the repeated application of a very high intensity impact to the surface. The procedure consists of dropping a heavy weight from great height—in the case of Duke Point a 20-tonne tamper through a height of 30 metres.[63] Relates Wightman: "I phoned up this French outfit back east [in Montreal] and asked them what they could do for us. And their guy was on the plane the next day. We came up with a scheme, wrote a contract, and the work was done. That company [Geopac West] has been here ever since."

Adrian Wightman and his assistant, Nelson F. Beaton, wrote a paper on this project, which was presented to an international conference.[64]

A further application of ground improvement that has come into vogue in the 1980s is in "earthquake engineering," a discipline particularly appropriate to the west coast of British Columbia, situated as it is within one of the most seismically active areas in Canada. Earthquakes of 7.0 to 8.4 on the Richter scale have been recorded in this region.[65] The Fraser River Delta adjoining Vancouver (in particular the city of Richmond) is heavily populated, and so is a prime area of concern. Wightman has been in the vanguard of preventive work done in this area:

"There's a lot more ground densification going on now than was happening ten years ago, or even five years ago. There's more and more awareness of the potential for subsoil liquefaction and more realization that we have to do something about it. One of the prime designs here is vibro-replacement, to densify the ground underneath the footprint of a building and for a certain distance outside. What they often do is actually leave 'windows' in the ground improvement zone and drive piles through there. But even with pile support, if the material around them liquefies, you're concerned about very large lateral deflections, which can destroy the pile foundation. It's a belt and braces sort of approach—a combination of pile support of the building loads and densification to stop the ground around the piles from liquefying in an earthquake. It's the same kind of approach that we used at Powell River."

On the Fraser River Delta, Klohn Leonoff was among the first to use ground improvement techniques at such industrial sites as B.C. Hydro's liquefied natural gas (LNG) plant at Tilbury Island (1980), a sand bank of the Fraser River, and at the Toyota wheel manufacturing plant (1982–83) located at Tilbury Industrial Park, Delta.[66]

In recognition of the increased contribution of the Alberta operations, through the pipeline and Kuwait jobs, KL's 1975 semi-annual directors' meeting was held, for the first time, in Calgary at the Sheraton Summit Hotel. The intention was to start alternating these meetings between Vancouver and Calgary, but this has never proven to be practical, and in fact, most of the subsequent meetings have been in Vancouver and Richmond.

At this 1975 meeting, an important discussion having long-term ramifications ensued on the subject of premises.[67] The Vancouver office presently occupied 7,000 square feet of space on Broadway and an additional 1,000-square-foot laboratory in a separate building. As a comparison, Calgary now occupied 5,500 square feet of office-laboratory. The Vancouver lease would be terminating in the fall. With increased growth in the volume of work and staff, the walls were being figuratively pushed out. What's more, the existing space was considered second class and inefficient—separated as it was on three floor levels and situated near the busy, noisy, and dusty main intersection of Broadway and Burrard, with limited parking space. So a decision was made to look for new offices.

Preliminary architectural plans which had been drawn up to construct a building on the First Avenue property confirmed that the firm had already outgrown the maximum 8,200 square feet that could be developed on this site. As a result, the property was sold. Another decision made at the time, which has been adhered to ever since, was that the company's expertise lay in engineering, not in property development or management. Consequently its resources would be devoted to enhancement of the company's engineering practice and staff, rather than to real estate. The principals were also cognizant, from their own sad experience, that conflicts of interest and ill feelings could result from a split ownership of the business and buildings.

Cyril Leonoff undertook to scout out new premises. Office parks were just then coming into vogue, where leased space on a modular system offered the greatest flexibility for the economic peaks and troughs common to a consulting engineering practice. Ideal facilities were found in the Airport Executive Park—then under construction, with a few buildings completed—in the neighbouring bedroom community of Richmond. Advantages of this site included access to a major freeway, ample parking, proximity to the international airport for the now frequently air-travelling staff, and adjoining hotel-restaurant facilities. Nevertheless an in-house selling job had to be done to convince personnel of the wisdom of moving out of Vancouver. The firm had been located close to the central core of Vancouver for a quarter century. Most of the staff lived in Vancouver, the North Shore, and Burnaby, all easily accessible to the Broadway office. As well, the move to Richmond was perceived by some to be a move away from the downtown offices of most of the company's clients and generally away from the "swim of things."

Sanity prevailed, 11,500 square feet of space was leased (9,000 finished), and the move to Richmond made effective November 1, 1975. Custom designed and decorated, these deluxe premises were (for the first time in the company's history) tailored to the special needs of the company, containing board room, library, print shop, laboratory, and space for drafting, word processing, accounting, and offices all on one floor and under one roof.

The move to Airport Executive Park proved to be a wise long-term choice. Today, Richmond, in the heart of the Greater Vancouver Regional District, has grown into a city in its own right, containing an equitable mix of industrial, commercial, and residential developments. And the firm now occupies an entire building of 35,000 square feet in the same development. On May 18, 1976, the company celebrated its twenty-fifth anniversary by holding an open house in its brand-new Richmond offices, an event well attended by clients, friends, and dignitaries. Klohn Leonoff Consultants Ltd. had finally "come of age."[68]

One of the immediate dividends from the move was the upgraded quality of support staff. The seventies witnessed the height of the "hippie" era, and in Vancouver's Kitsilano District, where the office had been situated, available secretarial staff tended to be young women with no particular interest in their job. During the summer they preferred to be lying on the beach, were frequently absent from work, or quit. Compounding the problem, "workhorse" Terry Garrett, the head secretary, had moved with her husband to live in the B.C. Interior.

While the move to Richmond caused competent people such as Barbara Leach and Leah Tevyaw, the latter who had been with the company for eight years and was Klohn's private secretary, to leave the company because Richmond was too far for them to travel, generally speaking the resulting transition in support staff was astounding. (Phyllis Barrington, an older woman who lived on the North Shore, was considered so invaluable to the Vancouver Accounting Department that a special concession was made to bring her to and from work by taxi.) In Richmond, mature women were available in the work force. Their families had grown up, and these women were now dedicated to pursuing a permanent career. To many of these people, an office in Richmond was closer to home, and working there preferable to downtown. The outstanding example was Letta Lewis for whom, as she perhaps immodestly but accurately states it, "Here was a company waiting for me to come along."

Letta W. Lewis, born to a Scottish family, was six years

The offices on Shellbridge Way, Airport Executive Park, Richmond, B.C.
Photos: Cyril Leonoff

The move on October 31, 1975.

Michael Dyck, office assistant, with van in front of offices, June 5, 1991.

Twenty-fifth anniversary open house, Richmond, B.C. – Chaim Perach demonstrating magnetic M-Scope, May 18, 1976.

old when World War II broke out. She vividly remembers during the Battle of Britain being put to bed every night in an air raid shelter built underground in the backyard of their house. In particular she recalls the night Coventry was bombed, twenty-five miles away—most of the city centre was destroyed by a single dusk-to-dawn German air raid on November 14 and 15, 1940:[69]

"It was a dreadful night and the whole sky was lit up with devastation from the bombing. I also remember being in bed one night when a stray bomb fell on the golf course behind our house. We suddenly had no windows left, and all the glass was across my bed. It was a miracle that there were no serious injuries that night. And really I am surprised that so many of us kids grew up to be normal people. Something happens to the British people in times of conflict—they all pull together."[70]

Letta's father and a grandfather were both engineers. As well, her maternal grandfather was a director and chief accountant for Stewart and Lloyd, the largest steel company in Great Britain. Both sides of the family were in fact involved with this company. Letta received the traditional education of an upper middle-class British family, attending a parochial Church of England junior school, followed by a scholarship to Queen Mary's High School—a venerable old school for girls—until the age of sixteen. Then she went on to attend a two-year business college:

"I did everything—bookkeeping, commerce, shorthand, typing, and all the academic subjects too—it was very intensive. You were a shorthand-typist in England. Shorthand was very widely used at that time and I loved it. To me shorthand was like learning another language, and once you learn you never forget. Even in this electronic age, it is still used by people like myself in senior positions for taking board minutes—any kind of minutes. It's very useful to take down speech verbatim, then weed out what you don't need, rather than struggling to make longhand notes. [Business college] was probably the highlight of my education. I thoroughly enjoyed it and I think it stimulated me for the rest of my life to seek further education, seminars and the like, anything I could get my hands on to learn more. My one regret is that I didn't go to university, because I feel that I would have done very well. But I am a war child, and things were pretty tough after the war. In England at that time the opportunities for girls to go to university were few and far between."

Letta was almost eighteen when she got her first job as a junior secretary with a barrister in Lichfield, Staffordshire, a beautiful cathedral city:

"The offices that I worked in were like something out of Charles Dickens, all dark oak and poky. I remember the senior partner, Mr. Mosely's great big office—lined with hundreds of books. I was very impressed. The senior secretary was a real old maid, as we called them in those days, and I could see that she was there forever and a day, and there was going to be no advancement for me."

So Letta took other employment and within a few years worked her way up to the position of secretary to the managing director of a large lithographic company.

By then Letta had married a bookkeeper/accountant. She had cousins who had recently emigrated to Vancouver and written home "extolling the virtues of this beautiful place." So, the day after Gamal Abdel Nasser of Egypt took the Suez Canal,[71] she wrote for the applications for immigration. Air travel was in its infancy in the fifties and, for Letta, coming to North America seemed like going to the end of the world. As well, there was "the worry that you would never see your family again." The Lewises came straight to Vancouver, arriving on the Dominion Day weekend in 1957, and being immediately impressed with the beauty of the city: "I will never take the beauty of this place for granted. I think people who are born here do take it for granted. But we have a different perception."

And there is no doubt in Letta's mind that the move to Vancouver was a wise decision: "When we go back to [visit] that highly industrialized area in the Midlands, it's just like a ghost town. All the big factories that we knew are closed and there is massive unemployment."

Letta's husband, "Ernie," quickly found work in Vancouver. And soon Letta read an ad in the newspaper for a secretary at Crofton House School, a place that, when she visited it, reminded Letta of her own high school. The difference being that Crofton House, founded in 1898, was in its comparative infancy. Queen Mary's High School, where Letta attended, had by then celebrated its 400th birthday. So, "in this lovely sitting-room in the residence of Crofton House," Letta Lewis, just "twenty-four and a greenhorn from England," found herself being interviewed by the imposing headmistress, sitting next to "this pile of air-mail envelopes—all these applications for the job that [she] had applied for." Nevertheless, she won the job and progressed to become the administrative assistant and registrar of the school, staying for six years until the first of her two children was born.

Letta's daughter Caroline would later grow up to join the staff of Klohn Leonoff but, while her children were younger, Letta was at home with them and therefore out of the work force until 1974: "There were never any latch-key children in our house. It's sad but I think this is why there are so many problems with the young people today. We have never had any problems with ours because both my husband and I were with them when they needed us. But I don't think that is realistic today."

Letta Lewis

Eventually however, as her children grew older, Letta grew restless with life at home: "I got tired of not having enough to do and not using the brain enough. So I decided that I needed some stimulation. Much against my husband's will, I took a casual job with CP Air in what they call the steno pool."

The steno pool gave Letta the opportunity that permanent airline employees don't get—to acquire a broad knowledge by working in virtually every department. With CP, for instance, she learned word processing, which in 1974 was in a fledgling state: "I really loved it. We started off on the old IBM's with the magnetic tapes. And then they got these marvellous new Redactron machines. Still a tape system, but now we moved from a single to a dual tape, which was very sophisticated."

What Letta didn't like about CP Air was the fact that they used a "line count" each day to access productivity—though her own line count was extremely high.

At the time, Klohn Leonoff was advertising for secretarial staff through Drake Personnel, and when Letta appeared one morning at that firm's office, in recognition of her experience Drake quickly waived all their usual tests. Instead she was sent for an interview with Keith Douglass—"a gentleman, a really nice man." For evaluation, Douglass used a point system on a scale of ten and Letta rated a nine. Obviously Letta was in demand:

"Two days later I got called in again, and these two great big tall guys—Ian Morrison and Mark Olsen—walked into the room. I felt a little intimidated. Ian insisted I do a test, so he gave me one of his tapes, sat me down at a typewriter, and I had to transcribe this letter. Ian is wonderful on the dictaphone, but what he didn't tell me was that the machine I was typing on had been adapted to French. So it had lots of dead keys, which were used for accents, and I had to struggle with this machine to type the letter. Anyway, they must have been impressed because I went home and within four hours they offered me the position of typist, starting at $700 a month."

This offer came three days prior to the company's move to Richmond.

Far more than mere typing, Letta Lewis brought to her job professional secretarial and organizational skills the like of which the company had not experienced before. She quickly rose to the top of the vital Office Services Department. Most of all, says Letta, she has done so well because of her ability to anticipate and confront difficulties head on:

"I am a communicator. And because communication was opened up with senior management, we were able to resolve problems, discussing where we should go and how we could get there. Also I never stand in awe of anyone and won't allow anybody to walk over me. They may be experts in their profession, but I am at the top of mine."

Starting virtually from scratch, with new offices, new personnel, and rapidly developing electronic office technology, Lewis worked closely with Cyril Leonoff in overhauling the entire office support structure. In particular Letta was very "fussy and careful" about the hiring process. The best people available in the marketplace were hired to do a certain job, and they were required to have the ambition to progress to more complex tasks, to be willing to give a long-term commitment to an expanding engineering company.

In Letta's mind, the image projected by the company came first of all from the "shop window"—the reception desk. Therefore receptionists were brought in who were a credit to the front desk, and the telephone, though not necessarily visually. "One of the best wasn't a beauty," says Letta, "but she had such personality that she could just win anyone over." Recognizing the fact that a receptionist's working life is typically about eighteen months (before they are ready to go on to something else), a plan was developed for promoting former receptionists into another area following their stint at the front desk. (A notable example of someone who benefited from this program is Wendy Bowden, who started with KL as a receptionist and today fills Letta's former position as administrative assistant at Crofton House School.) This was true also for other entry-level tasks, allowing support staff ready access to upward mobility. As the company grew, a steno pool was opened up. Explains Letta, "Although I did my share of ten-hour days and Saturdays and Sundays, I then had resources for calling in people on a part-time basis if we got busy, so that the onus wasn't always on just one or two women to do all this massive production of reports."

The most revolutionary change undertaken by the support staff was the opening of a Word Processing Department, changing over from manual IBM Selectric typewriters to state-of-the-art Redactron equipment with memory—one of the first such uses by an engineering firm in the Vancouver area. Recalls Letta: "Redactron did a good job for us. When I think of how many drafts I had to go through, having to type and retype before I reached the white bond final copy, the advent of word processing was just wonderful." No doubt the "big hit" of the twenty-fifth anniversary was the novel word-processing demonstrations given at the open house. The office restructuring could finally be said to be completed as of May 1977, with the issuance by the corporate office (with input from all departments) of the comprehensive "Operating Procedures and Policies Manual," which became the working "bible" of the company for that period.[72] Concludes Letta, "Everything [we] achieved in this company has been through dedication and hard work."

In September 1976, Letta Lewis was appointed to the position of administrative secretary to the corporate president and vice-president, this while continuing her duties as co-ordinator of the secretarial area. In November 1977 the latter job was taken over by Maureen Luck and later by Wendy (Seath) Sellars. In January 1989, Letta transferred to Klohn-Crippen Consultants Ltd. (Chapter 14) where she is the executive assistant and office manager. Other people who have been senior word processing operators include Fran

Holbrook, Bonnie Lee, and Carey Oliver. Currently Trish (Proctor) Pharey heads the Word Processing Department.

Linda Davidson is another example of the kind of dedicated and reliable employee who works at the core of the support staff at KL. Vancouver-born, Linda grew up in the working-class East End where she attended Charles Dickens Elementary and Sir Charles Tupper High School. Linda began her working career as a switchboard operator, but then left employment to marry and raise a family. She returned to the work force with KL in mid-1980. Progressively, she has filled positions in records, accounting keypunch, switchboard, word processing, as secretary of the Water Resources and Mining divisions, and is now corporate secretary to the vice-president of finance. Linda attributes her longevity with the firm to the interesting variety of work she has undertaken, and the opportunity for advancement, but more than anything else, "because of the people."

The new office coincided with the advent of the electronic age, which caused a revolution in business practices. The Redactron word processors gave way to the microcomputer using WordPerfect software. The first fax machine was purchased in the mid-seventies to transmit direct messages between head office and the Reserve Mining job in Minnesota. The Xerox copy machine replaced carbon paper and the Gestetner. Portable cassette recorders replaced the dictaphone. Supplanting the traditional engineers' slide rule was the pocket calculator. The first computer programs were initiated by Bob Maartman in the early seventies. The first personal computers were brought into the office by Ken Lum and Ian Morrison at the end of the seventies. Today one can count some one hundred personal computers in the individual offices—indispensable to engineering data compilation and calculation. Telephone systems became much more utilitarian with the advent of such features as speed dial, conference call, call hold, call forward, and call back. And today desktop publishing has facilitated the production of professional reports and brochures. Perhaps the most labour-saving device of all is AutoCAD (Automated computer-assisted drafting).

Eric D. Pharey became supervising draftsman for Klohn Leonoff in 1975, co-ordinating the drafting work that goes through AutoCAD, a system which handles the majority of the work load today. (Traditional manual drafting is now only used for certain small jobs.) Pharey is of British descent, and was born in North Vancouver in 1944:

Eric Pharey
Photos: Cyril Leonoff

At drafting board, Broadway office, April 21, 1970.

AutoCAD operator, Richmond office, February 19, 1991.

"It wasn't a very large community then. We lived virtually in the middle of the woods on a dead-end street—fantastic area just north of the present Upper Levels Highway. But you go up there today and all these big houses—it's the smallest house on the block. The trees are gone and there's so much traffic."

Pharey graduated from North Vancouver High School, where he usually did well enough to pass, but "no more, no less." He enjoyed reading, but preferred to set his own schedule, and curriculum whenever possible, a habit which persists with him today:

"Basically I've managed to learn just by reading—more than by taking courses. That way you can read the topics that interest you and set your own pace. I took up photography just by reading books. I haven't got much time for fiction because there are too many other things to be read that you can learn from."

Ironically, one of the few courses he failed while at high school was drafting. He was required to draw up plans for the wood and metal items he was to build in his industrial arts class:

"What I produced passed but the drawings never passed; they were just atrocious. My teacher said, 'You'll never make a draftsman.' And I tended to agree with him. I had no intention of becoming a draftsman."

After graduation, Eric Pharey took a job with the Department of Highways on a field crew that was surveying a projected highway link between Port Alberni and Comox on Vancouver Island. He worked on the Island for ten months, most of them winter months, and it was not an experience he enjoyed: "It was miserable; it was rotten. So I said, to hell with this, I'm going to try and get a job a little more civilized, because I don't want to do this for my whole life."

There was an opening on the survey crew in the city of North Vancouver, where his father also worked as a backhoe operator. Having some experience, he got the job and worked outdoors for eighteen months. Then a position came up for a draftsman in the Engineering Department:

"So I applied for that, took a little test, and managed to pass it, believe it or not. It was quite ironic. I had been there for about a year when my old industrial arts teacher came into the city hall to pay his taxes. And he saw me there and asked, 'What are you doing here?' And I said, 'Oh I work here. I'm a draftsman in the Engineering Department.' And he just roared with laughter, after having told me I would never be a draftsman.

"Everything was then drawn by hand with pen and ink on linen. I guess I did reasonably well. From having the field experience surveying, you were a little more familiar with reducing the notes on cuts and fills for the roads, sidewalks, and sewers that we were designing."

But Pharey could see no future with the Engineering Department. The office was unionized, with a regimented system for advancement. It could take fifteen years to move up to Draftsman III. What's more, according to Pharey, having achieved that goal, "You'd still be no further ahead—doing the same job—than when you started." So Eric found work with Versatile Drafting, a firm which would contract out draftspersons to various companies.

His employer's office was located above a clothing store at Pender and Seymour streets in the hub of "old-town" Vancouver. While there, Eric's attention was drawn to the adjacent office of a mechanical engineer who was well into his eighties. It was the late 1960s, but the old man was still running an engineering practice reminiscent of the early decades of the century:

"This guy was just phenomenal—a one-man operation. And he was still using the tools of the trade that he would have had when he graduated—gooseneck lamps, old T-squares and set squares, ancient manuals and textbooks. He died shortly afterwards. This sea of stuff was probably very rare and a real collectors' item if somebody could have got their hands on it."

In January 1968, RKL needed extra drafting help to work on the Brenda Mines project, and so contacted Versatile Drafting. Arriving at the old Broadway office, Pharey was taken upstairs and introduced to Dick Read, whom Eric was later to replace.

In working on a temporary basis on the Brenda Mines project and its Peachland Dam, Pharey found himself drafting alongside Walter Shukin, an engineering student who was taking a year off school. Soon ideas of a more permanent position were occurring to Eric:

"Around the beginning of March I said, this doesn't seem like a bad place to work; I'll see if they need anybody. So I talked to Mark Olsen, who was in charge of the project. I asked him how to get a job in this place, and he gave me an application to fill out, with a space to fill in my salary request. In those days I was making $425, and I wanted to get a little more. So I thought, well, I'll put down $475. And I talked to Walter and asked, 'What do you think Walter, do you think I'll get $475?' He shook his head and said, 'I don't think you will.' Then a fellow named Cyril Leonoff came and said, 'We'll give you a job at $450 a month. So that's where it all started."

Leonoff recalls the encounter with equal clarity, and he was willing to make the monetary compromise because of a sense he had of possible long-term benefits for the company. It was a hunch that was to prove sagacious:

"A year later, Eric strode into my office and with an air of certainty declared, 'I've decided to make this my permanent career.' He was true to his words. Thus we acquired a competent draftsman and a dedicated employee who has been at the heart of our Drafting Department for over twenty years."

Pharey considered his new job a decided advance, inasmuch as RKL had actual drafting machines on actual tables:

"The last place I worked, it was on a door with Borco covering put on. At RKL you had a straight-edge that ran up and down on wires to make horizontal lines, and you used your set square for vertical lines. These old drafting tables, which I thought were wonderful, were German manufactured and had this huge counterweight which would swing out on a big arc. So that actually you needed an area of about 100 square feet in order to operate it. And I think we made a fair amount of money when we sold them because they were unique—actually a collectors' item as they weren't making them like that anymore. On the last one, which we kept for a number of years, we lost the counterweight, or somebody took it for an anchor, 'cause this thing weighed over a hundred pounds!

"In the first office, every time they hired more engineers they decided to change things around, and the Drafting Department always got moved into smaller back rooms. And you were climbing over things to get onto your drafting table, hitting your head on these huge machines. Finally they put us in the basement, because we were out of the way down there. When we moved into the second Broadway office, again Drafting got what was left over and stuck into a corner. I think the drafting room moved four times in five years and every time it was to a smaller corner of the office. Finally we got some sense and decided to upgrade with modern drafting machines; now we could stick two tables in the space of one. Then the office just physically ran out of space, and we ended up going to Richmond, which was really nice.

"When we moved out to Richmond, we were still working on the big Reserve Mining job (Chapter 12). Then all of a sudden work dropped off. It was kind of scary having all this space and hardly anybody in there. You could shoot a cannon through that office and not hit anybody. For the first ten years of my time with Klohn Leonoff there were just two draftsmen, myself and John Kan. And, depending on work load, we brought in a temporary for a month here and there. Then in Richmond things picked up, and boy, we had three or four draftsmen besides myself working for us. Now we could grab some territory and actually set up a real drafting area. Then we got another large job, B.C. Rail tunnels, and we took another building over. We had to set up a drafting shop over there with fourteen drafters for that project. So, along with the main office, we were up to nineteen or twenty drafters, all on boards and doing it by hand. When that job finished we were back down to three. We basically stayed like that until we got another large job, the Ok Menga project (Chapter 11), where we brought in a bunch of ex-B.C. Hydro drafters to work on that New Guinea job.

"What pushed us into automated drafting is that one of our [mining] clients in the Highland Valley sent down drawings for our review. They had been done on a computer and everybody looked at these drawings. We could find a lot wrong with them, but the fact was that our client was ahead of us technically. They were doing something that we weren't doing and we should have been doing; we should have been the ones that were in the lead and not our client. It cost us a fortune to get this one whizzy AutoCAD station. Then we had to learn how to use it. I had to buy a computer on my own and learn how to run AutoCAD in the evening so that I could come to work and do what was required of me on the computer. It wasn't all that long ago [1985], but there was little automated drafting being done then. Now every technical college is offering computer drafting courses. Now the problem is that we're getting these people who know how to run a computer, they know how to move lines around and draw circles and arcs. But they don't know how to draft, how to lay anything out, how to give it some depth, how to present something and make it look like a drawing. So rule number one these days is that these people should know how to draft manually in order to appreciate what a computer can do.

"When I started on AutoCAD, I used to judge everything by how fast things could be done on a computer, compared to how long it used to take me to do it by hand. The time savings were astronomical. Probably one AutoCAD station takes the place of two manual drafters. Not only could we turn out drawings faster, they looked better. You don't have to worry about cutting pieces out, then scotch-taping other pieces in, then sending this thing out to the client after it's blueprinted, looking like a patchwork quilt of different shades of blue. You can add things in, you can take lines out, you can change scale. It doesn't matter how many times you change that drawing, it's revised or hacked apart, the client's always getting a fresh drawing that looks brand new. And if he wants to make a change, the cost is minimal—you can totally redo the drawing in a matter of minutes.

"Six years ago we had one; today we have eight Auto-CAD's in a room. Now if the power goes off you're dead, you can't do anything. In the old days you could still sit there and draw a line with a pencil. And it's going to be very hard to get us out of there because it's all wired with special plugs. So I think that the Drafting Department has finally found a home where it isn't going to be pushed into the corner anymore."

In the years 1974 through 1975, Canadians witnessed an overheated economy and a rampant inflationary spiral. At the beginning of 1976, the federal anti-inflationary guidelines, which involved price and wage controls, came into place.[73] While these measures did not have an immediate effect on the work load and profitability of the company, they did serve to dampen the economy, and their full effect was felt in the first half of 1977.

As well, during the mid-seventies, the company pressed ahead with its recruitment campaign and made two principal staff acquisitions that were to have profound long-term benefits in strengthening and expanding the company. In July 1976, Dr. Raymond P. Benson joined the firm, filling the office of Vice-President Engineering,[74] and in December 1976, Dr. Ernest A. Portfors was hired as Executive Engineer and head of the Hydraulics Section.[75] Benson would eventually rise to the office of President of Klohn Leonoff and Portfors to Vice-President Engineering.

John Benson was born in Sweden and came with his parents to the United States at the turn of this century. Fortuitously, the Bensons left San Francisco just two or three days before the earthquake of 1906, moving to Redcliffe in southern Alberta. There they were engaged in the hotel business, which had been their vocation in Sweden. In 1919 Benson married a young woman named Avis Dearborn, an American from Maine who, seeking adventure in Canada, was working as a waitress at the Banff Springs Hotel. She was just eighteen and John some twenty years older. The couple continued in the hotel business with some success, but Benson, who had come from a farming district in Sweden, dreamed of becoming a farmer.

Raymond Benson

So, though already middle-aged, John Benson bought a section of farmland near the town of Strongfield, just a few miles from the present Gardiner Dam on the South Saskatchewan River. The property was no ordinary Saskatchewan homestead. Actually two farms, side by side, had been built by an English gentleman, and this "fantastic" section of land contained a large old farmhouse, electricity obtained from storage batteries and generated by a windmill, a tennis court, and numerous groves of trees. The farm soon became a rallying point and meeting place for the entire area. Unfortunately the property was purchased just before the stock market crash of 1929, and, in the hands of an inexperienced farmer and with the onset of the Great Depression, the operation became a downward struggle. John Benson fell ill and died in 1943, at the age of sixty, and the farm was repossessed by the bank.

Raymond Philip Benson was born on this farm on December 1, 1935, the seventh of ten children. "I am a classic Saskatchewan farm boy," claims Ray, "I attended a single-room schoolhouse, called Cherry Dale, to grade four. Economics were poor at that time and continued to get worse. We had a difficult life. I remember doing chores on the farm when I was only six or seven years old. We had no money and I couldn't afford anything. My interest was sports—playing ball—which didn't cost anything. My mother worked like hell. She had a very hard life raising ten children. My father was a proud man and wouldn't go on relief. Losing a father in that kind of environment, where the dominant male is so important, had a big impact."

After John's death, the family moved first to a small town, then to Calgary. Says Ray: "Everybody had to work and help the family. So the first job I had was at age thirteen, digging up carrots in a Chinese garden in Calgary." Ray attended junior high and high school in Calgary. "I was always a good student, without realizing I was a good student. Coming from a farm, though, I was terribly shy, awfully backward, and completely naïve. On graduation from high school, I truly did not know what a university was. Nobody in my family knew much about advanced education, and they certainly couldn't advise me."

Ray Benson found a job as a rodman with Calgary Power, surveying in the mountains for potential dam sites, though he did not know the purpose at that time. One summer a high school classmate who was attending university came to work on the survey party. He told Ray how much he liked university and how challenging it was. "I always had a drive to succeed," admits Ray, "and I felt that I was as good as anybody in sports, in intellectual pursuits, or in anything. And so I thought, well goddamn it, if Bill Woods can go to this place called university, then I can go too. So I went to university, in engineering—exactly the same thing that he was doing. It's fair to say that this was as the result of a determination to prove myself, more than anything else."

Benson enrolled in engineering at the University of Alberta. He spent the summers with Alberta Water Resources "doing surveying, looking at dam sites, fixing up rivers," thereby becoming interested in soil mechanics: "I remember being out on a summer job when Dean Hardy turned up in the field as a geotechnical consultant. I still remember him poking around the hillside with a geological pick, looking at the soil, talking about how it related to the drilling. I remember being fascinated by that, and really that is the reason I went into civil engineering and then into soil mechanics."

At that time Bob Hardy was in the process of retiring from the university to devote full time to his engineering practice. But the University of Alberta still had a top Soil Mechanics Department under Professor "Stu" Sinclair and younger men such as Elmer Brooker, a new Ph.D. graduate from Illinois. An entirely new world had opened up in Ray Benson's life:

"I was a good student and I worked adequately to succeed, but I was not a top undergraduate scholar. I put in a lot of time on other pursuits. Of course I have always done a lot of sports. And we used to party. I matured late in life because of my upbringing, had three years out between high school and university, and came to a reasonable maturity around the time I started university. So when I realized there were other things in life, I took to them with a passion. University was certainly one of them, but it was by no means the central thing in my life. Actually I think I overdid it in other areas."

Benson graduated with a bachelor's degree in May 1960. By then his career was focused, and he knew he wanted to be in soil mechanics. He had two offers of employment, one from Alcan and the other from PFRA. He chose the latter because of the reputation of Bob Peterson (Chapter 1). Ray offers this retrospective of Peterson today:

"I still think Bob Peterson is one of the very best, if not the best, soil mechanics engineer that Canada has ever produced. He had a wonderful insight into soil mechanics, and I think if he were an American he would be known equally beside people like Terzaghi and Casagrande. Aside from all his capability in the design and building of earth dams, his knowledge of clay shales—being such treacherous materials—preceded that of Casagrande."

Unfortunately Peterson died prematurely in 1969, at the age of fifty-one.[76]

At PFRA Benson was an engineer-in-training. The agency had an excellent program for young engineers, requiring them to move from department to department in soil mechanics, concrete, and "all kinds of things." While he worked for second- or third-level supervisory staff, Ray nevertheless had ample contact with Peterson: "It wasn't a big office on the campus at Saskatoon. We were all on the same floor. He spent time with all the engineers, and I would be in meetings with him."

Benson spent the summer of 1961 on construction of the South Saskatchewan River dam project. "That was my first introduction to dam building, where I really began to flower, because I loved every second of it. It wasn't work for me, it was all just fun, and I dropped a lot of this partying because the engineering was such a challenge."

Dam building was to spark Ray's great ambition to succeed at the highest levels of engineering, a goal which no doubt also derived in part from his early deprivations. Ironically this inspiration occurred virtually at the very spot where he had had such a humble beginning in life. And at the South Saskatchewan project, coincidentally, he was to meet Earl Speer, who later would become his executive vice-president and chief operating officer at Klohn Leonoff.

For all of the impact it had on him, and as much as he loved the work, Ray Benson stayed with PFRA for only two years: "I had a hard time fitting in with the bureaucracy of a government organization. I was footloose and wanted to get other experience."

So, in the fall of 1962 he joined IPEC, a company anticipating construction of the Portage Mountain Dam on the Peace River. While with IPEC, he worked for Mark Olsen of RKL for a short time and met Professor Ralph Peck of the University of Illinois (Chapter 7). In so doing his future career path was firmly set.

Benson completed his master's degree at Illinois in the spring of 1966. Leaving the university, he spent the summer with his wife in Europe, planning to pursue a career as a construction engineer building earthfill dams around the world. However, in the fall of 1966, Benson was persuaded to return to Illinois to take a Ph.D. degree. He had a "tremendously difficult work load," but completed all of the courses by the spring of 1968. His advisor, of course, was Dr. Peck, one of the world's most distinguished soil mechanics engineers. At the time, rock mechanics was just coming into prominence as a specialty, and Professor Donald U. Deere, an engineering geologist at Illinois, was the foremost specialist in this field. (By this time, Illinois had surpassed Harvard to become the most highly regarded geotechnical school in the world.) Benson chose to do his Ph.D. thesis in rock mechanics, in association with Dr. Deere.

Deere was consultant to H. G. Acres, one of the premier engineering companies of Canada, in the design of the underground powerhouse at Churchill Falls, Labrador,[77] then the largest such powerhouse in the world. Ray and his wife had grown tired of the grind of university life, so he decided to do his thesis out in practice. Acres didn't have anyone with classical rock mechanics training in the company, and thus the opportunity presented itself for Benson to join their staff. He finished his thesis in 1970.

Benson spent ten years with Acres, half of these working under Bob Conlon, one of Canada's foremost geotechnical engineers. He travelled all over the world, working on a large number of hydroelectric projects, many of them

Presentation to Dr. Ralph Peck of a black bear soapstone carving, VII Panamerican Conference, Vancouver, B.C., June 19–24, 1983, from left: Tony Stermac (CGS president), Raymond Benson (Organizing Committee chairman), Ralph Peck (keynote speaker), Victor de Mello (ISSMFE president).
Credit: Geotechnical News, September–November, 1983

precedent-setting. Some of these projects included Alto Anchicaya, in Colombia, the highest concrete-faced rockfill dam in the world; a high earthfill dam, surface powerhouse, and tunnels in heavy earthquake country near Aslantas, Turkey; and the unwatering and repair of very high-head (3,000-foot) pressure tunnels at Nilo Pecanha and Cubatao, in Brazil. After Conlon left the company in 1971, Benson replaced him as head of the Geotechnical Department and found that, in being responsible for all aspects of geotechnical engineering at Acres, "the challenge was even greater."

Meanwhile, by the time of its silver anniversary, Klohn Leonoff was becoming increasingly involved in sophisticated engineering problems, beginning to develop international consulting assignments, and expanding its base into ever-larger general civil engineering projects. But the only engineer of international stature in the company was Earle Klohn. Thus the company was in need of a "chief engineer" with a broad background in heavy civil engineering projects and considerable international experience. As well, it was recognized that at some stage in the future an energetic younger heir would have to be found with the capability, reputation, and drive to head the company. Earl Speer had known Ray Benson since his days at PFRA, and when he mentioned Ray as a possible candidate for the position, the KL directors felt they had found someone fitting the desired specifications.

A self-confessed "very ambitious man," at the beginning of his forties Benson had reached the stage in his career where it was time for a decision. At H. G. Acres, he headed up, both administratively and technically, a specialized division of fifty people in a company of a thousand. In such a large company, the road to the top required a choice between either a management or a technical path. Benson had a "tremendous interest" in the technical side, but he knew that if he chose that route, ultimately he would be a specialist and so directed by others. On the other hand, in management the future was always unclear. Working in a large organization meant many bureaucratic dead ends. "I rebelled at that," states Ray unequivocally, "I wanted to have a bigger impact on my own destiny and a chance to prove that I could generate work on my own, without others bringing projects to me."

The objectives of Klohn Leonoff coincided with the ambitions of Ray Benson:

"I have always felt that geotechnical engineering, while certainly a fascinating field, is very restrictive. There is a limit to how large you can grow and to what extent you are your own master. You usually end up just being directed by other companies. In my discussions with Earle Klohn, he promised that the company was committed to developing beyond its geotechnical base into general civil engineering projects. What brought me here was the company's known expertise, high quality of work, excellent reputation, and the knowledge that I would be an integral part of an operation that would move out into other areas."

In 1984 Benson would become senior vice-president and in 1987 the third president of Klohn Leonoff. Summarizing the highlights of his fifteen years of participation in the company, he concludes:

"Naturally it has been a very hard fight to move a company with certain limited goals towards broader ones. You have successes and failures. But to me the greatest overall satisfaction is to see the growth of Klohn Leonoff as a general engineering company engaged mainly in the development of heavy civil projects. Another was the opportunity to have developed my own individual capability on a large number of hydroelectric projects in South America and other places. And I've been able to prove that I can operate at board level with the top North American consultants."

In 1976 Klohn Leonoff Consultants Ltd. remained primarily a geotechnical company. However the firm was encountering a growing variety of hydraulic-related tasks, particularly on mining projects. The Calgary office had also identified a number of pending water storage-irrigation projects in the dry-belt region of southern Alberta (Chapter 10). As soon as he came on staff, one of Ray Benson's priorities was to strengthen the capacity of the company in the disciplines of hydrogeology and hydraulics. Bob Maartman had worked in the early sixties with a bright young engineer in the Ingeldow-Kidd firm—Ernest Portfors—and so Benson was able to identify Portfors as a civil engineer who could fill KL's needs in this field.

It may have been no coincidence that Ernest Andrew Portfors, born and raised on dry ranch-land near Hanna, Alberta, 165 kilometres northeast of Calgary, where water is a precious commodity, would be attracted to water-related subjects. Yet the Portforses' family roots were principally in farming. Ernest's father, Eric Andrew Portfors, came from an ethnic Swedish family who had inhabited agricultural land on the west coast of Finland. Eric Portfors had come to America as a teenager to live with an older brother in Idaho, where Eric worked for a few years as a carpenter in the silver mines. In 1909 he took up a homestead ten miles south of Hanna. A bachelor, he was nevertheless chairman of the local school board when in 1929 he met and married Marjorie Warke, who, after teacher-training at the Calgary Normal School, was on her first posting to the Red Rose country school. Of English ancestry, Marjorie had grown up in the Pine Lake district near Red Deer, Alberta, the daughter of a doctor.

Ernest Portfors

Ernest Portfors, the younger of two siblings, was born in Hanna in 1939. The family operated a fairly large mixed farm of five-and-a-half sections. One section of this marginal agricultural land was cultivated and the remainder kept as grazing and hay land for cattle. Typical of the family farms that proliferated in Alberta in the period, in sharp contrast to the big mechanized farms of today, the Portforses ran about 150 head of cattle, had one or two milk cows, as well as pigs, chickens, dogs and cats. The family members, with the help of a hired man, did all the work required by the farm, and, according to "Ernie":

"The interest we had centered around the agricultural industry. When you grow up on a farm, you always have your chores to do—milking of cows, feeding of pigs and chickens, these sorts of things. The social life was largely local dances on Friday nights and going into town Saturday afternoon-evening. Sports were mainly recreational—we didn't have the leagues or organized sports that are prevalent today."

Ernest's primary education was obtained in the typical one-room country school, alongside twelve to twenty other students in grades one to nine. And afterwards Ernie boarded in Hanna for three years of high school.

In similar fashion to what her father had done, Ernie's older sister married the first male local schoolteacher and went off to raise a family. As the only male heir, Ernest Portfors had the option of inheriting the family farm, but after high school it was obvious that he wasn't really interested in agriculture:

"It is fair to say that the strongest impression I had during the years of growing up was of my parents talking about what the Depression meant to them. Along with everybody in the Prairies, they struggled very hard to survive. Even as things got better, they hardly spent much money. Going on vacations and things like that was just non-existent. If you have animals you just can't get away. It struck me that the only way to be successful in agriculture is to be much more specialized and businesslike, either with very much larger ranches running literally thousands of head of cattle and production feed lots or grain farming of several sections of land with very large equipment. Such large-scale operations didn't appeal to me."

On the other hand, education did: "My mother's father was a doctor—an educated man—and mother certainly was a strong advocate of higher education. During public school she insisted that I do my homework at night and practice spelling. My father realized very quickly that if one was going to get ahead in the world, that was what you had to do. Ultimately he became resigned to the fact that I was not going to become a farmer, sold the farm in 1954, and retired in Hanna."

For Ernest, when it came to university, engineering seemed the logical course to take. He had done well in mathematics at school, and on the farm had been a jack-of-all-trades: "I grew up in an atmosphere of having to do mechanical-related work. My background had been building things. Engineers were people who built things, so engineering seemed like a fairly natural field to go into."

Ernest Portfors entered the University of Alberta in civil engineering, mostly paying his own way with summer work and scholarships. In the fourth year, under the influence of the senior hydraulics professor Tom Blench, a world expert in sediment transport and river engineering, Ernie concentrated on the hydraulics/hydrology field: "We worked in small teams on a substantial number of project-related engineering problems, not experimenting but number crunching, and that got me interested in the consulting business."

The farm boy from the one-room country school did so well at university that he topped the 1961 civil engineering class of eighty students.

That September, Portfors received an Athlone Scholarship, granted by the British government, for two years of study towards a master's degree. He chose Imperial College of Science and Technology, London, which had a worldwide reputation in river engineering, hydraulics, and hydro power, under the renowned Swiss engineer Charles Jaeger. But after the first year Portfors had "twigged" into the way the British system works for advanced degrees: "You really don't take many courses. You simply do research until your prof decides that you have done enough and then they give you a degree."

Already married, he had funding for only two years. At Imperial College doctoral students were given preference, and that degree would take much longer to attain. Therefore Portfors completed his master's degree at Marischal College of the University of Aberdeen, Scotland, which was noted for a very good experimental hydraulics laboratory. He worked under Jack Allen, who had written textbooks on hydraulic modelling.

Upon graduation in 1963, Ernie Portfors was faced with the "horrifying thought" of finding a job. In Canada, only British Columbia and Ontario offered opportunities in water resource or hydroelectric work. As a westerner he was more attracted to British Columbia, where he was hired by Ingledow-Kidd. On this his "first real engineering job," he worked on the design of two major hydroelectric projects: Kundah in India and Maskeliya-Oya in Ceylon. After these projects wound down, Portfors spent a year with IPEC working in the Hydraulics Design Group under Jack Forster (Charlie Ripley's old friend and classmate) on diversion tunnel outlets for the Portage Mountain Dam.

By then, with some experience under his belt, Portfors was ready to complete his formal education. After considerable thought and investigation, he decided to study fluid mechanics in the Mechanical Engineering Department of the University of Toronto, working specifically on the subject of water turbulence generation. This highly theoretical-mathematical field, augmented by experimental work, provided sufficient challenge for a brilliant mind. Portfors spent three years at Toronto, earning his Ph.D. in the spring of 1969. Says Ernie, "For the Mechanical Department I think I set a time record, but this was governed by economics more than anything else." Already with "two small kids at home to feed," he earned his way by means of student loans, tutoring, demonstrating in the lab, and other various tasks that grad students typically do in universities.

After completion of his studies Portfors returned to IPEC. In 1973 he became head of the Hydraulics Section, overseeing the work of a dozen people. During this period of his career he gained a great deal of experience working on a wide range of hydraulic projects. However, although doing technically interesting work, professionally he was having misgivings. According to Portfors, much of this was generated by IPEC's management, who "treated their staff as bodies in a shop and didn't worry at all about their personal ambitions as professional engineers." That attitude led to formation of an IPEC group of professional engineers; this at a time when the NDP had just come into power, and the group was "quite left of centre, with a strong union tendency." Portfors "wasn't very comfortable with that happening," feeling it would accelerate the decline of professionalism within the organization.

In 1972, Dick Cooper and A. L. "Art" Charbonneau, one of Portfors's classmates at the University of Alberta, had formed Northwest Hydraulics Consultants in Edmonton. They were interested in establishing a Vancouver office, so Portfors joined this company in April 1974 as a junior partner and became the manager of an office of a dozen people located in North Vancouver. The company had obtained its start doing river engineering on the Alyeska Pipeline, and when that work finished, found a niche as a specialized group of hydraulic and river engineering consultants. This was Portfors's first experience in running a private enterprise business, and he found it very satisfying. While at IPEC, he had been doing hydraulics work closely integrated with civil engineering projects, and so he regarded himself as a civil engineer with a hydraulics specialty. Yet, with Northwest Hydraulics, he worried that he was ultimately to become a "very narrow hydraulics engineer." When he was approached by Klohn Leonoff, he believed he saw a much broader opportunity in the civil engineering field. In joining Klohn Leonoff in December 1976, this expectation was to be fulfilled.

Chapter Ten

BOOM TIMES

The Social Credit Party's interregnum in British Columbia proved to be short-lived. Following a snap general election call, in December 1975 the party surged back into power under W. A. C.'s son, W. R. "Bill" Bennett, spouting the slogan "Let's get B.C. moving again!"[1] Soon after, gathering together the ragtag assortment of assets acquired by its socialist-minded predecessor, the neo-conservative Socred administration introduced legislation to create the British Columbia Resources Investment Corporation (BCRIC). "Brick", as it came to be called, was the first Canadian experiment in "privatization", structured to encourage ordinary British Columbians to invest in the future development of their province. Indeed, while the provincial economy had recently shown a good deal of volatility, B.C. commodities—lumber, pulp and paper, minerals, coal, and natural gas—were still in great demand throughout the world. With natural resource prices rising, the "supply side" was burgeoning with new mines, new mills, and new oil and gas fields, ushering in a new boom period[2] later described by one historian as "a fragile prosperity."[3] Additionally, the Bill Bennett government embarked upon a number of major capital projects (in which Klohn Leonoff would participate), funded by billions of dollars of public and private investment that were designed to revitalize the sluggish B.C. economy. While these initiatives would later founder in the ebb tides of recession, oversupply, and low world commodity prices, in the short run they provided the impetus to fulfill Social Credit's campaign promise.

Klohn Leonoff's annual Directors' Meeting of January 1977, held in Richmond, was a milestone gathering, confirming as it did the recent changes made in the company's leadership.[4] The new executive configuration was President and Chief Executive Officer, Earle J. Klohn; Executive Vice-President, Cyril E. Leonoff; Vice-President Engineering, Ray P. Benson; Vice-President Alberta, Don M. Davison; and Vice-President Business Development, Earl W. Speer. Other directors were Mark T. Olsen, K. Ian Morrison, and James Hunter.

The increased importance and volume of work originating in Alberta was recognized by the fact that on the new board two resident officers were from the Calgary office. Winnipeg had one director, while the "head office" in Richmond had five officers-directors. A clear distinction was made among the executive members, indicating that Klohn, Leonoff, Benson, and Speer were "corporate officers" responsible within their fields of operation for the entire company. As well, in 1977, three "administrative committees" were set up—Management, Engineering, and Business Development—to guide all aspects of the company's operations (Appendix I).

Regional offices were being reorganized to "make certain that they have the administrative capacity to handle both the expected increase in volume of work and the greater complexity and scope of engineering services." Don Davison was to continue as Alberta Region manager responsible for both management and engineering (a post he held until his retirement in 1990). Cyril Leonoff was to share management duties between the corporate and B.C. Region offices (a duty he continued to fulfill until 1980), and Ray Benson, while responsible for all engineering operations, was also to be manager of engineering in the B.C. Region office.[5] Successive managers of the B.C. Region have been Ernest Portfors (1981–84), Earl Speer (1985), Myles Parsons (1986–90), and Peter Lighthall (1990–).

The "divisionalization" of the company into its various disciplines was developing apace. Ian Morrison, who had been "chief engineer" since 1966 when the company was primarily a geotechnical firm, became director of the Geotechnical Division in 1977. Ernest Portfors became head of the Hydraulics Section (later the Water Resources Division) in the same year.[6] Other divisions, their first incumbents and start-up dates were: Special Projects, Mark T. Olsen (1977); Materials Engineering, Lloyd E. Rodway (1978); Special Services, Robin G. Charlwood (1979); Geology, Myles L. Parsons (1979); Project Management, John

H. Saldat (1980); Mining Services, Vinod K. Garga (1981); and Heavy Civil, John A. Connell (1981).The new Vancouver premises had by now allocated adequate space for a technical library, and for the first time a professional librarian, Lynne Isberg, was taken on staff.[7]

Honouring Mark Olsen, first 25-year man, December 15, 1976, from left: Phyllis Barrington, Fran Holbrook, Mary Robinson, Mark Olsen, Maureen Luck, Letta Lewis, Christine McGrath, Bonnie Lee, Shirley Le Cours.
Photo: Ralph Wallis - Henry Tregillas

At the 1977 meeting, the long-range company plans were restated—to provide a "complete engineering service," project management as well as "pure consulting services" in the basic areas of mining engineering and hydraulics; this in addition to the company's "more conventional fields" of soil mechanics, rock mechanics, and engineering geology. Other objectives were to expand operations geographically by opening an office in the U.S.A. "as soon as the opportunity arises," to continually assess other regions such as "Eastern Canada" for similar opportunities, to develop a reasonable share of the overseas market, to move into new areas of civil engineering "wherever opportunities indicate that this would be advantageous to growth and profits," and to work with other companies "where a joint venture type of approach is desirable."[8] And indeed in KL's forthcoming "boom years" of 1978 to 1981 most of these objectives were achieved.

Evidence of the increasing growth and maturity of the company was the launching, in February 1977, of the first inter-office newsletter[9] "to keep everyone informed of the many things happening within the company both personally and technically." The front-page feature story of the first issue read:

"On Wednesday, December 15, 1976, a special gathering was held in the Vancouver office to honour the company's first 25-year man, Mr. Mark T. Olsen. Mark, who was the first employee of this company, was presented with a Seiko, quartz, liquid crystal watch. The presentation was made by Earle J. Klohn, who briefly outlined, for the benefit of some of the newer members of our staff, Mark's history with the company."

Vol. 1, No. 1, edited by Letta Lewis, went nameless.[10] Among names suggested were "The Latest Dirt" and "Soil, Rock and Water Bulletin," but instead a contest was held to choose an appropriate name. The winning entry, *The Klohnicle*, was submitted by engineer Byron Stewart, and this title appeared on the masthead of the second issue. "Milestone" events recorded in this second newsletter included mention of a significant anniversary:

"On September 24, 1977, a special occasion was marked by a dinner and dance held at the Airport Hyatt Hotel to honour Messrs. Klohn and Leonoff on their 25th anniversary with the firm. Master of ceremonies . . . was Ray Benson. Presentations were made to both partners by Mark Olsen. . . . Mr. Klohn received a very handsome wood carving, and Mr. Leonoff received a gold pocket watch. A presentation [of] four silver champagne goblets and four matching liqueur glasses was also made to Phyllis Barrington, who is retiring at the end of this year."[11]

This issue also reported on company achievements:

"Klohn Leonoff Consultants were given Honourable Mention in the civil engineering category for Gibraltar Mines Tailings Dam project. The award was accepted by Earle Klohn at the ACEC (Association of Consulting Engineers of Canada) Awards Night held in Ottawa, Ontario on October 20, 1977. The presentation was made by the Hon. Jack H. Horner, Minister of Industry, Trade and Commerce."

"Earle J. Klohn has . . . completed a series of lectures at a five-day engineering seminar held in October at the University of Missouri, St. Louis. The lectures covered the design, inspection, and operation of tailings dams, and were part of the Fifth Annual Short Course on Embankment Dams sponsored by the University's Department of Civil Engineering."[12]

"The Klohnicle" didn't stick, and in the third issue the name *Profile* was adopted.[13] The newsletter appeared through the years on an irregular basis, under various names, until February 1990, when, under the editorship of Art Alexander, *Profile* became a regular bi-annual printed publication suitable for external distribution. *Profile* covered the company's significant project and staff activities, and in January 1991, "The Klohnicle" was revived as a weekly in-house newsletter to communicate both business and social events.

The Canadian economy exhibited very slow growth during 1977, while inflationary forces continued to increase the costs of doing business. The company's performance during the first six months was "sluggish." However, a good second half was achieved, which more than regained the first half losses.[14] This ushered in a "vigorous growth" period for Klohn Leonoff, which lasted for the remainder of the decade and beyond. During the five-year period beginning in 1977, company income increased fourfold, and by 1981 was approaching $10 million.[15] In the same period, the number of full-time staff members increased threefold to a total of 209 persons, with the number of contract and part-time employees reaching a peak of some 240 persons.

The first two meetings of the newly launched Management Committee, composed of senior representatives from all offices, including the corporate office, were held in May and September of 1977. They dealt with current "housekeeping" items, as well as "efficiency" moves imposed to weather the current recession. Complete computerization of the accounting system, in order to provide more effective project cost control, was considered but, owing to the high price of implementation, was postponed until the economy improved.[16]

But the most far-reaching move, announced by the president near the end of the year, was the introduction of an ongoing share purchase plan, commencing on January 1, 1978, "to permit selected senior members of our engineering staff to participate in the ownership of the company." In making the selections for eligibility, the Management Committee considered such characteristics as "technical, promotional, organizational, and managerial abilities," as well as "a demonstrated interest in the development, improvement, and expansion of the company."[17] For purposes of ranking, share ownership, and setting of salaries, eligible staff were formally classified into four categories: principals, associates, engineers and geologists, and technicians. As of January 1978, there were twenty-one shareholders of record, of which nine were principals and twelve associates. All were engineers or geologists, with one exception, the in-house accountant.[18] In 1980 the share offering was broadened to include senior staff members "who are not engineers or geologists," that is technicians, accounting and other support staff.[19]

In fact, the new plan was an extension of the policy established by Charles Ripley in the first decade of the company's existence, when Klohn and Leonoff first became shareholders. Precedent was also followed in setting the price of shares at "book value," which closely represents the actual value of a company's assets should it be closed down and liquidated. Although this valuation makes shares available at a minimum price, with no allowance being included for such items as goodwill and potential earning capacity, Klohn announced that: "We consider this a reasonable approach, as it acknowledges the fact that all potential shareholders have been in the past, and will continue in the future to be major contributors to the success and growth of the company."[20]

This policy of share ownership has continued, virtually unchanged, through the years. As of 1991, Klohn Leonoff Ltd. was wholly owned by forty-seven shareholding members of its participating staff, with 74 percent of these holdings in the hands of its executive group.[21] One class of common shares is issued by the company with voting privileges and with no guaranteed rate of return. Therefore the accrual in value per share and the dividend paid out in any given year are directly dependent on the company's profitability that year. In order to provide operating funds, the company also issues a "preferred" class of shares with fixed interest rate for monies loaned back to the company by common shareholders.

With the advent of more widely held shareholdings, beginning with the year ending December 31, 1974, Annual Reports to Shareholders have been issued, and these include a Summary Report by the chairman and chief executive officer on behalf of the board and an Auditors' Report with accompanying financial statements. The first formal annual general meeting of the shareholders of the company was held at the Airport Inn, Richmond, on June 9, 1978.

Following reorganization in 1977, the company continued with its eight "inside directors," who also formed the Management Committee. This arrangement was satisfactory at the outset, but, following rapid expansion, by 1979 it was deemed advisable to separate the Board of Directors from the Committee and to elevate the board's status to that of a "watchdog" role. Henceforth the functions of the board would be mainly "long-range planning, monitoring of the company's performance, and review of all financial aspects of the operations." The Management Committee would continue to be "fully responsible" for the company's day-to-day operations in a "competent, professional, and profitable" manner.

The board was streamlined to include the five officers of the company plus one "rotating" director chosen from among the senior shareholders. In addition, "at least one outside director" would sit on the board in order to "provide a fresh viewpoint and a completely unbiased review of the company's performance."[22] On April 3, 1979, the first outside director elected to the board was John W. Burrows.[23]

Time has passed by quickly for Cyril Leonoff, Mark Olsen, and Earle Klohn, December 15, 1976.
Photo: Ralph Wallis - Henry Tregillas

Born in northern Ontario, Burrows received his university education at Toronto, Queens in Kingston, and at Yale. A resident of Alberta for twenty-five years, he has had an active and diversified business career in a number of industries, including rail and air transportation, hotel, hospitality and travel, oil and gas, and real estate development. In addition to sitting on the Klohn Leonoff board, he currently (1991) serves as a director of a number of companies including: TELUS Corporation (formerly Alberta Government Telephones), Novatel Communications Ltd., Alta Can Telecom Inc., Canadian Northstar Corporation, Northstar Energy Corporation, CARA Operations Ltd., Telesat Enterprises Inc., the Banff Television Foundation, and the Calgary Research & Development Authority.[24]

Prior to joining the KL board, John Burrows had no background in civil engineering whatsoever. But this has proven to be an asset rather than a liability. His broad business experience and sound judgment, uncluttered by the "nuts and bolts" of engineering, have provided a detached judgment of the firm's business performance. As chairman of the Audit Committee, he has remained an essential board member to this day, representing the interests of the common shareholders.

In 1981, a second outside director, Douglas J. Watts, was elected to the board[25] and has remained an incumbent director. A recently retired vice-president of marketing for the largest engineering company in British Columbia,[26] Watts added another dimension to the board. Graduating from UBC in 1954, Watts specialized in structural engineering under the brilliant tutorage of Professor Sam Lipson. His first job following graduation was on building the CPR dock in Vancouver harbour, which served the ferryboats travelling to Nanaimo. This work was just winding down when he read a newspaper advertisement placed by H. A. Simons Ltd. for a design drafting engineer. Watts was immediately interested:

"I could see that the CPR job wasn't the kind of work I wanted to do for the rest of my days. We were driving pilings—with the creosote, the mess, and everything. I had on my old clothes, old sweater, and what not. I'd phoned ahead and made this appointment with Mike McLennan, manager of the Structural Division, for after work, at five thirty. I had never heard the foggiest thing about that company."

In looking for Simons's office in the old Holdon Building, in the dingiest part of town—East Hastings and Carrall streets—"Doug" was on the wrong side of the street:

"It turned out to be a fish market. So I was a little late, but eventually showed up. Mike had been interviewing all these people when suddenly who walks in the door, but this guy in his old construction clothes, dirty with creosote from top to bottom, applying for this drafting job."

McLennan applied good judgment, and Watts evidently made an impression because he landed the job. And Doug ultimately worked his way up to become assistant manager of the Structural Department at Simons.

"Old man" Simons, like Karl Terzaghi and Charles Ripley, believed in modesty and frugality and felt no need to demonstrate his affluence in terms of his office space or in anything else for that matter. Comments Watts, "I think for years he still had the belief that he was only temporarily in business." A new, more demanding generation eventually took over, and management styles at Simons slowly changed. Years later, under the presidency of T.A. "Tom" Simons, Howard's son, with the urging of senior staff members such as Watts, the organization did move to more luxurious quarters in the "high-rent district."

When one of the recovery boilers exploded on a Simons mill project in east Texas, literally blowing the building apart and causing death, Doug Watts was sent down to investigate and rebuild. Doug recalls reporting back to Howard Simons, who was naturally worried about liability:

"Simons called the secretary in and dictated a letter, spelling the situation out. Then he looked at me and said, 'Will that cover it?' But the letter didn't cover it, so I said, 'No.' I don't know why I said it, because you just didn't say no to a man with his stature. God, he looks at me, takes some puffs on his cigar, and says, 'Well, you write the letter.' So I did."

This was one of the "windows of opportunity" that opened up to Doug Watts during his career at Simons. He had won the confidence and friendship of H. A. Simons, and Simons would thereafter on occasion invite the young engineer and his wife to golf and dine with Howard and his wife at the posh Shaughnessy Club.

Through his work with Simons, Watts came to know and respect the principals of Ripley, Klohn & Leonoff; in particular Doug became a good friend and confidant of Earle Klohn:

"There's been a remarkable symbiotic relationship between the Simons and Klohn Leonoff organizations. And the biggest reason for this tie, I think, is Earle Klohn. I remember way back, H. A. Simons said of Earle, 'He has good judgment.' That was a term he always used in sizing up people—good judgment, bad judgment, or no judgment. It was also interesting to see that many times he would ask Earle to come over and sit in on a meeting where foundation matters were quite a minor part because he always believed that he was going to get a considered, straightforward answer from Earle, with no beating around the bush. He respected the judgment and honesty of this firm. And that's exactly what the old man wanted. Like my thing with the letter."

In the last decade of his Simons career, Doug Watts did successful international marketing, a job he enjoyed. But ultimately the dilemma faced by many engineers on the international circuit caught up with him:

"This travelling and flying around and eating too much—I was continually away. I remember coming home one time when the kids were young, walking up to my oldest son, who was four or five, and saying, 'How do you do? I'm your father.' I just said to hell with it."

Financially Doug had done very well at Simons and had developed an independent income from investments in real estate. So in May 1980, after twenty-five years with Simons, the last six of them as Vice-President of Business Development, Doug had the gumption to retire at the age of forty-nine:

"Many people get too wrapped up in their work and it becomes their reason for being. I could feel myself missing some of the things in life that I wanted to do. I got rid of that element of my life, got into shape, went into mountain climbing, and have done a lot of travel since then. [He used his retirement gift from Simons, an ice axe, to scale Mount Baker, Washington in June 1980 and the Wetterhorn, Switzerland in September of that year.] And I really enjoy it."

Because Simons was a totally private company with only inside directors, Watts left their board when he retired. Coming onto the Klohn Leonoff board was a natural fit:

"I felt that I knew the company. Through my personal friendship with Earle, for years we'd golfed together, we'd partied and drank together, and we used to spend hours conversing about every subject in the book. It's always been a marvellous relationship, not only personally but professionally and businesswise. Since leaving Simons I had missed a lot of the business contacts. Sitting on the board and being plugged into the activity has provided that."

Doug Watts has added several strengths to the Klohn Leonoff board that have generally been in steady synchronization with the goals of the company. Because of his broad background in engineering and business he rarely hesitates to ask direct questions, and, like his mentor Howard Simons, to demand straight answers. Watts is a strong believer both in expansion into the world market and diversification into other fields, goals which he promoted in the Simons organization:

"In the fifties and sixties there were enough projects and work around that you could specialize. But the economy is so global and competitive now that companies have to diversify into different fields that support one another, even to the extent of looking at businesses that are completely divorced from engineering. I like to see other sources of revenue coming in, in order that in the worst of times you've got revenues that will support your key staff. I believe that the international market is generally out of phase with our local market, and hopefully you can fill in some of the gaps with international work. This company [Klohn Leonoff] has got some expertise in-house [such as dams] that will stand up to any firm anywhere in the world."

Such prognostication would prove itself correct in the eighties, when expansion into international markets and diversification into hydroelectric work would carry the firm through the worst recession since the Great Depression of the thirties. But such expansion was a very difficult task to accomplish. When the firm was busy on domestic work, the inclination or personnel available to go after overseas work was often lacking. On the other hand, in order to attract senior people, interesting and diversified work is always required. When the local market slows down, typically, in Watts's words, "Everybody gets excited. We've got to go after the international market." But this attention may come too late, since it takes a long time and a great deal of money to develop overseas clientele. Certainly it would take Klohn Leonoff over a decade to successfully achieve this goal.

The Engineering Committee first convened in November 1976[27] and thereafter met on a semi-annual basis. Earle Klohn chaired the initial meetings, but Ray Benson took over the chairmanship in 1978.[28] The committee was responsible for such matters as quality control, the development of standard engineering practices throughout the company, and inter-office communication and co-ordination of engineering operations. Other areas of responsibility included work load projections, assessment of engineering staff and any requirements for additional staff, staff education, conferences and conventions, and field and laboratory equipment purchases. A computer sub-committee under Robert Lo was set up to co-ordinate engineering applications, program development, and maintenance. Following the installation of an in-house computer terminal at the beginning of 1978, regular technical presentations were instituted to keep all staff updated on current projects and engineering methodology.[29] Today these continue under the Professional Development Committee, composed of a chairman and advisory board of the division managers, with meetings held at semi-monthly to monthly intervals.

The work of the Business Development Committee went on apace with that of its sister committees. An umbrella group chaired by Earl Speer, its main terms of reference were to develop a company marketing strategy, to produce marketing tools such as brochures and project sheets, to identify and promote new markets and services, and to provide an overview of "BD programs." Direct responsibility for regional marketing was left in the hands of the regional manager, assisted by division heads and senior engineers in their areas of expertise. In addition, outside consultants, such as Doug Watts in international work and George Mathias in the mining field, were retained on a periodic basis to advise and assist in client contact work. By April 1978 the president was able to report that:

"A major advance this year has been the production of high-quality business development material and a general improvement of our public relations program. However, we still have a long way to go to achieve the high objectives that we have set for ourselves in the PR and BD fields. In this regard, every effort has been made to free Earl Speer from some of his engineering duties so that he can devote more time to selling this company."[30]

A public relations firm was also engaged to facilitate press coverage of the company's engineering projects.[31] In 1977–78 numerous articles appeared in various publications: "Arctic Work a Specialty of Klohn Leonoff Consultants";[32] "Canadian Engineering Helps Minnesota Taconite Iron Ore Industry to Continue";[33] "For Export Made in Canada," a *Financial Post* feature on small- to medium-sized Canadian companies achieving success in sales abroad;[34] "What's Going on in World Mining";[35] and "Klohn Leonoff Consultants: Geotechnical Engineering Expertise at Work Around the World."[36] As well, staff were encouraged to publish technical articles such as "Support of Structures in Permafrost Areas: The Foundation Specialist Faces a Wide Range of Problems. . . ."[37]

Through the years, the company's principals and staff have continued to publish prolific numbers of papers covering both technical studies and case histories of their job experiences, thus adding appreciably to the literature in their disciplines. During 1988, for example, seventeen professional papers were authored by Klohn Leonoff personnel, and Earle Klohn personally, throughout his career, has published more than fifty papers. However it is interesting to note that some of the company's most experienced engineers—Maartman, Morrison, and Olsen—have produced only a few papers. Morrison offers this explanation: "I probably have been remiss in not publishing more, but I suppose some people publish and some people don't, and some people publish just to publish."

From the latter half of 1977 through 1981, the greatest boom period in the company's history ushered in a plethora of engineering jobs which in size, scope, and diversity exceeded anything the company had previously experienced. The lead project was construction of the Reserve Mining tailings disposal facilities in Silver Bay, Minnesota (Chapter 12), but several other key studies and projects were also carried out by the B.C. Region during this period.

Work continued in the B.C. mining sector with the construction in 1976–77 of Afton Mines mill and smelter, located on the trans-Canada Highway seven miles west of Kamloops. The 7,200 tons of copper ore per day produced by the Afton mines were processed in a smelter situated on the property, and the geotechnical assignment on this project included the investigation, design, and construction supervision of all work related to foundations, earthwork, and groundwater at the site.

In order to retain both tailings and waste water, rockfill dams with an impervious facing of glacial till were built for the Afton mines around a small lake. Any seepage through the dams was intercepted at a small reclaim dam and returned to the pond. And a set of monitoring wells was drilled downstream from the tailings pond to determine any possible effect on groundwater.[38] The assignment also included the design of a four-mile-long Trans-Canada Highway diversion around the open pit.[39]

The Highland Valley is a broad, U-shaped valley in the Interior Plateau of south central British Columbia, a physiographic unit of the Canadian Cordillera. Bethlehem Copper (Chapter 7), the first producer in the valley, began working its ore body in 1963, followed by Lornex Mining Corporation,[40] Cominco, and Highmont Mining Co.[41] To optimize the assets in the valley, Highland Valley Copper was formed on July 1, 1986 and is a partnership of Lornex, Cominco (which had acquired Bethlehem), and Highmont.

Valley Copper L-L Dam, Highland Valley, B.C., 1988.
Photo: Valley Copper

This amalgamation makes Highland Valley Copper, located south of Kamloops, one of the largest copper mining operations in the world, ranking second on the basis of tonnage milled and fifth in terms of copper metal production. The quantity of material mined is currently (1991) 275,000 metric tonnes per day, of which 133,000 tonnes is ore. The remaining life of the mine is estimated at twenty years, but this may well be extended as additional mineralization is confirmed—it has long been known that low-grade porphyry copper deposits exist at the site.[42]

Klohn Leonoff had investigated a number of consecutively lettered tailings dam sites in the valley, but the international engineering firm, Bechtel (from whom Charles Ripley had first learned of tailings dams), was engaged to design the starter dams. Begun in 1972, the H-H Dam, having a projected height of 107 metres (350 feet), forms the eastern end of the tailings facility. The L-L Dam, 9.6 kilometres to the west, and started in 1976, will ultimately rise to 166 metres (544 feet), making it one of the largest tailings dams in the world.

In 1977, when foundation problems were encountered with the L-L Dam owing to very soft swamp and lacustrine deposits of clay and silt in the valley bottom, KL was engaged and have continued as the geotechnical consultants on the project ever since. Two measures were taken to improve the foundation stability of the L-L Dam, for both static and dynamic loadings and to allow the construction rate of the dam to accelerate according to the storage needs of the mining operation. The soft deposits from beneath downstream construction stages of the dam were excavated and replaced with compacted granular fill, and a large buttress berm was constructed downstream of the starter dam where it was founded on the soft deposits.

The flexibility inherent in the centreline-construction method employed for both dams has served to develop an effective tailings-storage operation and to maintain key earthquake and flood design criteria. The facility will eventually be reclaimed in an orderly fashion, allowing for multiple uses of the land. A permanent spillway system will be installed at the L-L Dam to ensure the safe passage of flood-water through the storage facility, back into the natural drainage course downstream.[43]

One of the more unusual jobs for the mining industry, undertaken in 1978, was the design of the foundations for a cable suspension bridge spanning 1,300 feet over a 1,000-foot-deep canyon of the Similkameen River, near Princeton, B.C. The bridge was to carry an ore conveyor from Copper Mountain to the mill site of the Newmont Mining Company. KL provided geologic investigation and rock stability analysis for a deep rock anchorage system.[44]

The Saskatchewan Wheat Pool annex, constructed in 1977–78 on the north shore of Burrard Inlet in North Vancouver, is a major offshore shipping terminal for Canadian grain. The designer of the terminal was Carr and Donald of Toronto, and Crippen Consultants was the resident engineer. KL was responsible for several geotechnical aspects of the project.

The foreshore site of this terminal is covered by a surface layer of fill which contains wood waste, boulders, and logs. In order to support the heavy silo loads, a thousand 150-ton, 20-inch-diameter concrete piles, both vertical and battered, were installed by Franki Canada, penetrating through any obstructions in the fill. The piles, founded in dense silt and sand subsoils, have an average length of 30 feet. Load tests were carried out to verify the design capacity. As well, a "design earthquake" based on recorded historical earthquakes was generated by computer projection to assess potential for liquefaction of the loose foreshore soils, a phenomenon which could cause buckling of the piles. As a result, a vibro-flotation process was employed to densify the soils around the piles and thus reduce the earthquake hazard.[45]

The Duke Point Industrial Park, located immediately south of Nanaimo on Vancouver Island, was developed during the period 1977–80 by the B.C. Development Corporation, a crown company. Consisting of mostly forest products facilities, the complex was to occupy a 350-acre site on the Nanaimo River estuary. It was described at the time as "one of the most remarkable industrial developments in British Columbia," and was to have projected land sales of $40 million and developments totalling $320 million. It was predicted to generate 1,600 permanent jobs.

Klohn Leonoff was involved from the outset on the site development, which called for the movement of 2 million cubic metres of rock and earthwork and the dredging of 1 million cubic metres of sand. Projected to serve a complex of two sawmills, two pulp mills, a 60-acre assembly wharf, a tank farm, and several other industrial developments,[46] with the onset of the recession of the 1980s, the potential of the project has not yet been realized. It is the site of the present Doman Industries sawmill.

Driving Franki piles, Saskatchewan Wheat Pool extension, North Vancouver, B.C., 1977.
Photo: Cyril Leonoff

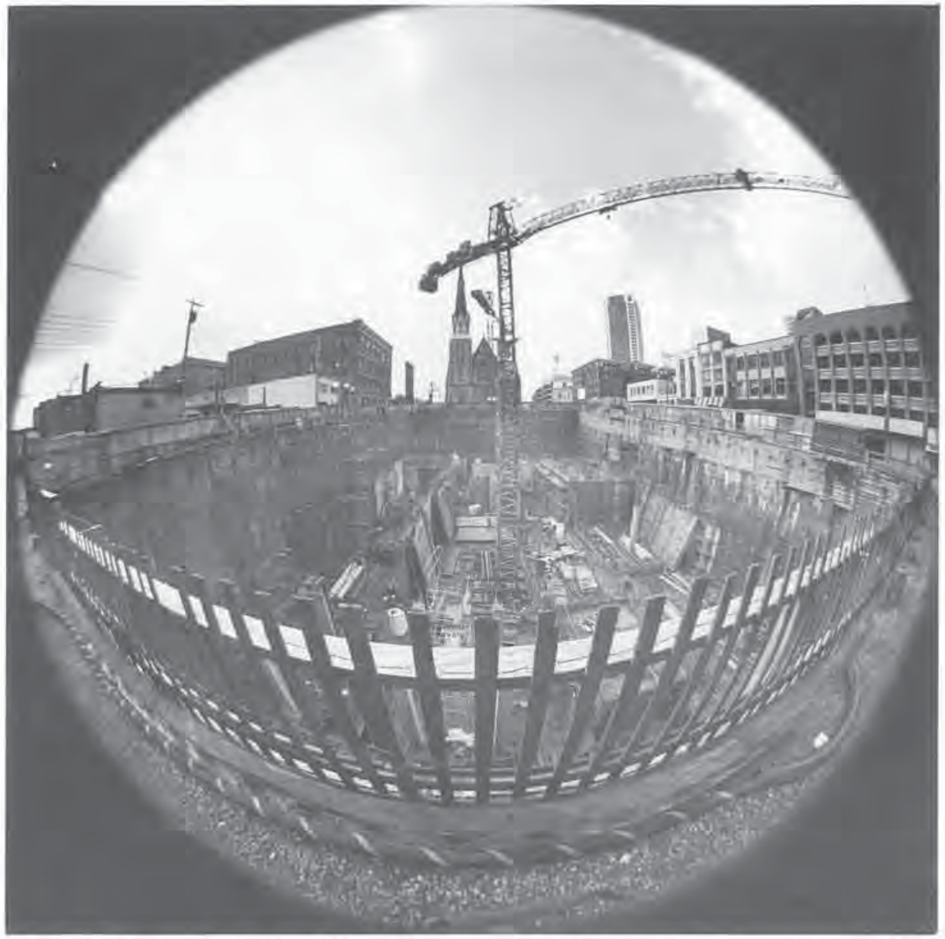
Cathedral Square Substation, a completely underground electrical facility in the heart of downtown Vancouver, was a unique project for British Columbia Hydro and Power Authority. Comprising four working and two parking levels underground, with a civic park at ground level, the building required an open excavation to a depth of 20 metres (65 feet), one of the deepest excavations ever made in Vancouver. The design was complicated by the presence of a railway tunnel and a post office conveyor tunnel running along two sides of the site, as well as the presence of surrounding heritage buildings, particularly the 1899 Holy Rosary Cathedral, where any settlement would be critical.

Cathedral Square substation, Vancouver, B.C. – Shotcrete application.

The bedrock, weakly cemented sandstone of the "Kitsilano formation," was investigated by diamond drill holes carried to 40 metres depth. KL was responsible for all aspects of the excavation: foundations, design of the tie-back anchor system, contract specifications, construction drawings, and supervision. While the overburden was retained by conventional soldier piles and timber lagging, the rock walls were supported by a system of tensioned rock anchors, whose pull-out capacities were tested. Deformations of the excavation were monitored during the construction period using inclinometers in holes close to the excavation faces, extensometers in the faces, and precise surveys of observation points. The bulk excavation and shoring were completed by August 1981. Support was incorporated into the substation walls, and, following completion of construction, the rock anchors were de-stressed.

Owing to moisture sensitivity of the electrical equipment for the substation, an adequate waterproofing system had to be provided. This consists of a wire-mesh reinforced shotcrete membrane placed over the excavation walls. As well, a perimeter drainage system of vertical and horizontal drains was installed. The water collected flows into the substation sump.[47]

In the spring of 1978, KL was briefly involved in one of the last of the grandiose North American pipeline schemes. Northern Tier Pipeline proposed a 42-inch-diameter oil



Cathedral Square substation, Vancouver, B.C. – Twenty-metre-deep excavation and shoring, February 17, 1982.
Photo: Cyril Leonoff

pipeline extending 1,544 miles from Port Angeles on the Juan de Fuca Strait to connect with the existing Lakehead Pipeline at Clearbrook, Minnesota. The U.S. Department of the Interior, Bureau of Land Management, was responsible for preparing the environmental impact statement for the project, including an assessment of the effect of construction on the existing environment. Fugro Inc. of Long Beach, California were contracted to assess the geotechnical and water quality components of the study. In the spring of 1978, KL, under the direction of Ernest Portfors, acted as a subconsultant to Fugro in reviewing the engineering conditions at ninety-three river crossings and assessing impact problems during construction and operation.[48] Like so many of the other pipeline projects, this venture, too, would prove to be stillborn.

While the foregoing jobs are representative of the company's traditional work in geotechnical engineering and tailings dams, other projects under way at the time illustrate the firm's diversification into such fields as hydraulics, tunnel engineering, highway design, environmental and socio-economic assessment, and project management.

In British Columbia, formation of the 25,800-acre reservoir behind Revelstoke Dam necessitated relocation to higher ground of sections of Provincial Highway 23, part of the historic Big Bend Highway which now provides access to the Mica Dam from Revelstoke. In its first major design project for the B.C. Ministry of Highways, KL was responsible for 16.5 miles of the new highway. The scope of this work in 1978–79 included field surveys and investigations, construction drawings and contract documents, quantity and cost estimates, and the drawing up of construction schedules.

Lying on the western edge of the Selkirk Mountains, Highway 23 presented many design challenges. These mountains are composed of old fragmentary rock.[49] Incised rivers and streams have developed large talus fans in some areas, while in other locations the mountains rise steeply from the banks of the Columbia River. Achieving a balanced design was one of the challenges. The relocated highway was constructed of a series of rock cuts and high embankment fills, using spoil from the cuts as riprap for the portions of the embankments submerged by the river.

Environmental considerations in preserving the natural beauty of the Columbia River Valley, as well as the provision of access to recreational sites, were a requisite of the design. Game fish inhabit the river and tributary streams. Therefore highway stream crossings were built to provide for fish access to the spawning grounds in the river's tributaries.[50]

In 1977, in order to reduce the steep mountain grades through Rogers Pass in the Selkirk Mountains, preliminary design and cost estimate studies were carried out by KL for the Canadian Pacific Railway on an 8.5-mile-long tunnel. (With the accession of Ray Benson to the staff, Klohn Leonoff had acquired an expertise in tunnel engineering that heretofore was not locally available in British Columbia.)[51] The tunnel was eventually built, although KL was not involved in the later stages of this project.

The economic growth of western Canada during the 1970s resulted in major increases in freight traffic to the West Coast port, and in December 1979, as part of the Canadian National Railways' plans for improvement to its existing line between Edmonton and Vancouver, Klohn Leonoff was retained to assess tunnel requirements through the mountainous Cordilleran Region of Alberta and British Columbia. The studies involved two components. First was double-tracking of the existing single-track alignment. Recommendations were made to accommodate a second track at twenty-nine existing tunnel locations and for the driving of twelve new tunnels along the narrow Thompson River-Fraser Canyon section, where widening of the surface line is impractical. The second phase of the study investigated the feasibility of shortening the Edmonton-Vancouver track distance by a substantial 145 kilometres, this by means of long tunnels through the Selwyn Range of the Rocky Mountains and the Thompson-Fraser sections. Ranging in length between 27 and 43 kilometres, such tunnels would be without precedent in the world. The studies were completed in 1980, but with onset of the 1980's recession, the project was shelved. With the advent of better economic times, the scheme may well be revived.[52]

The first of the "megaprojects" developed by Bill Bennett's Social Credit government involved the vast coal fields of northeastern British Columbia. The sale of coking coal to the Japanese steel industry was envisioned, and the major obstacle to this plan was lack of access to Pacific shipping—the area is cut off from the coast by the Rocky Mountains. The mountain barrier could only be breached by extensive tunnelling—one of the most ambitious railway projects ever undertaken on the North American continent. Exploitation of the Sukunka and Denison coal fields would require the extension of the British Columbia Railway 129 kilometres through the mountains to the existing main line at Anzac, north of Prince George. At this crossroads, linkup would be made with the Canadian National Railways line westward to tidewater at Prince Rupert, where loading facilities were to be built for shipment of the coal to Japan.

From 1977 to 1981, Klohn Leonoff carried out feasibility studies which included surface mapping, rock quality assessment, groundwater occurrence, and diamond drilling at portals for tunnels along two alternative routes. The Hominka River route would involve five tunnels varying in length from 1.3 to 3.9 miles.[53] The Table River route which was ultimately chosen involved four tunnels aggregating 15 kilometres (9.3 miles) in length.[54] Two types of tunnels were found to be technically feasible—conventionally driven horseshoe-shaped tunnels and circular tunnels, the latter driven by giant "mole" machines. Design and construction supervision of these tunnels would be a major project for KL in the early 1980s (Chapter 14).

In Alberta, by 1977–78, the pipeline work that had been sustaining KL's Calgary office had largely dropped off. Only a few studies for the Foothills gas pipeline remained. These involved the selection of a test site to study frost heave, the setting of preliminary seismic design parameters for the pipeline, and the development of a data bank computer program. In the Yukon, a seismic risk study was conducted along the 500-mile Alcan route through the southern part of the Territory, where an active fault system had historically produced earthquake magnitudes ranging up to 6.5 on the Richter scale, and this was probably the first such risk study ever done for a Canadian pipeline.[55] Additionally, in the summer and fall of 1978, twenty river crossings were investigated for the Alberta Gas Trunk Line Company on the Alberta section of that line. The assignment was to evaluate river and stream bank slopes up to 600 feet in height and to prepare designs to ensure the stability of the crossings.[56] And in 1979, in preparation for an application to the National Energy Board, a program of drilling, laboratory testing, and evaluation was conducted for Foothills along the Dempster Lateral, which would run from the Mackenzie Delta in the Northwest Territories to join the Alaska Highway Pipeline at Whitehorse, Yukon.[57]

However, just as the pipeline work was coming to an end, a new opportunity in civil engineering was opening up in Alberta. Alberta Environment, a government department, was beginning to carry out a number of water resource planning and feasibility studies, many of them focusing on an arid region in the south and southeastern section of the province known as the Palliser Triangle. This work would ultimately entail earthfill dams to impound water storage reservoirs, river and stream diversions to provide for flood control and irrigation, the creation of fish and wildlife habitat and certain recreational benefits, and the limited production of hydroelectric power. Klohn Leonoff, with an established office in Calgary and the expertise in soil mechanics and dam construction of people like Earle Klohn and Don Davison, combined with the hydraulics-hydrology expertise of Ernest Portfors and Bob Maartman, was ideally placed to undertake the engineering of such projects.

Impetus for these government-promoted initiatives had come in August 1971 with the triumphant election victory of the first Progressive Conservative government in the province's history, replacing the then stagnant thirty-five-year rule of the Social Credit Party. Under the dynamic leadership of native son Peter Lougheed,[58] the new government caught the imagination of Albertans, brought a fresh optimism to the province, and ushered in a period of economic prosperity that was to continue for the duration of the seventies. Spearheaded by the unique Alberta Heritage Trust Fund (more succinctly known as the Heritage Fund), which had been introduced in the legislature in the spring of 1975, Alberta had, by the late seventies, become a major business, financial, and political centre of western Canada, and indeed of the whole nation. The seminal idea of the Fund was that the government should invest a portion (originally 30 percent) of Alberta's revenues from the production of oil and gas in schemes that would be of enduring economic benefit to future generations of Albertans. This would provide a degree of economic security for the eventual time when the nonrenewable resources of oil and gas would be depleted. The idea of a government actually saving money was novel in the free-spending era of the seventies, but the assets of the fund did in fact quickly reach a staggering sum—more than $13 billion[59]—and just as quickly the Fund became the envy of other provinces, and particularly of the federal government in Ottawa, who wished to share in the proceeds. The projects of Alberta Environment became one of the beneficiaries of the Heritage Fund.

The Paddle River Dam in northern Alberta was one of the early small flood-control projects undertaken by Alberta Environment. But after difficulties were encountered with the initial site, a design review panel was appointed on which Earle Klohn served, and this panel selected a better site.[60] In the wake of this change, the department recognized that it didn't have the in-house capacity to engineer future large-scale projects, which were already in the planning stage, and so it began to employ private consultants for such work. This was consistent with the government policy announced by Premier Lougheed that Heritage Fund monies "must be invested with a minimum interference in the competitive private sector."

From the spring of 1974 to 1978, Klohn Leonoff was engaged by Alberta Environment to conduct a series of studies on the Red Deer River Basin. This work was initiated by Earl Speer, who was known to a department official as a former colleague during their work for PFRA on the South Saskatchewan River project. Initially Speer was supported by Bob Maartman of the Vancouver office, whose technical knowledge impressed the department. As well, after Ernest Portfors joined the company at the end of 1976, he assumed a key role in the water resource aspects of the studies. And the final figure who was to play a major role in these studies was Donald R. Pettey. Pettey was a 1966 graduate of Queen's University, Kingston, Ontario who had taken postgraduate training in foundation engineering at New York State University. He had ten years' experience with H. G. Acres company on heavy civil engineering projects in Labrador and other regions of Canada, Alaska, and the Far East. In 1979 Pettey became manager of the KL

Calgary Water Resources Division and in 1982 project manager for the massive Forty Mile Coulee project (Chapter 14).

Ernest Portfors recalls these Alberta undertakings as many and varied:

"We did a vast array of these planning studies for Alberta Environment on water diversion and storage, with one $25,000 to $30,000 job after another flowing into the Alberta office. Very quickly I ended up spending a large chunk of my time working in the Calgary office, providing technical support for Pettey on those projects."

The headwaters of the Red Deer River rise in the Rocky Mountains some 185 kilometres northwest of Calgary. The river flows northeasterly through the town of Sundre and the city of Red Deer. Thereafter it makes a hairpin turn, flowing southeastward through the incised Drumheller Valley to join the South Saskatchewan River just beyond the Alberta-Saskatchewan boundary. Alberta Environment studied several alternatives for storage on the Red Deer River and its various tributaries. Site 6 was ultimately selected and is located southwest of Red Deer on the main stem of the river, fifteen miles west of Innisfail. The purpose of the undertaking was to provide low-flow regulation, flood control, recreational benefits, and potentially up to 18 megawatts of hydroelectric power. KL was commissioned to provide feasibility studies including investigation, preliminary design, and cost estimates for the complete project. The work would eventually include construction of the 2,800-foot-long Dickson earthfill dam rising 120 feet above the lowest point in the valley, perimeter dykes, a spillway, a low-level outlet, diversion works, and also the relocation of roads, a power line, and an oil pipeline.[61] As part of the overall river basin study, flood control protection works were also investigated for Sundre and in the Drumheller Valley where flood damage has historically occurred.[62]

In response to concerns raised by landowners and farmers about the effect of the proposed seven-mile-long, 4,420-acre reservoir, Earle Klohn and Earl Speer led a team of geological and groundwater specialists on a seepage and groundwater study of the dam site,[63] described as "the most detailed one ever done before a project has been officially approved." Speer remembers it as a study that soon turned into a kind of grassroots tour:

"We were doing this waterlog study, and the government asked us to visit with the farmers because those people didn't want to see a government person on their land. They could accept us. I was the one doing the visiting, and Earle Klohn came with me a few times. We put our cowboy boots on, got an old big truck, and away we went. It wouldn't do to drive up in a Cadillac, you see. We went around and visited with the farmer and his wife in the kitchen, telling them what we were planning to do and what the impact would be on them. It was rather stressful, I must say, because we were not attuned to this. Engineers are far too blunt and factual, and we don't do a good job of it. Now people like our Patty Randall, an educator, or a sociologist, they don't have to know the technical ins and outs of things, [but] they know how to conduct themselves."

Calgary laboratory, ca. 1979.
Photo: Mathieson Photo Service

The final report of the $350,000 study, including five volumes of technical data and maps, was presented at public information meetings in January 1978, and it concluded that suitable cut-offs, interceptor ditches and drains would minimize the seepage losses from the reservoir.[64] The report was accepted by the government and the project built. Klohn Leonoff and H. G. Acres submitted a joint proposal for the final design, but this work was awarded to others.

In 1977 Klohn Leonoff was commissioned by an Alberta Environment task force to carry out feasibility studies on water resource developments in the Oldman River Basin of southern Alberta. The Oldman Basin supplies water to nine of thirteen irrigation districts in Alberta and serves some 125,000 Albertans in fifty different communities. Following such service, by an apportionment agreement, Alberta is obliged to pass along half of the natural flow downstream and into Saskatchewan.

The Oldman River and its main tributaries, the Belly, St. Mary, and Little Bow rivers, depend on precipitation and meltwater from the Rocky Mountains for most of their flow. The system moves eastward through the dry-belt region of southern Alberta until the Oldman joins the South Saskatchewan River at a point midway between Lethbridge and Medicine Hat. In its natural state, the flow of these rivers is highly variable and volatile—60 percent of the runoff volume passes through the system during the two-month period from mid-May to mid-July. On the other hand, minimum flow occurs during the peak water-demand period from July to October. As well, the flow varies from one year to another, depending on the precipitation. Consequently water was wasted during wet periods and in short supply during dry periods.

In order to adequately meet present and future demands within the basin, it was obvious that storage would be required, and the water stored would then have to be equitably distributed. In the initial phase, some fifty-two possible water supply alternatives were considered, including major on-stream storage dams, off-stream reservoirs within irrigation systems, pumping schemes, and smaller reservoirs on tributary streams.

The long list was ranked, then screened so that just ten projects remained, which were then studied in detail. The assignment included extensive public hearings and input.[65]

The result was an integrated water management plan that would meet the diverse municipal, domestic, industrial, agricultural, and recreational uses. The two major projects that grew out of these studies, both constructed in the 1980s, were the Oldman River Dam and the Forty Mile Coulee Irrigation Reservoir. Earle Klohn sat on the review board and Klohn Leonoff acted as a reservoir subconsultant[66] on the former, while KL and it's associates did the complete design and project management of the latter (Chapter 14).

On August 1, 1978, Lloyd E. Rodway joined the Calgary staff as manager of the company's Materials Engineering Division.[67] A recognized authority on concrete technology and the author of numerous papers on the subject, Dr. Rodway has served for twenty years as a member and chairman of various subcommittees of the Canadian Standards Association (CSA) on concrete, reinforced concrete, and the testing of concrete. He has also acted as Canada's representative on the International Standards Organization (ISO) for concrete and prestressed concrete.

Manitoba-born Lloyd Rodway has deep family roots in western Canada. In 1845, his great-grandfather, Joseph Rodway, from Gloucester, England, arrived at Lower Fort Garry as a private with the 21st Warwickshire Light Infantry. Three years later, his bride-to-be, Elizabeth Stanley, a sixteen-year-old from the same district in England, came by sailing ship into Hudson's Bay, thence down the Nelson River, Lake Winnipeg, and Red River by York boat. Married at St. John's Church, on January 1, 1849, both were illiterate, each marking their marriage certificate with an "X." The marriage produced thirteen children, all of whom survived to adulthood.

Lloyd Rodway's father, Charles, was first a carpenter and contractor, and then, for the greater part of his career, an inspector of buildings for the Manitoba Telephone System. Lloyd's interest in buildings stemmed from summer days spent as a young lad helping his father build houses. "The interest in buildings and what made them work just seemed to become part of me," says Lloyd, "but I could never get any satisfactory explanation, for example, as to what size of wood beam to put up in a given place. My father's answer was always, 'It looks right,' or 'I just know.' This got to be such a mystery that I determined I'd have to find out how do you know what is safe and what is unsafe."

At the age of eighteen, Lloyd did a three-year stint with the RCAF during World War II. While with the air force he had an opportunity to visit New York City: "Seeing these 100-plus-storey buildings, I again had to find out how there could be such things. Solving the mystery of how buildings work, and the bigger mystery of what concrete—their building material—is and what holds it all together, has occupied the whole of my working career. Not surprisingly, I still don't have all the answers."


Lloyd Rodway

Upon demobilization as an air crew flying officer, Rodway enrolled in the veterans' engineering class at the University of Manitoba, becoming a classmate of Cyril Leonoff. As a student and after graduation in 1949, he was employed as a structural engineer with Truscon Steel and Dominion Bridge in Winnipeg, then Cominco in Trail doing mostly reinforced concrete design. Rodway had left Winnipeg "because [he] felt it's a big world and it didn't make too much sense to live and die in the place you happen to be born in." But in spending six months in Trail he found the geography dreary and depressing—in those days the fumes from the smelter had killed most of the vegetation. So, near the end of 1952 he moved to Toronto, joining the Canada Cement Company. His new employer immediately sent Rodway to take the three-month Portland Cement Association course at the leading North American concrete research laboratory in Skokie, Illinois. There he learned how to design concrete mixes, the various uses of concrete, and "all sorts of related things given by very knowledgeable people—both research oriented and practical." But the object of Canada Cement was to market cement, and so they exposed their engineering staff to the sales side as well. Thus, upon completion of the course, Rodway spent the winter as a sales engineer "going around with the salesmen of the Toronto office to visit concrete block plants, prestressed concrete plants, and other users of cement."

In the spring of 1953, Lloyd Rodway was posted to the Calgary office of Canada Cement, where his extensive territory ranged from the western half of Saskatchewan, through Alberta, and into the eastern half of British Columbia as far as Kamloops. The job was a hybrid of various duties—salesman, troubleshooter for diverse technical problems that arose periodically throughout the region, and instructor for courses on the assorted uses of concrete. In those years, Canada Cement had a virtual monopoly on cement in the Prairies, and Rodway almost single-handedly promoted the widespread use of soil cement in building roads in those areas where concrete aggregate was scarce. "Just by mixing relatively small amounts of cement with the native silt and sand soils," explains Lloyd, "they were able to inexpensively get a very good base for city streets and highways. I remember going to town councils throughout the West, talking to contractors, and appearing on TV pushing this stuff."

Lloyd Rodway spent ten years becoming very adept at his job with Canada Cement. He describes an interesting educational process that resulted: "If you give enough lectures to contractors and lay audiences who don't know nearly as much as you do, you fall into the trap of believing your own rhetoric. That is, you begin to believe that you are the authority on concrete and cement and have all the answers. It was ego building and pretty good for a while." Eventually, however, he began to look for "something more." For one thing, the constant travelling and being away from family had become overly arduous for Lloyd, especially during the winter.

So Rodway spent the next seventeen years in the materials testing business in Calgary—testing concrete and asphalt and doing quality control work for soil construction. (Initially this was with his own company, Western Testing Limited. Fifteen years followed as Chief Materials Engineer for R. M. Hardy & Associates.) Then, during the late sixties, the newly formed University of Calgary developed a Civil Engineering Department. The first dean of engineering was Adam Neville, a leading world expert in cement and concrete, and thus Calgary became a recognized centre of concrete study. In 1970 Lloyd Rodway was the first master of engineering graduate of the university in concrete and structures.

Wanting a change, and while still in his prime, Rodway briefly retired in 1978: "I flew an airplane, motorcycled, read books, went to the lake, and did all the things that I thought I had wanted to do. But again it wasn't enough, and after six months I didn't know what to do with myself." That same year, having been acquainted with both Earl Speer and Cyril Leonoff, the former as a business colleague and the latter from his university days, Rodway joined Klohn Leonoff.

With Klohn Leonoff, Rodway found himself in charge of a division that was not exactly prodigious in its scope. In fact the entire staff of the division numbered just one—himself. Comments Lloyd, "At that time, the company had a rudimentary concrete machine and not much more." By the end of the decade, however, working with a small permanent staff, augmented by summer help, the Materials Testing Division was billing $500,000 worth of fees annually, mainly for concrete testing at the request of the city of Calgary. As well, Rodway continued his consulting assignments in building failure, structural evaluation, fire damage, nuclear testing research, northern engineering, and as an expert witness in court cases. He had gained international recognition by this time, as evidenced by his lectures in China, Spain, and Norway, and by the consulting work he did for CIDA in Zambia, Africa. Rodway retired from Klohn Leonoff in 1990, at the normal retirement age of sixty-five. He currently continues an active consulting business.

Lloyd Rodway has seen and participated in great changes in concrete technology during his forty-one years of practice, contributing many papers to this field.[68] Environmental concerns long ago compelled the cement companies to take much greater care in combatting pollution. Electric precipitators now collect much of the dust from fumes expelled through stacks, for instance. However, as is often the case, this positive action has a concurrent negative effect, since when this material is recycled through the cement kiln, it raises the alkali content in cement. Certain aggregates previously thought to be totally inert now react adversely with this higher alkali content, resulting in more pop-outs, cracking, and disintegration of concrete than was seen before.

Contemporary pre-stressed and post-tensioned beams keep many structures in a constant highly compressed state, rather than in their natural unloaded state of near-zero stress, resulting in another common problem with present-day concrete—the prevalence of creep.

Additionally, freeze-thaw forces, combined in particular with the common use of de-icing salts, are nowadays causing the all too well-known disintegration of concrete highways, bridges, and parking structures.

Perhaps the most revolutionary advance in concrete technology during the past decade is in the design of very high strength structures. Where 3,000 pounds per square inch (psi) or 3,500 psi concrete was the norm twenty-five years ago, 10,000 psi or 15,000 psi and higher is often used today. This great increase in the practical, attainable strength of concrete has come about primarily through the use of superplasticizing agents. This development has allowed the design of much more slender, daring, and aesthetically pleasing structures. In the past, architects have dreamed of building 100-storey towers containing no columns, but such construction was simply not practical. Only with recent advances in structural design methods and concrete technology have such feats become possible.

Comments Rodway, rather wryly, on the role of the architect as compared to that of the engineer: "The architect serves a function as the interface between the public and the design team. But the engineer is the only one that can make idealized sketches of buildings become actual buildings. It's sort of back-room, unexciting stuff from the public's viewpoint, as opposed to the nice glossy sketches and upfront PR man that the architect has become, in part, in order to get any assignments at all."

By the end of the 1970s, KL's Alberta operation had stabilized nicely. Under the management of Don Davison, and with senior staff members Ken Gillespie in geotechnical, Don Pettey in civil and water resources, and Lloyd Rodway in materials, the Calgary office was equipped to provide a full range of service in all of the firm's major engineering disciplines. In April 1979, new premises were leased comprising 8,120 square feet in an office park at 6320-11th Street S.E.,[69] and the company move to this location entailed an extensive updating of both office and laboratory facilities.[70] By this time, Winnipeg had long foregone its role as the pivotal business centre of the West. There were few significant industrial or building projects on the drawing board in KL's Winnipeg office, and, as a result, the Winnipeg office was closed, and the company's Prairie operations consolidated in Calgary as of October 31, 1979.[71]

Two members of the Winnipeg staff have continued impressive careers with Klohn Leonoff in other offices.

Steven R. Ahlfield, an American from Illinois, was a research assistant and took his master's degree at the University of Illinois, studying geotechnical engineering under Dr. Ralph Peck. Upon graduation in 1976, he was hired by Klohn Leonoff for field work on the Reserve Mining project, but because the work was delayed, "Steve" was assigned to the Winnipeg office. In Winnipeg one of his jobs was resident geotechnical engineer for construction of bridge foundations using rock-socketed caissons. During the summers of 1978 and 1979, Ahlfield did in fact work as a field engineer on the tailings disposal system at Reserve, and, after closure of the Winnipeg office, he continued residence at Reserve until 1980, when he joined the staff in the Richmond office. Ahlfield has since been engaged in a great variety of projects in British Columbia and Alberta, paper mill expansions in Minnesota and Maine, and international assignments on the Ok Tedi project in Papua New Guinea, and the St. Lucia project in the West Indies. His most recent key assignment was resident geotechnical engineer co-ordinating a team of engineers and geologists at work on site investigations for a hydroelectric power development at Kemano, B.C.

In 1987, Kay Omoto, an honours UBC civil engineering graduate, joined the KL Vancouver staff. In 1989 she became a research and teaching assistant at UBC, earning a M.A.Sc. in geotechnical engineering. She married Steve Ahlfield, and, on her return in 1991, they became the first husband and wife engineering team in the company's history.

John A. Odermatt, the other Winnipeg employee who stayed on with Klohn Leonoff, is in fact one of the firm's longest-serving employees. After forty years of work, he is among western Canada's most experienced technicians in the geotechnical aspects of construction projects. Odermatt has specialized in field surveys, drilling investigations, field inspection and instrumentation of engineered earth structures, all types of pile foundations, rock tunnelling, and laboratory testing which has included direct shear and triaxial shear tests.

Born in Switzerland, Odermatt was a child of age nine when he came to British Columbia, just prior to World War II. In 1951, following graduation from Chilliwack High School, he was hitch-hiking to Vancouver to look for a job. The man who gave him a lift happened to be the contractor's superintendent on the Wahleach power project, and he asked John if he would like to work at the Wahleach site. This was just the type of opportunity Odermatt was looking for, and he started immediately as a surveyor's helper during the construction of the dam and tunnel. While there he met Mark Olsen. Odermatt continued work as a surveyor on a number of highway projects—the road from Chilliwack to Hope, a bridge approach at Creston, and the Burnaby freeway. The latter project was built over a peat bog where a great deal of instrumentation was installed to measure the deformation of the weak foundation soils. Says Odermatt of that work: "I took a lot of slope indicator readings. And that's actually where I got the first exposure to soils, and I thought it was pretty interesting."

Tired of surveying, and because of the uncertainty of steady employment in that field, in 1964 Odermatt thought of RKL. He applied to the company and was interviewed by Cyril Leonoff, who referred the application to Mark Olsen. Mark said tersely, "This fellow is okay," and Odermatt was hired. Thereafter John learned "as [he] went along," eventually developing a keen interest in geotechnical work. His first major assignment for the company was on pile inspection for the Port Alberni pulp mill. He subsequently did various other jobs in the British Columbia wilds, such as core drilling for a mine near Stewart where men and equipment were "helicoptered in." In 1967, Mark Olsen began direction of the caisson placement at the Richardson Building in Winnipeg (Chapter 8), and he chose John Odermatt as his assistant on this daunting work. After completion of this task, Odermatt continued as a technician in the Winnipeg office, where he became a specialist in caisson and pile foundation installation. A major (three-year) engagement for Odermatt was on foundation installations for the Reed Paper Mill at Dryden, Ontario. Since closure of the Winnipeg office, he has continued as a senior technician working out of the Calgary office.

Two members of KL's Calgary staff who contributed markedly in the latter half of the 1970s and early 1980s were Terry Haigh, a materials engineer, B.A.Sc. (honours) in civil engineering from the University of Calgary, and Leslie F. Sawatsky, a civil-hydraulics engineer with a B.A.Sc. (honours) in civil engineering from the University of British Columbia and a M.S. in hydraulics from Colorado State University. While on assignment with Canadian University Service Overseas (CUSO), Sawatsky had served for two years on irrigation, flood control, and land development projects in Sri Lanka and Sierra Leone, as well as a lecturer at Njala University College in Sierra Leone, Africa. Sawatsky returned to Vancouver in 1977, and Cyril Leonoff was taken slightly aback when the tall, self-assured Sawatsky stepped into Leonoff's office with the pronouncement that, of several possibilities, he had carefully selected Klohn Leonoff as the firm of choice for the furtherance of his career. No job was being advertised by KL at the time, yet, in Leonoff's words, "With that line, who could refuse 'Les' a job?" Sawatsky went on to competently serve the company on water resource projects in Alberta, British Columbia, the United States, and Sri Lanka.

Thomas K. Murray graduated in civil engineering from Queen's University, Kingston in 1975. After experience with other firms in Alberta and the North, in 1977 he joined the Klohn Leonoff Calgary staff as a geotechnical engineer. Murray has played a significant role in several water resource projects in Alberta, specifically in the application of computer analyses to slope stability, groundwater, seepage, and hydraulic flood models, and on construction supervision. A down-to-earth person, Don Davison has paid him this back-handed tribute: "I've got 'Tom' Murray, who is really good in dealing with the farmers on the irrigation projects."

In addition to working on several of the Alberta pulp mill ventures, Tom Murray is currently project engineer/manager for the Alberta Pacific Forest Industries Inc. (ALPAC) Pulp Mill at Athabasca, responsible for construction monitoring, which includes caisson pile inspection, pile load testing, borrow investigation, earthwork quality control, and foundation recommendations.

Sandra G. Housken, another key person in the Calgary office, joined the staff there in November 1974. She has been with the company ever since, and, with her superior secretarial skills and extroverted personality, has risen to the position of office manager. A career-oriented woman, "Sandy" articulates the principal reason for her interest in work: "I am a people person. I can't function without people. And I don't like the coffee-klatsch syndrome. So [work] gives me my way out. It makes me a happier person at home. Actually the family benefits from me working, not only financially but generally."

And part of the reason for Sandy's success at the office can be found in her attitude toward office technology, with its constant, rapid advance. Whereas some people find the increasing sophistication of such technology intimidating, Sandy's viewpoint is quite the opposite: "I think machines are neat. You often hear of user-friendly machines, but I was once told on a course, 'You are a machine-friendly person.' I don't find machines threatening. I find them a challenge and love to work them. They have helped tremendously."

She concedes that computers, copying machines, and facsimiles tend to produce more paper than typewriters, carbon copies, and telex machines ever did, but makes the point that, businesswise, the new technology is a good deal more efficient. Concludes Sandy, "I would never go back, ever."

Does Sandy believe in the women's movement? "I believe very strongly in equal pay for equal work. But I don't need ten women behind me saying what I can or can't do. I feel, as a human being, that if you want something badly enough, you will accomplish it."

Sandra Housken, the up-front smiling face, the morale booster, the social convenor, the concerned person in times of illness or death, the optimist through many ups and downs, has embodied the working spirit of the Calgary office.

Ella I. Toovey, also noteworthy in the Calgary office, is a business college graduate and Certified General Accountant (CGA) who joined the staff in 1979. Ella served as accounting supervisor for the Calgary office until 1990, when the accounting and invoicing were centralized in the Richmond office.

One of the positive outcomes of this reorganization, coinciding as it did with substantial completion of the northern pipeline and Kuwait projects, was the releasing of Earl Speer for other important tasks within the Klohn Leonoff operations. By 1979 Speer had over twenty years of varied engineering, business, and marketing experience in both the public and private sectors and had been with KL for nearly a decade. While self-described as "not a natural salesperson," Speer's attributes of entrepreneurship, persistence, dedication, and common sense had over time won the confidence of a myriad of clients and brought in a number of major projects to the company. In 1979 Speer became the company's Vice-President of Business Development[72] and the principal in charge of KL's new United States office in Denver, Colorado (Chapter 12).

Given the demands of the heated-up Canadian and American economies of the late 1970s and early 1980s, obtaining adequate numbers of staff suitably trained and experienced in the specialist engineering services provided by Klohn Leonoff, was a difficult task. Not only were the company's normal sources of new graduates from the British Columbia and Prairie universities falling well short of the demand, but, because of the paucity of Canadian-trained engineers just before and immediately after World War II, the scarcity of experienced engineers was even more acute. The Management Committee meeting of December 1979, facing a shortfall of fifteen engineers in the Vancouver office,[73] instituted a full-scale recruitment effort. Advertisements were placed in appropriate publications across Canada and the United States, as well as in England. In addition, several "headhunters" were retained. The costs of these recruitment programs were high and the results mixed. The company was successful in obtaining several key staff (Appendix II). Many filled an immediate need and later moved on to other employment. Some later had to be let go as a result of the deep recession which ensued in the 1981–84 period. A number stayed on as valued permanent employees of the company.

Dr. Robin G. Charlwood, originally from Brighton, England and a 1970 Ph.D. graduate in civil engineering from the University of British Columbia, came to Klohn Leonoff in 1979 to manage the newly formed Special Services Division. He had previously been manager of research and development for Acres Consulting Services of Niagara Falls, Ontario. Perhaps the most brilliant technical man on staff, his areas of expertise were the development and application of advanced analytical and computer simulation techniques in engineering mechanics, geoscience, and management science. This work included radioactive waste management, earthquake engineering, foundation dynamics, structural and mechanical engineering, the provision of project planning, decision and risk analysis services, and conceptual designs utilizing multidiscipline teams. Charlwood also had a grandiose plan for the establishment of an "earthquake engineering centre" to be operational by 1981.[74]

Gail M. Atkinson, with a degree (B.Sc. Honours) in physics and geology from Carleton University and a M.Eng.Sc. in civil engineering from the University of Western Ontario, joined Charlwood's Special Services Division in 1980. While at university and in her professional life, Gail Atkinson's specialty has been earthquake engineering. She conducted studies assessing earthquake hazard and probability for British Columbia, and together she and Charlwood published a number of technical papers on the topic.[75]

British Columbia is one of the most seismically active regions in Canada, with moderate- to large-magnitude earthquakes presumably having occurred in the area for eons. The first documented evidence of a major earthquake occurred in 1872, when a quake of M 7.0 to 7.5 on the Richter scale, with its epicentre south of Chilliwack, was felt throughout most of settled British Columbia and as far south as Oregon. Near Chilliwack large landslides and ground waves were observed, while in Vernon buildings and tepees were knocked down.

In more modern times, the most damaging earthquake (M 7.25) took place in 1946 along the east coast of central Vancouver Island. It caused many ground cracks, landslides, and seiches on lake and coastal waters. Although building damage was limited mainly to overthrown chimneys, some houses and industrial structures were harmed by sliding or slumping of the foundation soils. In 1949 the largest Canadian earthquake of record (M 8.4) occurred in the Queen Charlotte Islands. While this quake caused no significant damage in the sparsely settled region surrounding its epicentre, it was equal in magnitude to the disastrous 1906 San Francisco earthquake, where surrounding population and building density were high.

From this record, it's evident that earthquake damage in

Ph.D. candidate Alexander Sy conducting research on density of granular soil and resistance to liquefaction, 1991.
Photo: Science Council of British Columbia

British Columbia has been light to date, owing to scant populations and few buildings in affected areas. However, over the last four decades, because of large increases in both population and buildings (many of these located on tidal and deltaic soils subject to liquefaction), earthquakes of equal or greater magnitude to those already experienced could cause serious casualties and damages.

Considering these recent developments, it is regrettable that, following the economic downturn experienced by KL in the first half of the 1980s, the Special Services Division, with its emphasis on earthquake engineering, was dissolved. Both Charlwood and Atkinson returned to central Canada.

Almost from its inception, Klohn Leonoff has been proud of the international composition of its staff. Initially, the international component came largely from Great Britain, Scandinavia, continental Europe, Australia, and New Zealand. Increasingly, however, in the period 1970 to 1980, Canada was turning to immigrants of Asian ancestry to supply its skilled manpower needs. As well, children of these immigrants were excelling in the sciences at high schools and universities and graduating from Canadian engineering schools in substantial numbers. Klohn Leonoff was fortunate in recruiting several of these people.

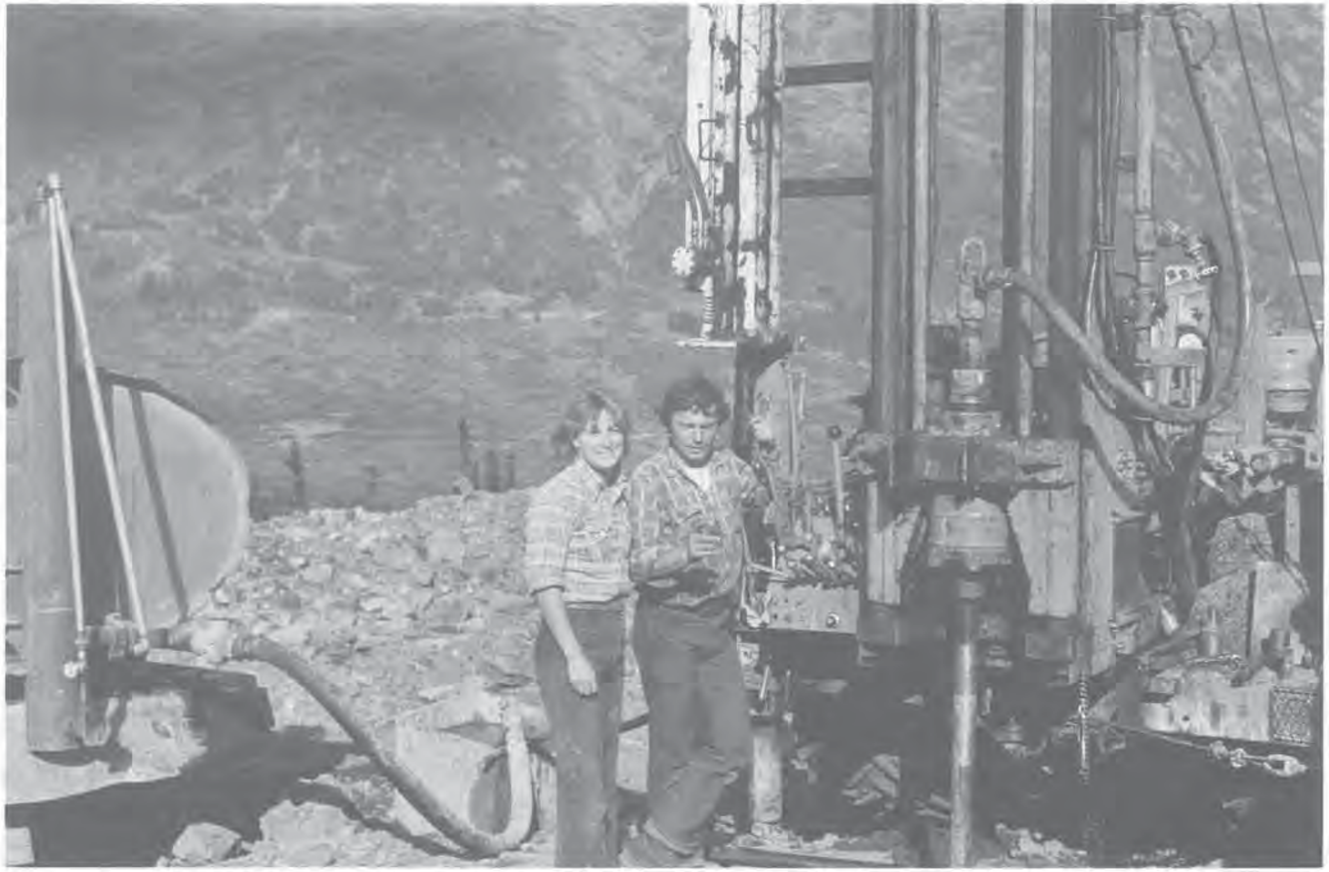
In 1966, Dr. Milton Hsu, educated at Queen's University in Belfast, was the first engineer of Chinese ethnic background to join the RKL staff.[76] Later he was to found his own consulting practice of geotechnical engineering in Vancouver.

In 1976 Bill G. Chin was the first of the Canadian school of Chinese engineers to arrive and stay. Born in China in 1952, at age four he migrated to Hong Kong along with his parents, a labourer and a seamstress of modest means. When Bill was aged six, the family moved to British Columbia. In 1976 Chin graduated with a B.A.Sc. in civil engineering from the University of British Columbia and later earned a M.Eng. at the University of Alberta. First in the B.C. Region, and later in Alberta where he became manager of the Geotechnical Division, Chin has worked on a vast array of engineering projects over a period of fifteen years, making a sizable contribution to the geotechnical achievements of the company.

Alexander Sy was born in 1949, a second-generation Filipino of Chinese descent. When he was ten years old his father died, and "Alex" came under the influence of a maternal uncle who was an engineer in Australia and later a professor of civil engineering at the University of Singapore. Sy attended high school in Australia and received his B.E. in civil engineering from the University of Queensland in Brisbane. After graduation and some work experience in Australia, he came to visit a sister living in Vancouver and decided to stay. Joining Klohn Leonoff in 1977 and displaying considerable engineering excellence, Sy is now a senior engineer with the firm. While involved in all aspects of geotechnical engineering, he has specialized in earthquake work, foundation vibrations, and pile dynamics. Continuing his education, in 1985 Alex Sy earned a M.Eng. (Geotechnical) from the University of British Columbia. In 1988 he was one of the first two students to receive the Science and Technology Awards for Returning Students (STARS) of the Science Council of British Columbia. STARS scholarships are substantial—valued at $25,000 per year over a three-year period—and are granted to students with previous applicable work experience.[77] Under this program, Sy has been studying for a Ph.D. at UBC under Professor R. G. Campanella, doing research and a thesis on the topic, "Dynamics of the Standard Penetration Test and the Becker Penetration Test" to "help strengthen structural foundations against earthquakes."[78]

Born in China in 1952, Ken Lum came with his family, via Hong Kong, to Vancouver at age six. His parents, unlike many of the Hong Kong arrivals of recent years, were of limited financial means. Seeking increased economic opportunity for their children, they encouraged them to enter the professions. Consequently, four of the five sons of the Lum family went into engineering. Ken, the third son, was influenced by his older brothers and earned a B.A.Sc. and a M.A.Sc. in geological engineering and a M.A.Sc. in civil engineering (soil mechanics) at the University of British Columbia. Ken Lum joined the KL staff in 1977 and was the first to introduce the use of personal computers (a MacIntosh Apple II Plus) into the office, becoming a specialist in microcomputer applications in geotechnical engineering. On one of his early overseas assignments, Lum implemented on-site microcomputer facilities at the Betania hydroelectric project in Colombia, South America. This included the training of local engineers in the use of spreadsheets and various engineering software programs. He also has participated in the analysis and design of the company's projects at Reserve Mining in Minnesota and at the Ok Tedi and Ok Menga sites in Papua New Guinea.

Loren Tung, educated in civil engineering at the National Taiwan University, came to KL in 1979 and has since



Adanac Ruby Creek Mine investigation, Atlin, B.C. – Engineer Peri Mehling and driller with rotary drill, August 12, 1980.

worked as a professional engineering technologist in British Columbia and Alberta. He has been involved in all aspects of field investigation and laboratory testing of soils in B.C., the Prairies, and overseas.

The Calgary office also benefited from Asian immigration. In 1975, T. Leon Kung joined the Calgary staff with impressive credentials: a B.S. in civil engineering, Chen-Kung University, Taiwan; research assistant and M.E., Asian Institute of Technology, Thailand; teaching and research assistant, M.E., hydraulic engineering, and a Ph.D. in civil engineering, University of Windsor. His northern experience included river crossings for the trans-Alaska pipeline, design of a gravity-based offshore structure in Alaska, Beaufort Sea ice hydrology and ice scour studies, and a computer model to estimate peak discharges for rivers in permafrost regions.

Through the years, engineers of East Indian extraction have also contributed materially to the success of Klohn Leonoff. After obtaining his B.A.Sc. and a M.A.Sc. from the University of British Columbia, Hari K. Mittal joined the staff in 1963 as a soil mechanics engineer with a strong technical affinity. He remained until 1971, when he left to commence three years of study at the University of Alberta, graduating with a Ph.D. After graduation, Dr. Mittal worked as a consulting engineer involved with tailings dams, waste dumps, open-pit slopes, and other geotechnical aspects of several oil sands and coal mining projects then flourishing in northern Alberta.[79] Mittal rejoined KL in the 1980–83[80] period as a project manager and staff consultant and for a time served as manager of the Mining Services Division Alberta Region. He left as work diminished in the ensuing recession. Currently he is a consulting engineer in Saskatchewan.

In 1976 Kishin S. "Kris" Khilnani was hired as a senior engineer. Khilani held a B.Eng. (civil) from Nagpur University and a M.Eng. (soil mechanics and foundation engineering) from the Indian Institute of Science, Bangalore, and possessed considerable experience on major hydroelectric projects in British Columbia and Manitoba. He later joined the B.C. Hydro and Power Authority engineering staff.

Dr. Vinod K. Garga, a senior engineer of international reputation, joined the Klohn Leonoff staff in 1979.[81] A Kenyan of East Indian descent, Garga had earned his B.Sc. in civil engineering at University College, Nairobi in 1966, and a Ph.D. in soil mechanics at Imperial College, London. Following his education, Garga spent eight years in Brazil and Argentina as a consultant and professor. His expertise related to mining and hydroelectric developments, including earth and rockfill dams, tailings embankments, rock excavations, and pit slopes. Serving KL variously as a project manager, manager of the Mining Services Division, and staff consultant in British Columbia, Yukon, Mexico, Chili, Peru, and Venezuela, Garga resigned from the company in June 1985[82] to become professor of geotechnical engineering at the University of Ottawa.

In 1979 Chander M. Khosla became Materials Engineer in the Calgary office. Khosla had a M.Tech. in civil engineering from the Indian Institute of Technology, Delhi, and a M.A.Sc. in civil engineering from the University of Windsor, as well as experience in a number of laboratories and on materials consulting projects in Ontario and Alberta.

Additionally, by the end of the 1970s, women engineers were beginning to graduate from the universities in more meaningful numbers, and the company was able to access an additional source of talent.

When the principals of Ripley Klohn & Leonoff were studying engineering at the western Canadian universities during the war and immediate post-war period, no women candidates were anywhere to be seen. Society's viewpoint at the time was that engineering was a man's profession, and a woman was neither suited for nor interested in civil engineering, which supposedly involved rugged field work out in the Canadian (or foreign) wilds for much of the year. (In fairness, this was prior to the computer age and the art of "number crunching," when so much of engineering is done on a desktop.)

Other societies were ahead of Canada in utilizing the technical abilities of women. By the mid-forties, when Charles Ripley was attending Harvard University, Ruth Terzaghi was a geologist there of considerable repute. When Cyril Leonoff attended the University of Washington in the early 1950s, there was already a woman engineer on the research staff. And upon visiting Moscow's Lemonosov University in 1973, he found that women were occupying senior positions in many of the science faculties.

By the mid-seventies, in suffering a chronic shortage of suitable university graduates, the Canadian engineering profession was just beginning to recognize that the female half of humankind could be more effectively utilized. As a consequence, public relations programs were being introduced to encourage women high school graduates to enter the universities' engineering faculties. These programs proved to be at least partially successful, and in British Columbia a trickle of women began to appear on the professional scene.

In the spring of 1979, Peri E. Mehling, a new civil engineering graduate from the University of British Columbia, was the first woman engineer to apply to the firm. Says Cyril Leonoff: "We were looking for good young engineers, so we hired her without hesitation. We didn't know it at the time but learned later from her geotechnical professor that she had topped the civil engineering class." Next came Sheila A. Porter, a 1980 UBC graduate in geological engineering. These bright young women were at least equal to their male counterparts of that period and were fully accepted by their supervisors. They also worked well alongside their male peers, who did not feel threatened as long as the women were given no special treatment. For instance, like the men, they were expected to "pay their dues" in the field. In fact, both Peri and Sheila spent the 1980 field season in the extreme northwestern corner of the province

Adanac Ruby Creek Mine investigation, Atlin, B.C.– Geologist Sheila Porter logging test hole, September 3, 1980.

Jenny MacDougall conducting cyclic triaxial laboratory test, Richmond, B.C., 1981.

carrying out site investigations for the proposed Adanac molybdenum mine of Placer Developments Limited, at the Ruby Creek deposit near Atlin, B.C. The physiography, surface water hydrological regime, and the geological and geotechnical conditions for a 110-metre-high tailings dam, and 23-metre-high freshwater dam were investigated. In view of concerns raised by low-level radioactivity in the ore, field and laboratory radioactivity measurements were made in groundwater and biota, while field radon gas emissions were measured to define background levels.[83]

Other women engineers, trained in other universities, also joined the Vancouver office at the beginning of the 1980s. M. Suzanne Ramsay Woeller, a B.Sc. graduate in civil engineering from Queen's University, Kingston worked on air photo interpretation and field investigations for the selection of landfill sites in western Canada.

In the spring of 1981, KL purchased cyclical triaxial testing apparatus for the laboratory at a cost of $10,000 for equipment and installation.[84] This equipment provided testing services superior to those currently available elsewhere in Vancouver or at UBC. At this time, Jenny MacDougall, a geotechnical engineer from the University of Alberta, came on staff and performed sophisticated laboratory analyses which included cyclic triaxial and direct shear tests for such projects as Cauquenes and Barahona dams in Chile, Brenda Mines and the B.C. Rail Tumbler Ridge line in British Columbia, and the Forty Mile Coulee dams in Alberta.

Adrian Wightman, to whom Jenny was responsible, recalls her work with enthusiasm: "She did a helluva good job for us. Jenny applied her organizational skills to the laboratory and got a lot of things done that our technicians were never able to accomplish. She was around for a couple of years, then got married and moved back to Edmonton. [Jenny became pregnant with her first child and left the company in 1982.] Jenny has four or five kids now and has settled into a home lifestyle. I don't know whether she's planning on getting back into engineering."

Concurrently, other women technicians and engineers were being employed in other KL offices: in Calgary (1979) Diane M. Lehto, a geological and geotechnical technologist; in Denver (1981) Marla M. Moody, a senior engineer/hydrologist with a M.S. in civil engineering from Louisiana State University; and on the Quebec-Cartier project (1981), Valerie E. Crooks, a geotechnical engineer with a M.E.Sc. from the University of Western Ontario.

Thus, within a period of three years, Klohn Leonoff had assembled a rather impressive array of female talent from around the country. Unfortunately none of these people were to remain long enough with the firm to occupy senior positions. The reasons for leaving varied. Some left to raise families; others wanted to pursue further studies. And, in the ensuing recession of the early 1980s, some left, as female and male staff were reduced.

Chapter Eleven

GOING INTERNATIONAL

One of the differences in viewpoint that developed among the original principals of RKL had to do with international work. Earle Klohn and Cyril Leonoff felt that it was necessary to pursue overseas work, if only by way of developing a reputation at home, but Charles Ripley was reluctant to move into areas that he knew very little about. Klohn viewed that attitude as disadvantageous:

"Charlie was lukewarm about overseas work. He felt you should tend to your business at home. His attitude was if you develop work here, who needs to go overseas? I might add that the R. M. Hardy organization ran that way until recently. Going back to my exposure to the review board on the Squaw Rapids project, almost everyone at those meetings except me had worked on engineering projects overseas. Certainly your opinion didn't carry any weight if all you could say was, well, yesterday in Red Deer I did this. From the beginning, I felt very strongly that as a marketing tool the company needed overseas exposure."

Despite Charles Ripley's reluctance, the company had received a number of international assignments over the years, and it was in fact Charlie who was engaged on these initial jobs. In October of 1959, Ripley was asked by H. A. Simons (International) Ltd. to review the use of pile foundations for a state-owned paper mill in Piteå, Sweden. Local consultants had expressed doubt as to whether the sensitive mill structures could be supported on piles and had instead recommended the use of piers put down to bedrock—a much more costly construction method.

After a foundation investigation had been carried out, Ripley visited the site in September 1960. En route from the site he filed a personal handwritten note to Howard Simons, followed by a formal report:

"Throughout my stay in Sweden I was warmed by the feeling of welcome . . . and wholehearted co-operation of . . . both the officials of Statens Skogsindustrier and their engineering consultants, in making information and data available . . . and in sharing their own thoughts with me. . . .

"In essence my conclusions concerning the foundation problem [are] that the entire plant could be supported on piles. . . . With the benefit of your experience with paper mills supported on pile foundations in glaciated areas of North America with similar soil conditions, it is possible to eliminate the doubt about pile foundations in Piteå. Specifically the soil conditions are physically and geologically similar to Port Alberni, although not as difficult and complex. . . . The Port Alberni foundation experience, and in particular the detailed and reliable settlement records have been of much use. [This] is a tribute to you and to the Port Alberni mill owners for your active participation in the assembly of positive engineering data in an area where it is so scarce and yet so vital. . . ."[1]

In fact, the mill was satisfactorily supported on precast concrete piles up to 13 metres long, driven through soft organic clay into a fine silty-sand glacial moraine.[2]

In February 1963, Charles Ripley was in Egypt attending a conference on large dams. Sandwell and Company Ltd. took advantage of Ripley's presence in the region to obtain his advice on the Sangu Irrigation and Power Project, built under the Colombo Plan near Bandarban in East Pakistan (now Bangladesh).[3] And in the spring of 1964, Mark Olsen was sent on his first overseas engineering assignment to inspect drilling investigations at that same site. On this job Mark was to meet and work with Jack Laurence, Cyril Leonoff's classmate at the University of Manitoba and the husband of Margaret Laurence, later to emerge as an important Canadian novelist. (It was in fact the Laurences' experience living in foreign lands that formed the setting for some of Margaret's early writing.[4]) While in the country, Olsen was also engaged by Sandwell to do a preliminary foundation investigation for the Sylhet Pulp and Paper Mill at Chhatak in the northern part of Pakistan.[5] However, despite these sojourns, Ripley, Klohn & Leonoff was never able to develop the rapport with the Sandwell organization that it had with H. A. Simons Ltd.

Driving precast concrete piles, Aktiebolaget Statens Skogsindustrier pulp and paper mill, Piteå, Sweden, 1961.
Photo: Kjells FoTo AB

Although it was fashionable at the time to include "International" in a corporation's name, Ripley, Klohn & Leonoff International Ltd. had in fact been incorporated in May 1967 with the specific intent of doing overseas work. However, while it is one thing for an engineer to work as an international consultant on an individual fee basis, payable in Canadian or American currency, it is quite another problem for a company to develop such work from the outset. Overseas promotion is very costly, therefore has to be targeted to a specific geographic area, and the client must be able to pay in an internationally negotiable currency.

While Canadian-supported international aid agencies such as the World Bank Monetary Fund and the Inter-American Development Bank provide substantial development funds to Third World countries, Canada is a relatively minor player in the international field. As well, the granting of contracts on such projects is highly political, thus often limiting the role of western Canadian firms. Yet Vancouver-based companies have certain advantages. They are located on the Pacific Rim; indeed Vancouver is at a crossroads of international air travel. And in the post-war development of much of its own virgin country, particularly in the West and the North, Canada had created a great deal of engineering expertise which would be valuable to developing countries. So a solution adopted by Canadian firms in the face of this international marketing quandary was to pool their resources in order to offer a broad range of services and share the promotion costs. In August 1967, under the headline, "Firms Join in Consortium to Bid on Projects Abroad," a local news item reported one such assembly:

"A consortium of Vancouver firms, each with capabilities in special fields of engineering and development, has been formed to offer comprehensive engineering services in the developing countries. . . . Cancon[6] [Engineering Services Ltd.] . . . is equally owned by Swan Wooster [Engineering Co. Ltd.], Associated Engineering Services Ltd., J. C. Sproule & Associates Ltd., Ripley, Klohn & Leonoff International Ltd., Underhill Engineering Co. Ltd., Rhone & Iredale, Architects, and Woods Gordon & Co. All are Vancouver-based groups except Sproule (Calgary) and Woods Gordon (Toronto). . . . [While] no single company is large enough . . . to compete internationally for contracts . . . as a consortium . . . which commands the services of 778 professionals and 250 non-professionals . . . they can offer a comprehensive service unmatched anywhere in Canada . . . in engineering, architecture, economics and management. . . ."[7]

Quoting a spokesman for the group, John O. T. Lee of Swan Wooster, the article went on to state:

" 'We feel we are in a unique position to work in the developing countries of the world because we have had the recent experience of developing a country. Canadians have gone into absolutely virgin areas, creating towns, water supplies, all the basic services and designing and building the required facilities. We feel that developing countries can use this experience. . . . Obtaining a volume of work of this kind is of great benefit to the engineering group because it is able to retain a staff and maintain an organization that otherwise would have to disband at the end of each big project. . . . The Canadian group will be competing with similar groups based in Japan, West Germany, Britain and other countries. . . . Canadian engineering talent is underused internationally [and its overseas employment returns] less in dollar value than Canada's cash aid to developing countries. . . . When an engineering group such as ours

Water well drilling to 150-foot depth, village on Ganges delta, East Pakistan (Bangladesh), 1963.
Photo: Charles Ripley

Mark Olsen, accompanied by Jack Laurence, investigating dam sites on Sangu River, East Pakistan, spring 1964.
Photo: Jack Laurence

obtains a project overseas it opens the door for Canadian manufacturers and suppliers of all types. This fact is recognized by governments of West Germany and Japan who actually subsidize basic engineering in order to obtain commercial contracts later.' "[8]

Cancon was the brainchild of the irrepressible B. D. "Buck" Bohna of Vancouver, who was hired on as the first manager. Later he was replaced by a retired navy man, Commander John Lee. Operating out of Beirut, Lebanon, Cancon focused its promotional activities in the Middle East. This region was selected because of its underdeveloped economy, yet plentiful hard currency gained from increasing oil exports to the Western World and Japan. A few members of the group, notably Swan Wooster, obtained some jobs through Cancon.[9] And in the summer of 1971, Earle Klohn travelled to Yemen to carry out foundation investigations for oil tank "farm sites."

Klohn was still relatively green in international travel decorum, especially with regard to Arab customs, and before embarking to Yemen, he had stopped for a day in Riyadh, Saudi Arabia. When his suitcase was checked at the airport, Klohn was promptly arrested by two burly officers and taken to a private room for interrogation. What to Klohn was a select Canadian refreshment, appropriate to a desert country was to his host country contraband. After pleading his ignorance and signing a long document in Arabic which he could neither read nor comprehend, Klohn

Earle Klohn with native fishermen's children, Yemen, summer 1971.

was freed to board the airplane. But not before being escorted to a washroom where the bottle of liquor was ceremoniously poured down the drain. Today, after logging well over 2-million air miles, Klohn is a much more seasoned international traveller.

On the Yemen trip, Klohn also realized some of the practical difficulties involved with working in hot, foreign countries, as quoted, upon his return, in the Vancouver press:

"It's hard to plan a schedule based on full working days when people work only half days. This was the problem discovered by Earle Klohn, president of Ripley, Klohn & Leonoff International Ltd., foundation engineers, after spending two weeks in Yemen. 'We think of working a full day,' he said, 'but in Yemen, people came to work between 7 and 8 in the morning and worked until 12 or 1. . . . Here there's still half a working day left after lunch, but there the day is finished.' Klohn felt that the weather could be a major cause of the abbreviated working day. 'By 11 A.M. the sun is pretty hot,' he said. 'Between 11 and 3 the temperature is 100 to 110 and the humidity over 90 percent.' Klohn said North American engineers working in Arab or Asian countries simply have to adjust to local working conditions. 'We know that time means money, but the people there don't realize what it is we are getting upset about when things don't get done as quickly as we think they should,' he said. 'There is no point in becoming frustrated. The more upset you act, the worse the situation gets.' "[10]

Politically the Middle East is a turbulent region. Competition for work in the area is stiff. And, even when jobs were obtained via Cancon, it proved difficult to interest KL staff in going there. Thus, while it put the company's name in the media and provided some preliminary experience in the realities of selling and doing overseas work, Cancon could hardly be rated a success. The consortium dissolved in the early seventies.

In 1970, the Pacific Development Group [PDG], "a combination of business, professional, and educational concerns," was formed as "probably the first concerted effort to bring Canadian expert advice to Asia outside the official aid field." Instigator and president of the group was Douglas A. Whelen of Associated Engineering, and, while comprised of many of the same players as was Cancon, PDG was nevertheless a broader-based group.[11]

The PDG was "backed informally by the Canadian Government as part of Prime Minister Pierre Trudeau's new Pacific policy, . . . but on the premise that Ottawa has no intention of officially supporting competition [to] already established Canadian companies in the field."

In the spring of 1971, Ian V. Macdonald, an official of the Department of Industry, Trade and Commerce in the newly created External Services Division, was dispatched on a two-month Asian and Pacific tour to sound out possible projects for the group, which hoped to offer specialized services in fields such as geology, transport, housing, tourism development, health, education, economic planning, industrial research, and finance.[12] A colour brochure was issued indicating the services offered by the individual firms.[13]

PDG limped along for half-a-dozen years, but, being a loosely knit group that lacked any genuine focus, integration, or promotional clout, it's success was mainly in the category of "wishful thinking." Klohn Leonoff left the group in 1976, after having derived no work from its efforts, and PDG was to be KL's last major group endeavour to sell to foreign markets.

In February 1969, on his first overseas assignment, Earle Klohn was in Bangkok, Thailand as part of an International Board of consultants which included noted American engineers Thomas M. Leps and Eugene B. Waggoner. They were working on the design and construction of Sirikit Dam for Thailand's Royal Irrigation Department. Klohn had been retained by the World Bank, the funder of this $40 million, 110-metre-high earthfill dam project straddling the Nam River in north Thailand. The dam was to be built to store monsoon rain water for irrigation in the dry season and also to generate hydroelectric power.[14] In February 1971, a news item in a Vancouver paper reported on the project's inauguration:

"In charming English, Vancouver consulting engineer Earle Jardine Klohn has been invited to the 'occasion of the royal performance of Sirikit Dam foundation stone laying' by their Majesties Bhumibol Adulyadey and Sirikit, King and Queen of Thailand.

"The elaborately embossed invitation card asking him to attend the dam opening also advises that he may wear his ordinary dress uniform. As he has no regimentals he will doubtless on the day be sweltering in his best business suit."[15]

Sirikit Multipurpose Dam, Nan River, Thailand – Construction, ca. 1970.
Photo: Royal Irrigation Department of Thailand

Sirikit Multipurpose Dam, Nan River, Thailand–
Hand grading of riprap on upstream slope.
Photo: Earle Klohn

On the Occasion of the Royal Performance of
Sirikit Dam Foundation Stone Laying Ceremony
The Minister of National Development
requests the honour of the presence of
Mr. and Mrs. Earle J. Klohn
in attendance on Their Majesties the King and Queen
on 27th February 1971 at 16.00 p.m
at the Headworks of the Nan River Project
Ta Pla District, Uttaradit Province

Ordinary Dress Uniform or
Lounge Suit

R.S.V.P.
Tel. 850647, 851630

In April 1969, because of his experience at Brenda Mines, Klohn was retained by Binnie & Partners of London, England as a specialist consultant on a tailings dam for a copper development by Iranian Selection Trust at Sar Cheshmeh, Iran.[16] The 300-foot-high dam was sited at elevation 7,000 feet, at the head of a valley which cradled numerous valuable plantations of pistachio trees. The requirements were twofold: first, that the dam be quake-proof; and second, that there be no escape of mine water, which could poison the pistachio trees.[17] No one from Klohn Leonoff has been in the area for some years now, but with the firm's experience on local tailings dams, it is assumed that the pistachio trees are still bearing nuts.[18]

Early in 1967, RKLI was also engaged by Wright Engineers and Placer Developments, both Vancouver-based firms, on mill foundations at Marcopper Mine in the Philippines.

Having tasted consulting assignments in Thailand and Pakistan, RKLI viewed the developing region of Southeast Asia as an attractive and fertile potential extension of RKLI's expertise. But it was a long way from home. Australia seemed to be a closer and more logical base from which to develop such work.

In the fifties and sixties the company had employed a number of young Australian engineers. As the Australian and Canadian language, culture, and schooling had derived largely from a common British background, RKL found that these engineers fitted in well with North American practice. The only problem was that the Australians were often itinerant. Their objective was to travel and work their way around the world, almost invariably returning home after a few years. And Vancouver was usually only their first stopover upon disembarking in North America. One of these Australian engineers, whom the principals of RKL had known, was David D. Coffey. Coffey had worked in British Columbia for Thurber and Associates, a competitor firm, and after gaining consulting experience, had returned home to found his own engineering company, Coffey and Hollingsworth, with offices in the principal cities of Australia. As well, in 1967, Kerry McManus, who had been employed by RKL, was a member of Coffey's firm.

Based on his already appreciable tailings dam experience at Brenda and Gibraltar Mines, in November 1972 Klohn was appointed as a specialist consultant on preparation of the "Tailings Retention Scheme" for Ranger Uranium Mines Pty. Ltd., at a site 140 miles east of Darwin, in the Northern Territory, Australia.[19] The firm of Coffey and Hollingsworth was the general engineer on this job. Growing out of this collaboration on the Ranger job, in March 1973 the following announcement was made:

"Ripley, Klohn & Leonoff International Ltd., consulting geotechnical engineers, is pleased to announce that it has formed an association with Coffey & Hollingsworth Pty. Ltd., one of Australia's oldest and largest consulting firms in the geotechnical engineering field. The association enables [RKLI] to offer its North American clients a completely integrated geotechnical engineering service in both Australia and Southeast Asia. This service has the advantage of combining North American and Australian expertise and experience with local knowledge of both geotechnical and geographical conditions in these areas."[20]

Despite the rhetoric, other than the Ranger job which continued into 1976, nothing substantial developed out of this collaboration. In hindsight, it's apparent that an association by firms competing in the same disciplines was unlikely to generate much mutual work.

In the struggle to develop overseas markets, RKLI was to experience other false starts. In 1973 with the drop-off in domestic jobs, there was an increased emphasis placed by the company on the promotion of foreign work. In view of his special expertise, European background and training, his fluency in French, English, Danish and working knowledge of other languages, Yves Bajard was provided with support to develop work in Europe and Africa. His efforts were to be related to his traditional fields of engineering geology and hydrology and to a methodology for establishing mathematical models for regional water management. In association with other firms from western Canada, Bajard also aimed to make available a multidisciplinary service "in countries where there is a need for foreign involvement in the fields of regional management, physical or general planning, water resource surveys and management, land use development and management, and industrial and urban development."

Bajard was evidently well equipped for the job. In 1972 he had given special advice on a groundwater study conducted in Thessaly, Greece.[21] In the Highland Valley of British Columbia, in 1972–73, he had undertaken a study to control groundwater flows for a large open-pit copper mine. In 1973–74 he was head of an advisory team sent by the Canadian International Development Agency (CIDA) to the Ivory Coast to evaluate a request for Canadian assistance in the development of rural water supplies. And in Ethiopia in 1974, again for CIDA, he carried out a water resources survey in the arid regions of that country.

In a news interview of September 1974, headlined, "When giving is not enough," Bajard described his approach:

" 'I don't want to downgrade the foreign assistance CIDA has performed—generally it's doing a good job,' he says. 'But Canada and other countries have made a lot of mistakes. We have been playing the elephant in the china shop. It's high time we gave more thought to the kind of assistance we give. The solution is not to stop trying, but to try to be more far-seeing. . . .

"Sometimes we give assistance without really knowing whether the people we are trying to help will be able to use what we give them,' he adds. 'We might give electric or diesel pumps, but when the pumps break down nobody knows how to repair them. This way you are giving water for [a time], and then when people are really used to having water—plop—they're suddenly without and worse off than they were before. . . .

"Fortunately our attitudes to foreign aid are changing. We are beginning to take much more care and trying to provide simple technological devices, rather than sophisticated equipment which needs oil and maintenance.' "

In a nutshell Bajard's philosophy, as stated in a company brochure, was, "Don't give a fish to the starving man; teach him how to fish."[22]

Bajard's most ambitious scheme, undertaken from March 1973 to August 1974, involved "pre-feasibility" studies on "Co-ordinated Urban and Industrial Development" in western Kenya. The objective was to resolve the problems produced by the massive migration of peoples from farmland to cities such as Nairobi and Mombasa, a migration which tended to generate unemployment, slum dwellings, and other forms of social stress. The study aimed first at providing a method of producing very low-cost, prefabricated modular housing and secondly at conceiving local industries that would make use of indigenous resources, using processes which could be understood by the available manpower. The end result was to be a balanced and diversified development of the towns and back country.

To carry out this work, Bajard put together a consortium of four firms under the name of Kendev (Kenyan Development), comprised of Klohn Leonoff, Associated Engineering, P. W. Tattersfield and Associates (Landscape Designers) of Vancouver, and Etienne Gaboury and Associates (Architects and Planners) of Winnipeg. Partial funding of the prefeasibility study was obtained through the Canadian government's Department of Industry, Trade and Commerce.[23] The hope was that, if the initial fact-finding mission proved positive,[24] continuing feasibility studies would be undertaken, including the identification of the necessary financing. Following the securing of funds, detailed design work would be undertaken by the member firms. While the Kenyan government apparently approved of the studies, there was no one prepared to finance even the studies, so the scheme died.

For his work, Bajard had also assembled an in-house group of specialists, named the "African Group," composed of himself, a groundwater hydrogeologist, a geohydrologist, a rural planner, an industrial planner, and an administrative assistant. Bajard's was in fact the first attempt by the company to expand beyond its traditional field of geotechnical engineering. Unfortunately, whether his ideas were idealistic or realistic was never fully demonstrated. Adequate funding from international agencies was not forthcoming, and so his visions were beyond the capacity of a small company to expound.

While still with the company, Bajard identified a list of other possible job opportunities in a variety of African countries and the Middle East. However, when this list was presented to the KL Board Meeting of January 1976,[25] the directors decided that much of the proposed work was hypothetical and that "a disproportionate amount of money [was] being spent on the African work." Bajard was instructed to reduce his staff and "to use a greater amount of his time and effort on promotion of work in Canada, as opposed to overseas."[26] Bajard left the company in May 1976 when the African work was shelved.

Cancon, the Pacific Development Group, and Kendev, from a monetary point of view were unsuccessful, but these efforts did give the company early experience in overseas work and were a lesson learned on the difficulties and costs of international marketing.

In 1989, a further international effort materialized when Robert Arciaga of Manila was appointed to represent British Columbia firms interested in obtaining Asian Development Bank (ADB) work. This marketing project has been jointly funded by the participating firms, B.C. Trade (a government agency), and the Consulting Engineers of British Columbia (CEBC).[27] Klohn Leonoff participated in this group for a couple of years, but nothing materialized for the firm.

Other than individual consulting assignments, the company's first substantial overseas job, involving a number of field staff, occurred not as a result of promotion but of happenstance. RKLI had come to know geologists J. C. Sproule and Associates, of Calgary, through the Cancon connection. When work developed on terrain and materials evaluations for the Arctic pipelines, RKLI engaged Sproule on these projects as specialists in air photo interpretation. At that time, the Sproule people were travelling the world promoting their firm in its own particular area of expertise, the oil industry. They had registered with the Kuwaiti government to do work in the "oil patch," and somehow their name appeared on a short list of companies to do a materials evaluation for the State of Kuwait. As they had no capability in materials engineering but knew of RKLI's expertise in this field, Sproule brought RKLI in to work on preparing a bid.

This was to be a competitive proposal, bidding against firms from Austria, England, and France. (Americans were unpopular in the Middle East at the time, and so were not invited to bid.) Although the bid price of the Canadian group was much higher than the competitors, the Kuwaitis were impressed with the Canadian proposal, mainly because the logistics that RKLI had employed in the Arctic searches were similar to those that would have to be used in the Kuwaiti desert. So the Kuwaitis eliminated the other bidders and called the RKLI-Sproule team to Kuwait City to negotiate the price.

Earl Speer of RKLI, along with a representative from J.C. Sproule, went to negotiate the contract. Speer recalls the sessions as arduous:

"To me it was a whole new world—there were some ten items to negotiate. We met every evening in the hotel with two financial people from the Ministry of Commerce and Industry of the government of Kuwait. There was no problem of language barrier. They were competent men, educated in Britain and the United States. But we were about to start negotiations when the Sproule fellow received a phone call that one of his family had passed away. So he departed, and then I was left by myself. The Kuwaitis' background was 2,000 years of negotiations, bargaining over everything. I had none. We haggled over the first item for some time and I thought, well this is hopeless—I can't get anywhere; I just shut my briefcase and said, 'I'm going home.' They said, 'No stay—that's fine.' So I kept shutting my briefcase for every item."

A final contract was negotiated and executed in July 1973 for the fixed sum of approximately $700,000 Canadian.[28]

Sproule was the geologist on the project, but in the agreement that was finally executed, RKLI was responsible for over 80 percent of the job. This was the company's first substantive experience in dealing with a foreign job and currency, and, while the contract price was favourable to the Canadian team, the terms were fraught with risk. There was a fixed completion time of 510 days, with a heavy penalty clause for any delay beyond that period. But the schedule was dependent on foreign drillers and workers whose labour standards were very different from what the company was accustomed to in Canada. And the RKLI directors had no idea how their own staff would react to alien desert conditions. Additionally, the consultant had to submit to the client a letter of guarantee for performance, totalling some $100,000, and RKLI's bank wasn't anxious to furnish this guarantee. Finally, RKLI was to be paid in Kuwaiti dinars, a currency that the company's insurers, the Canadian Export Development Corporation (EDC), were concerned about.

The EDC's concern was without solid foundation. The dinar, based on oil revenue, was hard currency. In the end, RKLI's bank provided the guarantee, and the work commenced. Once a contract was signed, the Kuwaitis honoured it to the word—in fact even went beyond the terms. RKLI worked through that winter and into the next summer. All work ceased for two months with the commencement of the Ramadan religious holiday, a period when it was too hot to work anyway. With the coming of the holiday, the company asked that it be paid regardless, so the Kuwaitis paid in advance, which was unusual.

This was the first international project in which Ripley, Klohn & Leonoff had more than a one-person advisory role. In this instance the company had a crew of

Earl Speer in the Middle East, 1974.

about six people working with three or four Arabs—technicians and engineers—who had been assigned to the project. RKLI's staff was assembled from the three offices. Among them were Bob Rennie of Winnipeg, Ken Gillespie (for a time) from Calgary, and Peter Lighthall, a new recruit from Vancouver who subsequently has risen through the ranks to become KL's B.C. regional manager. Says Peter: "I started with the company on November 15, 1973, spent a day in the Vancouver office, then went off to Calgary, which is the usual thing that happens. Came back after Christmas and off I went to Kuwait."

Peter Charles Lighthall, born in North Vancouver in May 1946, is a third-generation native son of British Columbia, and his forebears have an even lengthier history in North America. Peter can also boast of a long family tradition in Canadian civil engineering. Both his grandfathers were civil engineers, as is his father, a very unusual, if not unique circumstance in the West.

Documents confirm that the Lighthall family left England in 1725, settling in New York State where they soon intermarried with the Pennsylvania Dutch. As a young man, Abe Lighthall came west in the 1890s to work on pack trains in the coal fields of the Rocky Mountains. He returned east to graduate at the beginning of the century in one of the early civil engineering classes at McGill University. He worked in surveying and general civil engineering as a B.C. Land Surveyor and in mountain-top triangulation for the Dominion Land Survey of British Columbia. He joined the UBC faculty in 1920, retiring twenty-five years later as Professor Emeritus of Civil Engineering.[29] By that time, Abe had gained a reputation as the civil engineering teacher of many of the early builders of the province.

Peter Lighthall's maternal grandfather, Preston Charles Coates, a third-generation Canadian, studied at the Ontario School of Practical Science, and in 1905 he obtained a degree in applied science from the University of Toronto. (To this day Peter proudly displays his grandfather's hand-coloured pen-and-ink drawings and engineering degree on the walls of his office.) Moving west, Coates worked on a variety of engineering jobs, then became a schoolteacher in Victoria, and later a fruit farmer in the Okanagan.

Peter's father, Charles Lighthall, following in his own father's footsteps, graduated in civil engineering from UBC in 1940. In the 1940s, during the war, he worked on RCAF airport construction in the Prairies, then on bridge construction for the Quesnel extension of the Pacific Great Eastern Railway (now B.C. Rail). In the 1950s, "Charlie" worked on the construction of the Waneta Dam near Trail, where he first encountered Karl Terzaghi. Then he became resident engineer for B.C. Electric on a portion of the Bridge River project, where he again met Terzaghi, as well as Mark Olsen, who was Karl Terzaghi's representative on the project. Following the general cessation of hydro construction, Charlie Lighthall spent the remainder of his career, into the 1980s, working on a number of construction projects in the mining industry. In working on the Craigmont Mill foundation, recalls Peter, his father was again to meet up with staff from RKL:

Peter Lighthall

"Charlie was a great guy in getting things done. And he always thought very highly of any of his encounters with Klohn Leonoff, because people in the mining industry are young and aggressive, but they probably aren't as thoughtful about how they do things. He appreciated that KL was careful and practical and a little more conservative."

Peter Lighthall had an itinerant childhood, growing up in whistle stops and small mining towns as the family followed his father's career around the province. His siblings were born in various towns. But Peter has few regrets about his upbringing:

"I'd just as soon have lived in a bigger place and had better facilities all along. Most of my schoolmates were pretty rough material. But, in the long run, I don't think it really matters if kids move around. You don't miss too much along the way."

Peter Lighthall's first job came at age sixteen, and in many ways it launched his career. He worked on the construction of Craigmont Mines for two summers. Another summer was spent at Endako Mine, where his father was also employed, and another summer at Buttle Lake building the access road into Western Mines. In the mid-sixties, Peter enrolled in the general Science Faculty at UBC, with the vague idea of entering medicine. But he was not particularly motivated nor clearly focused as to what his future career might be. Typical of his generation, he took a year off, travelling with two pals in a van throughout Europe and into North Africa. Peter and his friends "kicked around, met a lot of interesting people," and experienced what Peter calls "the best bit of education I ever had."

Returning home in 1967, it was time to think seriously about a career. "I guess it was inevitable that I was going to take engineering," says Peter, "because I'd been doing it for so many summers." Did his father influence this decision?

"He used to kid about it and tell the joke, 'Did you ever hear the story about the rich engineer? Hah, hah, hah.' But I kind of liked what he did, although I didn't like the aspect of his being away from home so much. He didn't put pressure on me, but he was pleased with the decision."

While at university, Peter worked on construction jobs during the summers as a labourer, carpenter, pipe fitter, and electrician, and by the time he finished university, he had worked his way up to construction foreman. He graduated in 1971.

After graduation, Peter thought he would like to go overseas. So he looked into CUSO work. But instead he received an offer from Placer Developments to work on the construction of their huge Gibraltar Mines, and this was the beginning of his relationship with RKL. Assigned to work on the starter dam for the tailings disposal system, he met Bob Maartman and Walter Shukin on the design team, and worked alongside Tom Harper, RKL's resident engineer, on quality control.

"Tom looked after the day shift and I looked after night shift," recalls Peter. "And it was a very challenging job. My background in geotechnical engineering was pretty limited—little more than the usual number of university courses and shovelling dirt on construction sites. We had the usual problems with over-wet fills and weather shutdowns, but during that summer we got the job done. One of Earle Klohn's first big tailings dams, it was a wonderful design that has proven to be a real success over the years. It's still operating today and we're still consulting on it."

Lighthall continued on the site for a couple of years, working on various construction jobs. "Being their newest, biggest project," explains Peter, "Placer had put all their stars into Gibraltar, and I met a lot of people who fortuitously have continued to be my contacts and clients over the years." By the fall of 1973, with the mine going into production, Peter had realized that he didn't want to become a mining engineer. Nor did he wish to face another winter in Williams Lake. He spoke to Bob Maartman who suggested to Peter that he consider Ripley,Klohn & Leonoff. Thus Peter got his opportunity to do overseas work in Kuwait, the first of many foreign as well as domestic assignments he was to undertake for RKLI.

The RKLI crews worked out of Kuwait City, where living conditions were generally very good. Accommodation was modern; there was some bunkhouse-type arrangement, but most people lived in apartments. Staff who had family usually moved them there. Life was pleasant, but wives could not go out on their own during the day, a fact they didn't appreciate and one that often contributed to distinct boredom. Officially there was no liquor for sale in the state, but it seemed that contraband liquor could be purchased with relative ease.

Traditionally, work in Kuwait began very early in the morning, around four o'clock when it was cooler. But even in modern times, with most buildings air-conditioned, the workaday schedule carried on in the customary fashion. The Kuwaiti engineers and technicians were reportedly excellent people, but they would quit at two in the afternoon—that was the end of their day. The Canadians tended to work the hours that were conventional in Canada. Lighthall recalls the work as, "a tough job. We were working long hours—driving in and out of Kuwait City every day." He did come to enjoy the geography of the area however, overcoming the initial impression of the desert as a very barren place. "As you got to know the desert," continues Peter, "every day you'd see something different happening. You could see the seasons changing. And the Bedouin tribes migrating." On occasion RKLI crews spent the night with the Bedouins.

The job was a materials inventory covering 9,000 square miles of the state of Kuwait—looking for gravel suitable for use as construction material. Following the inventory, a development plan was to be devised. Kuwait is a desert area composed of wind-blown sand and gypsum- and calcite-contaminated rock and gravel. Construction materials had been found previously, but ensuing development was sporadic, unplanned, and wasteful. An operation would begin digging gravel out in the desert but might bury more than was extracted.

The RKLI investigation involved digging test pits and drilling test holes throughout the state.[30] The drilling was subcontracted to Water Wells Ltd., a local company of men who were essentially water well drillers. According to Peter Lighthall, however, crew members were rarely Kuwaitis:

"Our client's people were educated Kuwaitis. But they would sit in air-conditioned offices in the city and kind of administer. They didn't get too involved in the work. As a guy in the field, the people I was working with were all immigrants. Our contractor's superintendent was a very competent Palestinian. The workers were Palestinians and Iraqis, who really didn't share the same lifestyle as Kuwaitis."

The use of a Becker hammer drill was required to penetrate the cemented gravel, and this work was subcontracted to Cementation Company of London. The drill was brought in from Pakistan, accompanied by a crew of Pakistani drillers, but the foreman was a Scot. So the field crew was truly a multinational team. Earl Speer comments on the process of importing the drill:

"It was quite an exercise, getting that drill through the brokers. I spent something like four days, and discovered that I could have saved myself a lot of time. I just didn't know whom to pay. Once I did that, the job was done. But this applied to a lot of things in that part of the world—to get a hotel room, sometimes even to get on airplanes."

And Ken Gillespie adds: "There was no desire to get things done quickly. They don't mind taking time. You could spend weeks waiting to see somebody, and you could spend hours and hours over a cup of tea talking about nothing."

Because this investigation was a breakthrough for Canadian engineering, its completion in January 1975 was widely reported in the Canadian press.[31] "Sixteen months and many books later, the eight-volume 2,500-page construction materials survey is finished," wrote the *Canadian Consulting Engineer*. An accompanying photograph shows the 50-copy "1,600 pounds of paperwork" being given "one last check" in Calgary before being air-freighted to Kuwait City.[32]

Where sand and gravel exist in Kuwait, they form a concrete-like material weakly cemented together by clay and chemical action. A second stage of KL's work, under a new contract amounting to half-a-million dollars, was to develop a process for separating these natural aggregates. The objective was to separate out the gravel and sand and to

Construction materials inventory, State of Kuwait – Drilling in desert using Becker hammer drill with cyclone, Bedouin camp in background, 1974.
Photo: Rudolf Cech

size and grade it in order to provide clean materials that could then be blended for cement and concrete work.

The drilling exercise with the Becker hammer drill showed that the aggregate pieces could be separated from the matrix of gypsum, calcite, clay, and silt. And from that discovery, under the direction of Earl Speer, whose background is materials engineering, KL developed a simple separation methodology using an autogenous mill in which the crushing, scrubbing, and sizing operations are performed by means of steel balls, cyclones, and a circulating hot-air system. To test the process, a 20-ton sample was actually trucked out of Kuwait, through Europe to The Hague, then shipped over to the experimental facilities of Aerofall Mills in Mississauga, Ontario, one of the world's leading designers of mills for the mining industry.[33] Out of this, Klohn Leonoff designed the plant, the trucking system, and the whole infrastructure to process the Kuwaiti aggregates. The end result would theoretically be an efficient, uniform quality supply of product for the Kuwaiti construction industry.[34]

The total of the Kuwaiti contract amounted to $1.4 million, and, says Speer, the company's earnings were substantial: "I have to say that it was a lot of luck that we came out well ahead on that project—we made a profit about forty percent of gross. And it was an excellent process we devised. When we presented the final report (in August 1976), they were delighted with it. They told us it was the best that they had ever had."

Sixteen months and many books later, the eight-volume 2,500 page construction materials survey, shown by Klohn Leonoff's Bob Rennie, is finished. Here Mr. Rennie gives one last check to the 1,600 pounds of paperwork before airfreighting it to the Kuwaiti Ministry of Commerce and Industry.

Construction materials inventory, State of Kuwait – Robert Rennie in Calgary office makes final check of report before airfreighting to the Kuwaiti Ministry of Commerce and Industry, January 1975.

Credit: Canadian Consulting Engineer, May 1975

But there were other forces at work. Another group was importing aggregates from Oman on the Gulf, and they were able to land that material in Kuwait for less than the cost of processing the Kuwaiti aggregates. So, reports Speer, the client put its own project on the shelf:

"As far as I know they have never pursued it further. We have never gone back because the conflicts there weren't worth it. But I've often thought I'd like to go back some day and see what is happening—and maybe I will."

Peter Lighthall thoroughly enjoyed his Kuwaiti sojourn: "It was just a great experience. . . . Of course, I made a little bit of money, took three weeks off at the end, travelling home through Southeast Asia, so it was a lot of fun."

Peter Lighthall has served the Canadian Institute of Mining and Metallurgy (CIM) as chairman of the Vancouver Branch and District 6 (B.C. and Yukon), and on the national council. He was named to fellowship in the institute "for his outstanding contributions to the Canadian minerals industry and CIM."[35]

From the turbulent Middle East to the lethargy behind the Iron Curtain, foreign work was invariably a learning experience for KL staff. During the years 1975 through 1978, Klohn Leonoff was foundation consultant to Simons on the Kwidzyn Pulp Mill in Poland and on the North Slovak mill site in Czechoslovakia.

One of the innovations for the KL engineers (Morrison and Wightman) working on soil investigations for the Kwidzyn job was use of the "Dutch" or "static" cone, which was virtually unknown in the company's home region but widely used in Europe. This apparatus consists of a simple double-rodded probe which is pressed into the ground to determine the bearing and friction capacities of the soil. In this case the local contractor had a Dutch cone, which proved more utilitarian and faster than the crude hand drilling machines that were available locally. The pulp mill site in Poland is overlain by a glacial till, but not as dense a till as is found in British Columbia. The static cone proved very useful for defining the good bearing layer beneath the soft surface deposits and thus the depth of excavation required to place the mill foundations.[36] It was not to be until the early 1980s that *in-situ* cone penetration testing came into general use in British Columbia, using more sophisticated equipment such as the electric piezometer cone.

Peter Wiens was field inspector on these European jobs, involved primarily in soil investigation—drilling and soil sampling. Communication was a constant problem:

"I had to use interpreters most of the time. The foreman for the drilling company could speak about a hundred words of English. And we could occasionally communicate with people in German. My German is not fluent, it's sufficient. But it is not technical. I was there with Eddie Knowles [Simons's resident engineer] who did not speak any Polish or German. On one occasion, we were meeting with a group of Polish people, and the only interpreter we could get spoke no English, only German, so then I translated to English for Knowles. After a short period of time, one of the Polish engineers with whom we were meeting started talking to me in German. And from then on the interpreter was out of the picture, because she really did not know any technical terms in any language. So this Polish engineer and I, using German, could communicate, and then Knowles would be informed and would put in his say."

As in Kuwait, the work ethic encountered by KL staff in Poland was distinctly different from that typical of Canada. Wiens had a persistent problem in trying to get the work done by the drilling people—very little seemed to be accomplished most days. And when one has been on the job for an extended time and is looking forward to going home, such a slow pace can be very frustrating. But there was only so much "pushing" that could be done. According to Wiens, the workers' attitude was completely impersonal:

"It's all government and nothing matters. Once I wanted to know whether we could get a little extra work out of them, so I asked, 'Why don't you work a little harder?' Finally one of them says, 'If we work the way you want us to work, then we wouldn't have the energy to do the work we want to do when we get home.' After he'd said that, I could get a picture of what their thinking was and why, how it affected me, and how much pressure I could put on them. Then I was no longer as frustrated, because I could at least understand them."

Peter elaborates on their thinking, as he came to understand it:

"They start work at seven o'clock in the morning and are finished by three in the afternoon. Then they do their shopping, which takes an awful lot of time in perpetual lineups. But it still gives them a fairly long evening. There's a 'black-market' workforce. They help each other, which includes liberating some things from the government on the job. One liberates a few nails, another one liberates a board, another one a few bricks. And, with this contraband, they fix up their own houses. One person who's a little experienced in plumbing will do the plumbing for a whole group of friends. They in turn will help him with some other task. It's not only a social matter but how their living is made. They also have garden plots, often located far out in the countryside. They can go an hour or an hour and a half out to the plot by bicycle, to work out there. These are the things on which they spend most of their energy."

Peter Lighthall, who also worked on the Kwidzyn job, has added his perspective on the Polish economy and people, some of which may still be apropos today:

"The workers, the tradesmen, and even the professionals just didn't have enough incentives. They got paid whether they worked or not. The state provided a lot of the services for them, but they were kind of mediocre services—mediocre housing, mediocre food. As a consequence there was a lot of absenteeism and alcoholism on the job. I wasn't impressed with the state-controlled economy. It just didn't work. With old equipment and an obvious lack of funding, they couldn't get decent quality control on their building. It was very frustrating working in that environment. But I loved the Polish people. I think they are a horribly down-trodden people who have been kicked around by history for years. They deserved a better shake from history. And they need a good capitalist system to get them working."

In Czechoslovakia, Wiens spent nine months on the construction phase of the North Slovak mill, and again there were various ethnic groups and languages to contend with. Polish and Slovak are not identical languages, but they are very similar, so that a person speaking one is basically understood by someone speaking the other, and thus Wiens's Polish stint gave him "a little bit of knowledge" that could be applied in Czechoslovakia. But the contractor in Czechoslovakia was a Yugoslav, with a camp of two to three hundred Yugoslavian people who did the actual work. So there was another language at hand, with another set of interpreters to go through.

According to Wiens, the Czechoslovakian engineers themselves are quite capable. He recalls a meeting where one of the Simons engineers pointed out this fact, and asked, in candid fashion, why the Canadians were there at all. After some deliberation, a Czechoslovakian engineer replied that Simons had promised to build the mill in three years, whereas the shortest construction period that the Czechs could expect, working on their own, would be seven years.

"Their delays were of a kind that's foreign to us," says Peter. "Normally they would have a meeting of a group of twenty engineers or so, with one or at most two Canadians present. Then any decision would have to be made by consensus. Not only that, there was nobody present who could give a final word. Eventually the decision would have to go back to their headquarters for approval. Because, when it came right down to it, the final word was handled by the political people and not the engineering staff."

Sometimes the decision was vetoed. In that case, says Wiens:

"We would have to start over from scratch. But, by the time an okay came, things had usually already changed in the construction field. We'd have solved some of the problems without waiting for permission and other problems would have developed. So their system was too cumbersome to do fast work."

Another problem that Wiens, himself a teetotaller, encountered on the job was the consumption of alcohol. In inspecting the foundation construction, he made rounds of virtually every building on the mill site, both morning and afternoon. "Every place I came to," says Wiens, "the foreman would give me a little glass of vodka. This was a friendly gesture, and you had to accept it because refusal was seen as unfriendly." One drink may have been tolerable, but this social nicety was a real obstacle if repeated with every inspection of every building. Interpreters were used only for meetings, so that, on his rounds Wiens was alone, with no common language to communicate his feelings. "Fortunately," recalls Wiens, "after a while they realized that I was not trying to be offensive by not drinking with them, and then it got a little better. But I tried to compromise and take the odd one." According to Wiens, the problem was pervasive: "After the steel was erected, I saw labourers going up to the second and third storeys, lying down on a beam or leaning against another beam, with a bottle of vodka in their hand and drinking."

The North Slovak mill was built on a turnkey contract,[37] and the Yugoslavian contracting firm actually did very well on the job. Recalls Wiens, "We were told, right from the first day I was there, that any delay had to be documented, because they expected it would go to a court at the end of the work." Fortunately, court action was not required. The job was completed on time, surprising even the Simons organization.

The most alarming experience that Wiens had in his foreign work occurred in Nigeria in 1976, on a drilling program for Stothert Engineering Ltd. at the Iwopin Paper Mill, forty miles east of Lagos. The party stopped for a couple of days in Lagos, a city of 2 million, before travelling to the site. He had worked in poor countries before, but this was the first place that Peter saw actual starvation. The city had no traffic lights and congestion was horrendous. Cars had license plates with either odd or even numbers; only cars with odd-numbered plates were allowed to be driven on one day, those with even numbers the following day. In leaving the city, remembers Peter, "We were stopped by the police about every ten miles. We did not drive our own vehicles out there because we were informed that if we ever had an accident, the chances were the people would mob us. And that would be the end."

Wiens had a crew of six people doing drilling on the site, and at the end of the work he wanted to take a photograph of them. But he knew by then that one had to be very careful in taking pictures in Nigeria. "Of five I could take a picture," says Peter, "the sixth one absolutely refused; he turned his back and walked away. They still had a sort of voodoo concept that if you take a picture you have a hold over them—a replica in which you can put a pin and harm them."

Beginning in the late seventies, with the addition of new staff members such as Ray Benson, Manohar Walia, and Vinod Garga in the disciplines of engineering geology, rock mechanics, and tunnel and rock engineering, Klohn Leonoff began to obtain assignments on technical review boards and as specialist consultants in South America and Mexico. These jobs included earthfill dams, diversion and power tunnels, underground and surface powerhouses in Colombia, Peru, and Venezuela, tailings dams and dumps in Chile, Mexico, Peru, and Venezuela, and mining developments in Bolivia and Mexico.

By 1981 Klohn Leonoff was consulting on a number of projects in South America. In Peru, Vinod Garga was appointed dam consultant to Electroperu on the Recreta hydroelectric project. In Chile there were a total of five projects under way, and one result was that Diane McLean in the Mining Division was both translating reports and holding Spanish classes for seven staff members.[38] At the El Teniente Division of Codelco-Chile, a copper property incorporating the largest underground mine in the world, drilling investigations were ongoing to obtain undisturbed samples of the Barahona and Cauquenes tailings dams. The region is one of the world's most siesmically active,[39] and the soil samples were being tested at both the Richmond laboratory and at the Catholic University in Santiago in order to evaluate the cyclic strength and liquefaction potential of the hydraulically deposited sands used in these dams. Further, the Water Resources Division was analyzing probable maximum floods at these sites and designing works to deal with the floods.

Dave Larssen was one of the field engineers on site in Chile and has offered this report on culinary aspects of his experience at the Cauquenes Dam:

"A treatise on the technical aspects of the Cauquenes Field Program would pretty well involve paraphrasing the numerous learned works on 'the undisturbed sampling of sand' currently available in the library. Social survival in Chile is not quite so completely discussed, so it is into this arena I will fling my literary hat.

"The small village of Parron is about 1 km from the Cauquenes Site. It is a company town of perhaps 100 people. The men of the community work for the mine as a maintenance crew for a section of tailings transport flume. There is a small office, a corner store, and an elementary school, whose teacher bakes and sells excellent empanadas for 10 pesos a piece on Mondays.

"Quite early on, I found that a good lunch could be bought at the store. The owner spoke no English and I spoke no Spanish, but a lot of arm-waving on my part and trial-and-error on his resulted in a very fine cheese and salami sandwich.

Manohar Walia

"Daily repetition of this ritual quickly established the lunch ground rules. Basically, I walked into the store and he dropped everything to make up a sandwich. On Mondays we both gave it a rest and dined on empanadas. His command of English numbers and my Spanish food vocabulary slowly improved.

"The significance of this short-order sandwich service did not become apparent until much later. I was occupied during one particular lunch break so the drill helper [a local fellow] volunteered to get my daily sandwich. He returned empty-handed, gave my money back and reported that the store owner had rather bluntly stated that he was running a store, not a restaurant. Intending to pick up some oranges to eat, I went to the store, walked in, the owner made my usual, and sent me on my way. I continued to buy lunch this way as long as I was at Cauquenes. Toward the end of the project, with the aid of an interpreter, we found that the store owner thought I looked under-nourished, and was quite happy to do his part to keep me healthy. The same consideration was not about to be extended to non-gringos."[40]

In 1981 a further and significant addition to the international capacity of the firm came with the hiring of Manohar Lal Walia, who brought with him a particular expertise in tunnelling and underground excavations in rock. Born in 1944 in Lahore, the capital of the Punjab under British rule, "Mano" Walia grew up in the midst of epochal nation-building events following World War II. On August 15, 1947, when the subcontinent of India was partitioned along religious lines, Moslem-controlled parts became the Islamic Republic of Pakistan, while Hindu-controlled areas became the Union of India. Lahore, near the border, became a part of Pakistan. Because the Walia family was Punjabi Hindu (not Sikh), they were forced to flee. The family settled in Chandigarh, India, where the senior Walia was an assistant to the vice-chancellor of the university (and later deputy registrar).

Chandigarh, the new capital for the state of Punjab, created on an empty plain at the foot of the Himalayas between 1951 and 1958, was designed by the internationally renowned Swiss-French architect Le Corbusier, a leader in and polemicist for the International Style of modern architecture. His majestic complex of public buildings comprising the capitol, especially the 800-foot-long "raw concrete" face of the Secretariat (including the assembly and law courts), is perhaps the world's most monumental example of the International Style, which exploits the structural and sculptural uses of reinforced concrete.[41] Le Corbusier's principles of modern living extended into town planning, and Walia gives this description of Chandigarh:

"He [Le Corbusier] designed the whole town and the university. He was given a piece of land which didn't have a single building on it. There were only fields for growing crops. And . . . he put down a circle with something like a ten-mile diameter and divided it into sectors. Each sector had a little shopping mall and every three, four, or five sectors had a movie hall and a slightly bigger plaza. Right in the middle of the circle was the big plaza. Then the airport was at one end of the circle, taking into consideration wind directions and so on; the railway was in exactly the same location at the other end of the circle. And between the railway station and the airport was the industrial area. He also developed an artificial lake nearby for recreational purposes. [Chandigarh also incorporated the modern concept of separate ways for vehicles and pedestrians.] So it was all done with the most modern thinking."

While his parents and siblings were all university-educated in the arts and humanities, Mano found that, "Arts just didn't whet my appetite." Science and mathematics, in which he received the highest marks, were "challenging and more exciting." Says Mano, "It was pretty evident to me that I had the natural aptitude to go into the sciences and eventually engineering." He graduated from Punjab University, Chandigarh in 1967 with a M.S. (Honours) in engineering geology. As an undergraduate, Mano, a tennis star, represented the university in tournaments and each year was given a tennis scholarship. Upon graduation, placed on the merit list and encouraged by his professor to pursue further studies, he received a travelling allowance to go to the United States.

From 1968 to 1971, on scholarships, Walia took post-graduate courses and did research studies in geology, rock mechanics, geotechnics, groundwater, and geophysics. During the summers he worked for various companies doing geological engineering. One summer he found himself (on a special work visa) in New Brunswick. "The company treated me very well. I found that the country was peaceful, really beautiful, and people were very friendly—no problems." He was befriended by an immigration officer in Fredericton. "He talked me into—in fact bent over backwards—getting me immigration. Maybe he didn't have too many immigrants coming to New Brunswick."

Walia returned to his studies in the United States, but soon received a letter saying that he could indeed immigrate to Canada whenever he chose. While still on his student visa in the United States, he received other letters extolling the virtues of America and encouraging him to become a citizen of that country. But the Vietnam War was raging and Walia feared that if he did become a U.S. citizen, he might be drafted and sent overseas. Although his older brother was an officer in the Indian army (retiring in 1990 with the rank of brigadier-general), Mano confides that he "just didn't believe in that cause and didn't want to stay in the States."

Walia came to Canada in 1971 after having identified several job opportunities with "good companies." Upon arrival, after meeting friends in Toronto, he visited Niagara Falls. While there he thought of stopping by the H. G. Acres company, without an appointment, to see if he could talk to the head of their Geotechnical Department, who happened to be Ray Benson. "He interviewed me and right then told me that he would be able to offer me a job and would call me in a week's time. I felt very comfortable with the questions he asked." The offer transpired, and Walia went to work for Acres. Spending eight years with Acres on hydroelectric projects in various countries, Walia worked on twenty-six dams—earthfill, rockfill, and concrete—and over thirty tunnels, underground caverns, and powerhouses. Walia found the experience highly educational:

"You know, a hydroelectric project actually has so many structures in it that you practically get a complete lesson in geotechnical engineering. I was lucky enough to take part right from the proposal and planning stages to the design and construction stages. So it was a balanced diet of engineering for me."

During these years, Walia thought of going back to university, but Benson dissuaded him, stressing that the company needed him, and that Mano could always return to his studies at a later date. Mano did meet his university supervisor at a conference on one occasion, and the professor asked, "Is this Mr. Walia or is this his ghost come back from the frozen Canadian north?" Mano explained to him that he was happy doing what he was doing, and that he was likely learning much more than he could at the university. Since then, Walia has been kept so busy (mostly by Ray Benson) that he hasn't yet had a chance to complete his Ph.D.

SNC, one of Canada's largest engineering firms, based in Montreal, was partners with Acres on several projects. "In 1979," reports Mano, "they made me an offer that I just couldn't refuse." For SNC he continued working on international hydroelectric projects for the next two years. But Mano didn't care for the cold winters in Montreal, and he eventually tired of the constant travelling:

"I realized that with big companies like Acres and SNC you are always going to be travelling. I was spending more and more time on the road because they found that I could get in and out of a country very quickly, and I know how to work with limited resources. Although they said they would try, they didn't want to send anyone else and never got around to it. [Mano was a bachelor at the time.] It got to the point that on Friday afternoon I would be told, 'You will be going tomorrow morning at nine o'clock to Peru,' or somewhere else. I like to travel and you know that in this line of work we have to travel, but it has to be balanced in order to have a little bit of your own life."

Meanwhile Ray Benson had relocated to Vancouver. And Klohn Leonoff was advertising for tunnel engineers on projects at Tumbler Ridge, B.C. and in Sri Lanka. Walia was a logical candidate and was happy to accept the offer which came from Benson: "Ray was my boss at Acres—we worked together very closely—we had a good relationship. Ray knows a lot about rock engineering and tunnels, and I had learned much from him.[42] It was a good feeling to come to a smaller company, to do more detailed engineering, and to have Ray guide you." And there was another reason expressed by this world-wise traveller for his move to KL and Canada's West Coast: "The combination of the weather, the natural beauty, the air, the water, the people—there's no question that Vancouver is one of the best places in the world."

With KL, Mano Walia has progressively filled the positions of staff consultant, manager of the Tunnels and Rock Engineering Division, and manager of Civil Projects. He has worked on tunnel, rock, and geotechnical engineering projects in several Canadian provinces and various countries world-wide, including Sri Lanka, Papua New Guinea, and Turkey. Mano spent a total of three years in South America working on several assignments, two of these years on the Betania, Colombia project. There he received a special dividend—he met and married the librarian.

A successful world sojourner must be able to communicate in several languages. In India, Mano was of course fluent in Punjabi, Hindi, and English. In Montreal he studied French where, says Mano, his French teacher told him that he had a particular aptitude for learning languages—more so than anyone else in her class:

"I think it is a combination. Certainly aptitude. But once you know two or three, it becomes easier to learn more languages. And you do develop an ear to understand particular accents. I had been to South America on several assignments before, but not long enough to master the language—just a few words here and there. But when I was resident in Colombia, I had the chance to learn Spanish very quickly. After three months I was able to communicate fairly easily. After a year I was fluent. And having stayed there for two years, I was able to work on specifications and drawings and also to get up and give a presentation to people in Spanish. I can also understand Italian fairly well now because it's akin to Spanish."

Betania hydroelectric power tunnel, Colombia, September 1983.
Photo: Sedic

Through the 1980s, under the direction of Ray Benson, assisted by Mano Walia, Klohn Leonoff provided specialist consulting services internationally in the field of rock mechanics as they are applied to hydroelectric developments—specifically the construction of tunnels and portals and the excavation of spillways. And in Colombia and Venezuela, in particular, such underground excavations were often more challenging than those attempted in Canada.

Projects in the high Andes of Colombia, such as San Carlos, Jaguas, and Las Playas, were particularly demanding. The underground excavations at these sites were generally within hard, massive rock of the Antioquean Batholith. But, owing to deep surface weathering, soft-ground tunnelling problems were encountered until the excavation reached the hard rock. Even within the massive rock, major faults existed, charged with high water pressures. Care was necessary, as the tunnel penetrated these faults, to prevent the collapse of unstable ground.

In both Colombia and Venezuela, moderately mountainous regions of weak sedimentary rock also exist, resulting in special problems. At the 500-megawatt Betania hydroelectric project on the Magdalena River, Colombia, where Mano Walia was an on-site staff consultant to Sedic Ltda., KL's assignment involved review of the geotechnical aspects of two 12-metre-diameter diversion tunnels, three 10-metre-diameter power tunnels, two spillways, a powerhouse, main dam, six dykes, and several access and drainage galleries. The rock on site was comprised of soft sandstones and shales. Major cuts required little or no blasting, but the weak rock had to be protected by shotcrete to prevent erosion by rain. For the tunnels, temporary support was provided by a combination of shotcrete and rockbolts, prior to installation of the final concrete liner, which was necessary to protect the highly erodible rock. Similar conditions were encountered in driving the 10-metre-diameter diversion tunnels on the Vueltosa power project in Venezuela.

In Colombia, topography and youthful river regimes create sites with very high reservoir heads. Klohn Leonoff has provided consultation to the power companies and their engineering designers at work on several Colombian hydroelectric projects, for example Guavio, Mesitas, San Carlos, and Chivor, each with heads from 750 to 1,200 metres high. Successful design of high-head pressure tunnels and penstocks requires state-of-the-art application of rock mechanics principles, techniques that are at the very threshold of present civil engineering practice. To ensure safety and minimize costs, major technical and economic factors determine the alignment of the tunnels, design of the liners, and selection of penstock steel lengths. Optimum tunnelling conditions can be achieved by positioning the tunnel properly relative to topography and to the *in-situ* stress conditions in the mass rock. For high-head tunnels it is mandatory that the tunnel have adequate cover, both vertically and horizontally, to ensure suitable conditions for tunnel driving and to prevent hydrofracturing and excessive seepage through the overlying rock. As well, a tunnel lining may be necessary to control seepage against excessive energy loss and for stability of the adjacent valley slopes. Depending on assessment of conditions, which are much more critical than for traditional tunnels, the interior lining may consist of steel and/or concrete (unreinforced or reinforced) or shotcrete, and may be either intermittent or continuous throughout the tunnel.[43]

During the Trudeau administration, Klohn Leonoff had scant success in seeking assignments from the Canadian International Development Agency. The only CIDA work obtained by the firm amounted to a few small preliminary studies. Despite representations to British Columbia members of parliament, to the chagrin of western engineering firms it seemed that, given the political reality of Canada, Quebec and Ontario firms consistently landed the big and important jobs.

In 1978 CIDA developed an interest in a project in Sri Lanka (formerly Ceylon). A new government had just taken over in that country and was promoting the very ambitious "Accelerated Mahaweli Scheme," a. multi-billion-dollar program to develop hydroelectric energy and water reservoirs for irrigation of arid land in the largest river basin in Sri Lanka. The Sri Lankan government hoped to accomplish in five years what the United Nations had planned to achieve over twenty to twenty-five years. The purpose of the program was to promote land settlement and industry in a country where 1 million people of a total populace of 14.9 million were chronically unemployed. Sri Lanka was looked upon favourably by CIDA because of its democratic government, progressive social views, and geographically strategic location at the southern tip of India.

The Maduru Oya Reservoir project was to be the flagship project of the Mahaweli Scheme. Comprising a zoned rockfill dam—the first of this type in Sri Lanka—38 metres high and 1,008 metres long, a reservoir, and a six-kilometre-long transmission tunnel and headworks, the project would provide downstream irrigation via canals to 45,000 hectares of parched, undeveloped land. The project also provided for two small powerhouses. CIDA wanted to help and, in consultation with the World Bank and other bilateral donors, negotiated a $76 million soft loan[44] with the Government of Sri Lanka. Then in October 1978, CIDA and the World Bank put together an international engineering review board to look at ways of developing the project. Because of his international large-dam experience, Ray Benson of Klohn Leonoff was engaged as a member of this board. Myles Parsons, CIDA's project engineer, was that agency's representative on the board. The two men became well acquainted, and the result was that Parsons was eventually asked to join KL. He did so in October 1979, just at the time that proposals were being invited for design and management of the Maduru Oya project.


Myles Parsons

Dr. Myles Lyle Parsons brought to Klohn Leonoff a broad background in geological engineering, hydrogeology, and water resource development with governmental agencies at national and international levels. Like so many of the firm's principals, he has farm roots in the Canadian prairies. In fact his ancestry can be traced back to the farmers on the Salisbury Plains of England, where legend has it that settlement ensued following retreat of the ice age glaciers. What is known for certain is that Myles's grandfather, John Parsons, homesteaded near Grenfell, Saskatchewan in 1890, where Myles's youngest brother still farms his grandfather's original land.

Myles is the second youngest of six children, born in 1938, just prior to the onset of the Second World War. Shortly thereafter, his father, Denys, went off to join the army for the second time—he had already fought in the First World War. Before he left, Denys rented out the farm and moved the family to a house in town. So Myles was raised in the town of Grenfell but spent the summers working on the family farm. "We never went back to live on the farm," explains Myles, "although we retained it as a means of living and commuted back and forth. My first experience of commuting to work was actually on the farm." Such a practice is now common in Saskatchewan.

Growing up in small-town Saskatchewan, Myles participated in the usual activities—plenty of hockey and curling; he played trumpet in the Lion's Band and the high school orchestra, was in the militia and went off to cadet camp, worked part-time selling papers and in a grocery store, and attended church fairly regularly. But, for an ambitious young man, farming was not all that attractive; farms were getting bigger, and there just didn't seem to be enough land to go around. And neither did there seem to be much of a future for Myles in a small prairie town. Nevertheless, Myles reminisces nostalgically about his home town: "Having lived in cities a good part of my adult life, I still have a lot of straw in what little hair I have left and would still choose to grow up in a small town or on a farm."

Put simply, most young Prairie people of Myles Parsons's generation had to find new careers. His father, who had only a grade four education when he was forced to quit school to farm, had always felt disadvantaged and was insistent that any of his children who had an academic inclination would go on in school. "There was never any question in my father's mind that I would go to university," adds Myles, "and he had a very strong influence on that prime decision in my life. I was pretty good at mathematics and science, and that seemed to dictate my decision to take up engineering, although I didn't really have any exposure to it in my youth." Myles went directly from high school into engineering at the University of Saskatchewan, graduating in geological engineering in 1960.

Following his graduation, he found himself looking for work during a period of recession, when jobs were hard to come by. The best offer he had was from Hudson's Bay Oil and Gas in Calgary, to do well-site geology and mapping. After two and a half years of such work, he decided to pursue water resource work "basically because there were dry conditions in the Prairies, I still had farm blood in me, and I wanted to do something other than produce oil." In fact groundwater was just beginning to develop as a science in the early sixties, so Myles's decision to enter that field was quite timely. Completing his master's degree in hydrogeology at the University of Saskatchewan in 1964, Parsons went to work for the Geological Survey of Canada (GSC) as a hydrogeologist doing research-oriented work.

Stationed in Ottawa, Parsons was engaged in field work, installing piezometers at observation wells in Manitoba and Saskatchewan and doing groundwater availability mapping in New Brunswick, a "big thing" at the time. The GSC had a generous program in place intended to develop people in the science—the department would support employees taking Ph.D. studies, on the stipulation that they would return to the department. "I was already married by then and had a couple of kids," explains Myles, "so this seemed like a painless way of doing it—actually one of the best deals in my life because they paid half-salary, plus tuition and various expenses." Myles enrolled at the University of Michigan on a teaching assistantship, specializing in groundwater modelling, which was a new methodology at the time. Earning his doctorate in May 1969, Parsons returned to the GSC where he continued with groundwater research. The whole concept of environmental protection was coming into vogue in the late sixties, and in 1970 Parsons's group was placed within the new Ministry of the Environment.

At Christmas time 1971, "out of the clear blue sky," Parsons received a call from the External Affairs Department, requesting a bona fide scientist to assist them with international relations in science policy and environmental problems. Says Myles, "They needed someone to advise on such concerns as negotiating satellite agreements with the United States, United Nations work, and so forth." Spending a year and a half seconded to External opened up numerous new horizons for Myles and effectively killed his interest in straight research. So he "poked around" and finally approached CIDA about the possibility of working for them as an individual consultant. Instead they offered him an immediate staff position as a water resource specialist, a position which Myles happily accepted.

Parsons joined CIDA in May 1974, and would spend the next five and a half years with the agency. His work was broadly based water resource planning on the technical side of a project team. These project teams were headed up by project or planning officers, "desk people" who had administrative responsibility for projects but were generally non-technical. "They totally depended on us for good technical advice," says Myles. When a reciprocate country would make a request for a project on CIDA's bi-lateral program, the agency would send its people out to determine whether the project was sound. "It was exciting," recalls Myles, "we had lots of leeway, and I would go sometimes by myself, sometimes with other CIDA people on the desk side, look at a project, and make decisions fairly quickly in those years without hangups. We could cover a lot of bases, write terms of reference, do those things that only someone with a technical background could really do. I think we had a great impact on how things went on the bi-lateral program at that time." Today, according to Parsons, the time it takes for that same process is "just unbelievable."

Once a project was accepted and approved by CIDA for funding, Parsons's job involved setting up proposal competitions, evaluating the proposals that came in, negotiating contracts with successful bidders, and monitoring the performance of consulting firms during implementation of the projects. His area of operations ranged over Asia, Africa, sometimes even into the Caribbean, but mostly Myles worked in Indonesia, Pakistan, and Sri Lanka. It was the Sri Lankan Maduru Oya project that brought him into contact with Ray Benson, and launched Parsons on his future career in private enterprise:

"Ray and I got to know each other quite well, and somehow along the way, the question of employment came up and we began discussing the possibility of my joining Klohn Leonoff. We sparred back and forth for several months on that topic. Eventually I was invited out to Vancouver for interviews and accepted an offer. I was at the stage where I wanted to leave CIDA, after having had a pretty good dose of international exposure. When I joined CIDA, I recall the director of engineering advising, 'This is a good place to work and find out how things are done in international business. But, if you are serious about engineering, don't stay here any more than three years.' But I had stayed longer, was already forty-one years old, and thought that this was the best opportunity I would ever have to get into the consulting business. And yes, to tell the truth, it was a tough decision, after being in government for fifteen years, to choose to subject myself to the cruelties of the business world. The matters of pension, and security, and four weeks' holiday, I put that all to the back of my mind. Making money has never been the big interest in my life, as long as I make a good living and can retire with adequate financing to keep us going, and so I decided what I really wanted to do was to accept the challenge of getting into business, and to enjoy having that extra freedom of action to do things much more expeditiously than you can ever

Maduru Oya reservoir project, Sri Lanka.

Inspecting site construction, from left: Louis LaFlamme (Concept Canada), Cyril Leonoff, Gordon Gullan (resident engineer), March 2, 1982.
Photo: Faye Leonoff

Fifteen-hundred-year-old sluiceway, archaeological site.
Photo: Gordon Tanner

Maduru Oya reservoir project, Sri Lanka – Rockfill dam on completion, 1983.
Photo: Gordon Gullan

hope to do in government."

Crippen International of Vancouver was one of the companies that had been short-listed on the Maduru Oya project. And no sooner had Myles Parsons joined Klohn Leonoff than Crippen asked if the firm would join Crippen on their proposal. The bid also called for a link with Concept Canada Ltèe., a Quebec-based engineering group. So Parsons worked with Crippen on developing the proposal, which on receipt was rated highly by CIDA. The short-lived federal Conservative government, under Joe Clark, had recently come into office wielding a "new broom" approach, and the concept of a British Columbia-Quebec collaboration on this project, which at the time represented the largest-ever single contract for CIDA, appealed to the Conservatives. Thus in February 1980, CIDA awarded the contract as consulting engineer and project manager to Crippen International Ltd. in association with Concept Canada Ltèe. and Klohn Leonoff Ltd. Louis LaFlamme, Concept Canada's project director, proved to be a co-operative and energetic partner, and the result was an excellent overall team. The construction contract was carried out by FAFJ Joint Venture (Canada), a consortium of four Canadian construction firms, for a value of $125 million.

KL principals on the Maduru Oya project were Ray Benson, as chairman of the review board,[45] Cyril Leonoff, and Myles Parsons. Norman Alexander "Al" Morrison was to play a key role as deputy to the project director, Gordon Tanner of the Crippen organization. Morrison had joined Klohn Leonoff in 1977, after six years of experience in the design and construction of heavy civil engineering projects with three of Canada's largest engineering companies. As deputy director, Morrison proved his versatility as the liaison man between the design office in Vancouver and the field office in Sri Lanka, co-ordinating geotechnical design and construction drawings for the dam and tunnel, reviewing tender documents, negotiating with contractors, doing scheduling and cost projections, as well as site reviews. Subsequently, Morrison went on to serve as project manager for the Ok Tedi tailings scheme and as resident engineer on the Ok Menga hydroelectric project, both in Papua New Guinea.

The Maduru Oya project was officially commissioned on July 2, 1983 by President J. R. Jayewardene of Sri Lanka and Allan J. MacEachen, Canadian deputy prime minister and secretary of state for External Affairs. It was completed on schedule by the end of 1983.[46] The reservoir was filled in the spring of 1984, and water was on its way to the dry lands of northeast Sri Lanka.[47]

Other assignments were obtained by the engineers at Maduru Oya. In 1984 an earth dam was built downstream to form a "balancing reservoir," alongside the main right-bank canal. A further commission in 1985–86 related to the headworks administration, operation and maintenance of the irrigation works, and involved the training of Sri Lankan staff to carry on these tasks.

Through 1987–88, as a participant in various Canadian joint ventures, Klohn Leonoff was in line to continue on major CIDA assignments in the irrigation district of the Maduru Oya Reservoir and other parts of the Mahaweli River Basin, but, owing to political instabiltiy in this region, CIDA has withdrawn from these projects.

The Maduru Oya assignment was a great source of satisfaction for Myles Parsons:

"The project went ahead in 1980; the team was fielded, and we were subsequently involved in four or five years of interesting times on the Maduru Oya project. That was to me, and still is, a significant event in my years with Klohn Leonoff. It was our biggest foreign project of the time. The overall value of the initial project was $8.5 million, and with some add-ons and subsequent work was around $10 million.

Our participation in the joint venture was twenty-five to thirty percent. So we had a significant piece of business through some tough years in the early eighties."

In 1985 the project received a Canadian Consulting Engineer "Award of Excellence."[48]

A fascinating sidelight of the construction phase was the discovery of a significant archaeological site. During the excavations, a twin-conduit sluiceway structure was uncovered. It measured about 66 metres long, 10 metres wide, and 5 metres high, and was composed of watertight, fired kiln bricks and sculpted granite blocks of heroic proportions. Remains of a major bund (earth dam) and spillway channels could also be seen at the site. These structures were part of an ancient irrigation scheme that had functioned successfully and helped to provide a basis for Sri Lankan civilization. The sluiceway had served as the key structure to control water releases from the reservoir.

The extraordinary fact, attesting to the sophistication of the ancient society, was that their "engineers" had selected virtually the same site where the main dam of the modern project was to be built. Sri Lanka has a 2000-year recorded history. During the reign of the Kandyian Kings, extensive irrigation systems were constructed throughout the island. The Maduru Oya site was one of these works. Radiocarbon dating of a sample taken from charcoal remains beneath a wall of the structure indicates an age of 1,520 years—the fifth century A.D. But archaeologists have estimated that an earlier stage of construction may date from as early as 600 B.C.[49]

The existence of the sluiceway came as a complete surprise to all concerned. The government of Sri Lanka promptly declared that it should be preserved for future generations,[50] and, as a consequence, construction was halted in the area while engineering designs were revised to protect the sluiceway.

A correspondent to a Sri-Lankan newspaper summed up his view of the Canadian work ethic on this job:

"It is the hard work of every Expatriate personnel . . . engaged on this multi complex project that produces the exilirating [sic] results. Every Expat is dedicated to a cause—that is the expeditious completion of the construction work. Though expected to work ten hours a day, every Expat is working much more than the scheduled hours. That is the secret of their success. . . . No wonder that Canada is a very wealthy and advanced country. Let the perseverance and persistence of the Canadians at Maduru Oya be a shining example for local personnel to exhibit and mould for the future."[51]

Ok Tedi Mine, Papua New Guinea, June 7, 1988.
Photo: Norman A. Morrison

Other CIDA jobs followed for Klohn Leonoff, in consortia with other firms. These included the Lower Uva Irrigation Rehabilitation Study Project in Sri Lanka[52] and more recent work for CIDA in the Caribbean, the Frigate Bay Sewerage Development serving a large tourist-oriented area on the island of St. Kitts,[53] and the $35 million Roseau Multipurpose Dam and Water Supply Scheme for the northwest section of the island of St. Lucia.[54]

From the beautiful and fruitful "Garden of Eden" of Sri

Ok Tedi project, Papua New Guinea – Lukwi tailings dam site investigation with helicopter-transported Longyear 38 diamond drill, ca. 1985.
Photo: Mark Olsen

Ok Menga project, Papua New Guinea – 50 MW hydroelectric plant, July 29, 1988.
Photo: Norman A. Morrison

Ok Menga project, native workers at lower end of steel penstock at powerhouse, February 1, 1988.
Photo: Norman A. Morrison

Lanka to the depths of the physically hostile rainforest of Papua New Guinea, it was international work that tided Klohn Leonoff through the great recession of the early eighties. In 1984, Ok[55] Tedi, a mining company operating in the remote Star Mountains Region of Papua New Guinea, was bringing into production the largest gold mine in the world. The 70-metric-ton per day open-pit mine contained a rich gold-silver "cap" set on top of a very large copper ore body. The plan was that the gold would pay for the initial high cost of the mine development, followed by exploitation of the copper.[56]

The inhospitable combination of geological and climatic conditions encountered in Papua New Guinea were certainly novel to KL, if not unique. Long and laborious supply lines to the site extended from Port Moresby, 500 kilometres across the Gulf of Papua (which separates Papua New Guinea from Australia), 800 kilometres up the winding Fly River to Kiunga, and then 140 kilometres by gravel road to the mining town of Tabubil. Located five degrees south of the equator, the area is very warm and extremely wet. Rainfall at the mine is 10 metres per annum—the rain falls literally every day of the year. The sedimentary rocks are geologically young—very soft mudstone, siltstone, and some limestone, which erode very quickly. The surface soils are a colluvium formed by the weathering of the soft rocks. The water table is generally at ground level, resulting in the regular occurrence of landslides throughout the country and great difficulty in finding any substantial foundation on which to build a structure.[57]

Ok Tedi is comprised of four major shareholding groups: Amoco (United States), Broken Hills (Australia), a German consortium of banks and engineering companies, and the government of Papua New Guinea. During construction of the mine, owing to massive landslides, the company had lost both its tailings disposal site and its power site, although initially they were making do with comparatively expensive diesel power. So the company looked internationally for a firm that could help to solve the mine's problems, particularly that of tailings disposal. Ok Tedi was considering the use of sand for a tailings dam because sand was plentiful on the site, and Amoco had knowledge of Klohn Leonoff through earlier contacts made via KL's Denver office. And of course KL had developed a good reputation in the use of sand to build tailings dams. Thus Klohn Leonoff was one of three companies invited to submit a proposal for a two-month preliminary assessment and report on alternative sites.

Porgera Gold Mine containment pond for gold ore slurry, Papua New Guinea, 1990.
Photo: Placer Dome Inc.

Ernest Portfors, who in early April 1984 was managing the British Columbia Region for Klohn Leonoff, but was to head the project, recalls the start of what was to become the company's largest-ever job:

"Engineering was pretty slow around all of British Columbia at the time, and we were struggling along with everybody else. One day a telex 'request for proposal' came from Ok Tedi out of Melbourne, Australia to do a review of their tailings handling facility for a mine in Papua New Guinea. We sort of scurried around, first of all to find where Papua New Guinea was, then to find out a little bit about the project. In the end we got a fair amount of information from Placer [a Vancouver mining firm], because of their activities down there, and from the UBC library.

"I recall the day quite well. Earle Klohn and I were sitting in our board room trying to decide how to respond to this thing, and we concluded that, since we knew so little about that part of the world, we should send down a team of three or four of our most senior people to do the review on site. We concluded that Mark Olsen from the mining side and Ian Morrison from the straight geotechnical side should handle that area. Then we got on to hydraulics, hydrology, and other water-related areas, and Earle said, 'Who are we going to send there?' My response was, 'Well, I think I should probably do it.' Earle asked, 'Who is going to look after B.C?' And my retort was that B.C. was so slow that anybody could look after it. Klohn was travelling to somewhere in Southeast Asia at that time, so we set it up that he could come down for a few days as well.

"We sent our proposal and it was accepted almost instantly. Mark and Ian and I jumped on a plane and some thirty-odd hours later ended up in Port Moresby. After getting up to the site, we found that we were the only consultant that had responded by sending a team of people to do the job on site. Everybody else had said that they would send down people to pick up the data and go back to do the review in their home office. The project area is so tough geotechnically and hydraulically that everyday we were on site we learned a lot more. Being on site was the only effective way that we could have done that job."

The KL "emergency response team" reported to the Ok Tedi Board of Directors at the end of May 1984, recommending that the landslide site on which they had been building be abandoned, as there was no reasonable way of rebuilding at that location. The report went on to recommend that a new tailings dam site should be looked for farther downstream of the mine.

Field staff were back home in Vancouver for not more than two weeks when an urgent telex arrived from Ok Tedi asking that KL staff be in attendance at an Ok Tedi Board of Directors' meeting in July. The result was that from mid-1984 into 1985, field investigations and the complete design of a new tailings facility were carried out.[58] In all, thirteen sites were investigated, with a final site selected at Lukwi.[59] But the mine had already suffered considerable overruns in construction costs at a time when the price of gold was falling, and the company was not in a financial position to embark upon the construction of a costly tailings disposal system. In the end, in 1989, the company received permission from the Papua New Guinea government to dump the tailings into the Ok Tedi River, thence through the Fly River system into the Gulf of Papua. Environmental studies had concluded that the tailings would amount to only a small percentage of the sediments already being carried by the river system and would not appreciably affect sedimentation or fish stock in the Lower Fly. Keeping the mine in operation was also of vital concern to the government as it represented 40 percent of the country's foreign export.

In Papua New Guinea, Klohn Leonoff's resident staff was to witness a civilization in rapid transition from a village society not far removed from the Stone Age to an industrialized society of the twentieth century.[60] Hinterland Papua New Guinea is certainly one of the last frontiers of the world, and the transition from hinterland to modern civilization is nowhere more evident than in the mining town of Tabubil, where a native can be seen walking barefoot, dressed in shorts, and wearing an elaborate national hairdo, but wired for stereo sound from a Sony Walkman.

Port Moresby, the country's largest urban centre, is an attractive harbour city of 150,000 people, quite modern in the downtown core, with high-rise office buildings and expensive hotels. The local climate sees a lot of rain during the monsoon season, from May to September, but is otherwise quite hot and dry as the result of southeast trade winds. Tabubil, where the weather is not quite so hospitable, is comprised of some 3,000 people, about a third of them expatriates, mainly Australians, but also a number of New Zealanders, Britons, and Canadians. Living conditions for KL staff at Tabubil were satisfactory, with married couples residing in houses.

The high rainfall and very dense vegetation in Papua New Guinea make it exceedingly difficult to move around on the ground. The trees grow to 30 metres in height, and most of the bird life can be found on top of the canopy, as that is where the light is. It is a terrain not unlike the Pacific Northwest rainforest, but is of course very much warmer. At ground level, everything is dripping wet. Moss and ferns grow in abundance, whereas flowers are scarce due to the relative darkness. Most of the trees are "soft," grow very quickly, and die just as rapidly. Once down, the tree soon disintegrates to help form a thick vegetative cover which effectively masks the ground features. Very little of the jungle wood is marketable. There are many limestone cliffs, formed by landslides, but these are often visible only from the air. On the ground one can literally take a single step and unwittingly tumble over a 30-metre-high cliff.

The natives are gardeners, and basically vegetarians; their staple foods are root vegetables, primarily yams and sago. The indigenous animals, which are related to those of Australia because of the existence of a land bridge prior to the last ice age, are typically small in size and sparse in number, providing very little available protein. Traditionally, the nationals gathered in very small villages, typically consisting of ten huts of twenty or thirty people. The huts had thatched roofs and were built upon stilts set in the driest places, generally on top of a ridge. Villagers would cut down the jungle, plant their gardens, grow crops, deplete the soil, then move to a new spot and repeat the process. With the garden gone, the jungle would simply creep back in, so that garden plots continually revolved around the village. Because of the difficulty of communication and transport, trading was restricted to adjacent villages five or ten kilometres apart. And since the country was so fragmented, there were many tribes, much tribal warfare, and some 750 dialects spoken. Owing to the difficult living conditions, life expectancy for the native people has been short, in the order of thirty-five or forty years. As a consequence, with a population of 3.5 million occupying a relatively large country, Papua New Guinea is not overpopulated, unlike most other Third World countries.

During the Second World War, Papua New Guinea served as a bulwark for Australia against the Japanese, who controlled the northern edge of the island but were never able to take Port Moresby on the south side. Since the war, Australia has supported the country very strongly in order to keep it a western-style democracy. Papua New Guinea gained its independence in 1976. Extremely rich in ore bodies, mining is the primary resource, and there is some forestry. In addition to their work for Ok Tedi, Klohn Leonoff has also been working in New Guinea for Placer-Dome mines on their gold properties at Misima, one of the islands off the southeast coast, and at Porgera in the highlands.

Most of the first schools in Papua New Guinea were established by the churches, and there is now a national school system teaching a sound, if basic education. There is, as well, a technical school at Lae on the north coast, and some nationals are attending university in Australia. In the Ok Tedi mine and mill, all the labour up to and including the foreman level are locals, as are the support staff—accountants and secretaries. And in time the nationals will provide more and more of the operational and senior administrative staff. Motu is on its way to becoming the national language, and the language of business is English. But the language of the people is Pidgin, a dialect of mostly English words which has developed into a language of recognized sentence structure and vocabulary.

KL's first assignment in Papua New Guinea would open the door to a second, even larger assignment, the Ok Menga hydroelectric project, which was to firmly establish Klohn Leonoff in the field of hydroelectric power-generating design. While KL geotechnical people were on site for the Ok Tedi tailings investigation, they were asked about the possibility of finding a new hydro site to replace the old one, which had failed due to a landslide. After much searching, a piece of sandstone, not an ideal rock but much more suitable than anything else in the area, was located about a kilometre upstream of the original site, and KL thought a power station could be built there. Bechtel had designed the initial 50-megawatt plant. With a new site identified, the client asked KL to redesign the plant to fit the new location.[61]

While senior personnel of KL had done specialist hydroelectric work before, this was the company's first major design project in this field. Fortunately for KL, B.C. Hydro were, at the time, in the process of privatizing their engineering arm, and had laid off a number of experienced personnel. So out of this pool, KL assembled a team of twenty-five hydroelectric designers in Vancouver and proceeded to redesign the Ok Menga hydro station. Design work started early in 1986, and construction commenced that fall.

To supervise construction, KL placed a team of people on site under the leadership of Al Morrison, who had participated in the design and construction of the Maduru Oya project. At 4:00 P.M. on March 28, 1988, Portfors received a telephone call from Morrison with the news that the Ok Menga power tunnel had been successfully water pressurized. The sequence of filling was controlled by cracking open the intake gate, with pressure and leakage measurements taken as the tunnel was filled with water in careful stages. Leakage from the tunnel was minimal, well within the design limits.[62] With this critical test passed, commissioning of the generating units could begin. Power was first produced, and the official commissioning services took place, in June 1988. Even at a capital cost of $65 million U.S., the Ok Menga project proved to be a highly successful diesel-replacement operation, with complete payback (as compared to diesel) in something less than three years.[63] Thus, in remote Papua New Guinea, Klohn Leonoff was finally to come of age as a truly multidisciplinary project management team.

Peter S. McCreath, senior author (along with three others) of a paper entitled "River Intake Works for a Hydroelectric Plant in Papua New Guinea," won the 1990 Canadian Society for Civil Engineering Keefer Medal for the best paper presented to the Society that year.[64]

Other hydroelectric feasibility studies would follow: The Miso and Pongema river investigations for the Porgera Gold Mine in Papua New Guinea, the Lovo hydro feasibility study in Fiji, and reports on the Tortum 2 Mesopotamia project in Turkey.

In October 1981, Dr. Robert Lo was representing Klohn Leonoff in yet another part of the world that was opening up to western engineering technology—the People's Republic of China. Lo was a member of a Canadian delegation of engineers and geologists who undertook a four-week tour of eight cities and numerous engineering, geologic, and academic institutes throughout China. The delegation covered about half of the country, travelling by airplane, train, and river boat. An important task was to present technical papers in various cities, and the two titles delivered by Lo, in Chinese, were "Design and Construction of Tailings Dams" and "Seismic Design of Earth Dams." In Beijing, the delegation drew an audience of over 600 people representing almost all provinces.[65] Subsequent discussions revealed a strong Chinese interest in the technical aspects of modern tailings dam design, as the outdated upstream construction method was still being widely practiced throughout the country. (The upstream technique is the oldest, cheapest, and generally most unsafe method, whereby the dam is constructed by spigotting in an upstream direction off a pond behind a low starter dyke.)

In 1984 a delegation of senior officials from the China Ministry of Metallurgical Industry (MMI) made a reciprocal visit to Canada, studying Canadian large-scale open-pit mine operations and related waste management practices. Because of its international reputation, the delegation sought out Klohn Leonoff for site visits and technical discussions on KL-designed tailings projects. As well, they expressed an interest in having the company participate more formally in technical exchanges with China.

While China lags substantially behind North America in state-of the-art mine waste engineering practice, following the 1984 visit by the Chinese delegation, it was clear that China was embarking on an ambitious modernization program of some 500 existing coal, iron, copper, and gold mines, as well as the construction of new mines, with a planned quadrupling of mineral production by the end of the century. Consequently, at the invitation of the Central Research Institute of Building and Construction of MMI, and partially funded through the External Affairs and International Trade Canada Program for Export Market Development (PEMD),[66] in May 1985 Earle Klohn and Robert Lo conducted a series of technical seminars and site visits in northeast and east-central China, related to tailings dam engineering.[67] The training seminars followed the agenda of previous presentations made in North America by Klohn Leonoff in Richmond, B.C. (1979),[68] and in co-operation with the Colorado School of Mines (1980)[69] and the University of Calgary (1982). The tour gave KL a first-hand impression of the Chinese market, with the hope that further advisory or specialist assignments might ensue.

In the wake of these Chinese visits, however, it was clear that little money was available for foreign engineering in China. In looking to the future, the Chinese were training their own staff, and these technical interchanges were the most inexpensive way to do that. Any work in China would be only specialist consulting by individuals like Klohn and Lo.

And, as predicted, following the Chinese exchange of the mid-eighties, on July 3, 1990, a two-member Klohn Leonoff "geotechnical-hydraulics-hydrology team," composed of Robert Lo and Peter McCreath, travelled to China to provide an engineering design review for the Dexing Copper Mine tailings dam.[70]

Dexing Copper Mine, Jiangxi province, China – No. 4 tailings facility, August 1990.
Photo: Robert Lo

A KL staff member has given this lighthearted scenario of her introduction into the social formalities of doing business in the People's Republic of China:

"On October 5, 1990 the Inception Team of the CIDA-funded Phase II Integrated Intensive Forest Management project touched down in the People's Republic of China. As Klohn Leonoff had been contracted to carry out the 'Women in Development' component of the project, I was among the members of the delegation. My role on the project was to conduct a study on the status of women in forestry which would form the basis for women's involvement in the project's future activities.

"In reminiscence, one of my more memorable moments was the first banquet in the northeastern capital of Harbin, where I was introduced to Chinese white wine. White wine is a wonderful Chinese euphemism for the local firewater, commonly called 'mao tai' after the most famous brand, but more correctly called 'bai jiu' (literally white wine). Bai jiu

Earle Klohn and Robert Lo, centre, on Dexing site visit with staff of Central Engineering and Research Institute for Non-Ferrous Metallurgical Industries, May 1985.
Photo: China Photo Service

is extremely potent—it is the only white wine in the world with an octane rating on the label. The liquor smells vile and tastes worse, so the only way to drink bai jiu is quickly. It is seldom sipped or savoured, but thrown back with a flourish on the command, 'Ganbei!', meaning 'bottoms up'.

"Over the course of a typical banquet many speeches are made, at the end of which there is a toast, or a ganbei, to 'Canadian and Chinese friendship and co-operation.' Diplomatic etiquette dictates that you never turn down the challenge of a ganbei. As this banquet was the first of the inception mission, it is sufficient to say that international relations were suitably cemented. Not all the banquets I attended however, had such an ill-fated outcome. One eventually develops surreptitious means of avoiding bai jiu, such as replacing it with a soft drink when no one is looking, or appointing one team member a DD (designated drinker). . . ."[71]

While the dreams of the Pacific Development Group of the early seventies had been premature, by the mid-1980s, globalization of the world's economy was a reality. By this time too, KL's multidisciplinary projects in Sri Lanka and Papua New Guinea had brought a whole new range of engineering challenges to the senior staff at Klohn Leonoff. In 1986 Ernest Portfors was president of the Association of Professional Engineers of British Columbia and wrote a monthly President's Comments column for their magazine. In one issue he covered the topic "BC in the World":

"This editorial is being written from the middle of the Papua New Guinea jungle, where my company is providing consulting services to a major gold and copper mine. Working overseas for the last two years has dramatically demonstrated to me how small our world is, and how critical world markets are to the economic health of British Columbia and its residents. The world is truly a single large marketplace, with each country and town market a small component of the bigger market.

"For example, we are a Canadian consulting company working for a Papua New Guinea mining company which has as its major shareholders interests from Australia, United States, Germany, and Papua New Guinea. The main grinding mill was supplied by a Canadian manufacturer, and some of the gold output from the mine has been sold in Canada, yet the copper which the mine will be producing shortly will be supplied to world markets in direct competition to copper from British Columbia mines. Capital cost of the mine was very high because of its remote location and harsh topography, geology, and climate; but relatively inexpensive local labour helps keep operating costs low and makes the mine profitable even with today's depressed metal prices.

"This mine, nearly on the other side of the world from Canada, then has a direct impact on British Columbia engineers; a positive effect for those consultants or suppliers [who] have sold goods and services to the project, and a negative effect for mining engineers or geologists who are unemployed in British Columbia because of our closed mines. And this mine is only one single project of many thousands, located literally in every part of the world, that affect our British Columbia economy. It is obvious that our response to world competition will determine the success or failure of our economic and social future."[72]

Coupled with a deep downturn of the North American economy, during the mid-eighties KL's marketing program was increasingly directed overseas. In October 1984, Klohn reported this fact to his board:

"Capital works spending in North America and particularly Canada is at an all time low. The work which we are obtaining in Alberta and B.C. is very small in volume and inadequate to keep us alive. It is increasingly obvious that foreign marketing is becoming more and more important and, with this in mind, Klohn Leonoff have directed a large part of their efforts during the past year in developing strategies to obtain a larger share of foreign work. With this in mind we have set up a new International Region with Myles Parsons as general manager."[73]

Vinod Garga was the other senior staff member involved in this effort. As well as the geotechnical work, the intent was to broaden the company's scope in the fields of agriculture, water resources, and the environment.

An elaborate international marketing plan was drawn up, concentrating on visits and presentation of credentials to the leading lending institutions: the Canadian International Development Agency (CIDA); the Export Development Corporation (EDC); the Asian Development Bank (ADB); the Inter-American Development Bank (IADB); and the World Bank. Geographic focus would be on those regions where the company had experience—Southeast Asia, Central and South America, and the Caribbean.[74] However, the concept proved illusory and very little was achieved.[75] Although Parsons and Garga had appreciable international experience, it proved very costly for a relatively small Canadian firm, acting alone, to crack the politics of these international aid agencies.

Instead it became more pragmatic to concentrate on foreign work through CIDA and via the private sector. Consequently the company's international marketing group was melded into the B.C. Region.[76] Garga left the firm in June 1985[77] and, in September 1986, Parsons became manager of the B.C. Region.[78]

In Klohn Leonoff's continuing pursuit of international work in the 1980s, with much of it funded by international financial institutions and development agencies, it was evident that the competitive success of the company in this arena was tied to addressing social dimension components in Klohn Leonoff's projects. After many years of experience in developing and newly emerging countries, agencies such as the Canadian International Development Agency, the Asian Development Bank, World Bank, and United Nations Developments require that development projects incorporate strategies for the alleviation of poverty, improving economic conditions, and increasing the participation of women. The projects also must be environmentally sound, and involve partnership arrangements with other companies and non-government organizations. This increasing focus on the "human environment" led Klohn Leonoff to attempt to integrate human development needs into the firm's engineering planning for developing countries, and to set up a particular group in order to achieve this goal.

In 1989, Patricia Randall, with a background in education, joined the company. During the initial years, Randall, Maria Correia, and Catherine Thompson formed the basis of the International Community Development Division (ICD). Beginning in 1990, several assignments were initiated in India, China, and Africa—specifically Tanzania and Uganda.

Uganda is a land-locked East African nation with 19 million people, 20 percent of them living in rural areas. Situated on the equator, the country has a very pleasant climate and an abundance of natural resources. A British protectorate until 1962, after gaining independence Uganda

Patricia Randall with local children, northern Uganda, 1991.

suffered twenty years of unrest and civil war. In January 1986 the National Resistance Movement under President Y. Musevani took power, re-established security, set development plans in motion, and has maintained a high regard for human rights. The Uganda Ministry of Education has placed a priority on planning, training, and the rehabilitation of its elementary, secondary, and tertiary education programs, including upgrading of the system's buildings and equipment. Under the auspices of CIDA's Partnership Branch, in co-operation with the Ministry, ICD has undertaken a feasibility study on technical and vocational education; this in an effort to make such education more relevant to the country's present market demands.[79]

Klohn Leonoff's team, consisting of members from its staff and from consulting companies and universities specializing in educational issues, visited government-aided and privately sponsored primary, secondary, technical, and training schools throughout Uganda. Crossing the country on the investigative mission and going from the Tanzanian to the Rwandan and then Kenyan borders, the assignment took on a safari-like atmosphere. Outside of Kampala, the routine involved carrying enough petrol and water for each day's activities, returning in late evening to overnight rest areas, detouring around impassable mud roads, and stopping at district schools. In addition, the initiative focused on the informal sector of the labour force, in particular the efforts of women. Later in 1991, Klohn Leonoff also became involved in a technical-economic feasibility study to determine the socio-economic benefit of upgrading a rural road in western Uganda. Members of the survey crew for this project reported ten or twenty wide-eyed youngsters following their every movement with fascination.[80]

During its initial years, ICD has assisted with the international marketing of the company to the point where Klohn Leonoff is now regarded as more than just another traditional engineering company. Other projects undertaken by ICD include: World Bank Missions on Safe Motherhood and Population in India; a CIDA investigation into the involvement of women in an integrated, intensive forest management program in China; a CIDA study of the potential role of women in a labour-based rural road project in Tanzania; and an External Affairs Central and East European Task Force project involving the design and development of a self-employment training program for use in the Czech and Slovak Republics, specifically with unemployed and under-employed women.

ICD's mandate is to link with the traditional services offered by the company in multidisciplinary integrated projects, and to serve as a social science project development arm capable of introducing the company's expertise into new regions of selected developing countries. The division's activities in East Africa and Eastern Europe thus formed part of Klohn Leonoff's overall plans for international work.

Currently, Klohn Leonoff aims for international work to comprise 25 to 30 percent of its entire work load. Says Klohn, "It builds reputation and gets you work domestically." Moreover, international work gives staff an opportunity to work on jobs outside of the domestic market (Canada and the United States), and a lot of people enjoy the romance of working far from home. Yet foreign jobs require a high degree of expertise and place the greatest load on principals and senior staff. Ernest Portfors can attest to this fact:

"During the period 1984 through 1987, I made fifteen trips to Papua New Guinea, and it's a long way. I tell you, when you get on a plane and travel for twenty-four to thirty hours, then get off at the other end, and you're expected to turn around and start work immediately, it's not fun. So although there might be romance with travel, it still amounts to bloody hard work."

The managing editor of a Canadian engineering magazine, writing on the subject of "International Markets" in general, and on Klohn Leonoff's involvement in these markets in particular, has perhaps summed up the current feelings of the company's principals regarding international work:

"Senior management of Klohn Leonoff are enthusiastic about opportunities in the international field. Nevertheless, they caution that such opportunities are hard-won, since engineering capability in developing countries has improved significantly.... Significant opportunity, however, still exists for Canadian companies that have special engineering expertise, and when necessary, are willing to undertake a joint venture with local companies."[81]

In October 1985, in conjunction with International Trade Week, Klohn Leonoff was presented with the "B.C. Export Award" by the Minister of International Trade and Investment[82] for "achievement in international marketing and outstanding export performance."[83]

Chapter Twelve

THE AMERICAN CHALLENGE

For as long as the two countries have been neighbours, the United States of America has offered businessmen in Canada a market that is almost irresistibly tempting. With a population ten times greater than that of Canada, and a similar language, culture, and scientific and business outlook, the neighbouring country to the south inevitably appears as a logical place to expand for any reasonably prospering Canadian company. In the case of Klohn Leonoff Consultants this may have been particularly true, since most of the company's principals had trained and/or worked in the U.S.A. And the company had in fact, during the late fifties and early sixties, carried out work in the United States for H. A. Simons on pulp and paper mills at Gardiner, Oregon, at Brunswick, Georgia, and Androscoggin in Maine, and for Wright Engineers on a gold mining plant in Washington State.

The Androscoggin Pulp and Paper Mill in Maine, designed by Simons International, is one of North America's largest paper producers. RKL provided a complete geotechnical service for the plant's construction, beginning with site evaluation and continuing through foundation investigation, design, and construction supervision. Work began in 1963 with the evaluation of several sites and the selection of a site on the Androscoggin River at Jay, Maine. A detailed investigation for the locating of specific structures followed.

The area is underlain by 10 to 20 feet of glacial outwash sands above highly consolidated glacial till. Heavy settlement-sensitive structures such as the woodroom, the power group, the pulping group, and those housing the paper machines were to be built on heavily compacted granular backfill placed over this dense glacial till. Lighter structures would be founded on the glacial outwash sands. Building excavation began in 1964, but quickly ran into problems caused by working heavy equipment on the glacial till, which proved to be sensitive to disturbance. More suitable excavation procedures were established and supervision of construction carried out for the original plant, as well as major expansions in 1966 and then from 1975 to 1977. Pile foundations were required for several structures in the last expansion, where existing buildings would have been endangered by new excavations for deep footings.[1]

As a result of this activity, in a position paper of January 1977 on long-range company planning, Klohn stated a clear objective, "to expand our operations geographically by opening an office in the U.S.A. as soon as the opportunity arises."[2]

The opportunity envisioned by Klohn arose in the fall of 1977 when KL received an assignment from Reserve Mining to supervise the construction of the company's on-land tailings disposal facilities at Silver Bay, Minnesota. As a result, a few staff members were sent to manage the technical aspects of this project. Their work quickly evolved into three and a half years of intensive construction—building the starter dams, pumping facilities, and pipelines. Thus Klohn Leonoff established an entrée in the United States via the mining field.

In 1974, three years prior to KL's involvement, Reserve Mining Company, owned by the steel giants Republic Steel Company and Armco Inc., was operating a large taconite mill on the north shore of Lake Superior at Silver Bay. The iron ore was open-pit mined on the Mesabi Mountain Range, then transported seventy-five kilometres by rail to the plant. Reserve had developed a process for grinding the taconite, a flintlike hard rock, separating the ore magnetically, and forming it into iron pellets. In the concentration process, 30 percent of the taconite was recovered, the remainder being composed of coarse gravel-sand and a wet slurry of fine tailings. This waste was then dumped into Lake Superior at the rate of over 60,000 tons per day. An astronomical 800 million tons of tailings would be produced over forty years. As there were no reagents used in the process, there was no chemical pollution present, just the pollution of ground-up rock.

At the time KL was engaged by the company, Reserve Mining was being threatened by a double-edged sword. On the one hand Reserve was faced with a court order to stop discharging waste into the lake; on the other hand the state was refusing to permit the construction of on-land disposal facilities. Any closure of the mine and mill would eliminate some 3,000 jobs having a combined annual payroll of $60 million, and threaten the fate of two separate towns (at the mill and the mine).

When Earle Klohn first viewed the site, the tailings delta, almost a mile across at its mouth, had been built out in the lake half a mile from shore, into 600 feet of water. So, admits Klohn, "It was a pretty big pile started about ten years before I ever got involved." As Klohn recounts the story:

"They were battling the people who wanted to clean up Lake Superior. I was called to go down and review a few things, because we had developed some kind of reputation in tailings, and they were looking around for people to support them. This developed into my becoming the main expert witness on tailings dam design, a role I spent a good part of five years on.

"Reserve Mining brought in medical experts from anywhere you name—if he was from London, they flew him in and he appeared on the witness stand. The other side was doing the same thing. The case wasn't getting too far. As the court action went on, the mill was continuing to dump tailings into the lake, so as long as the battle went on, Reserve was happy. Then suddenly the ugly word cancer came up. Someone suggested that, because the fibres from the rock had a very long length-to-width ratio, they were the same as asbestos fibres. Consequently anyone drinking the water might get cancer—which of course has never been proven one way or the other. But once that bogyman came out, things really got wild."

At one point, the judge presiding over the court action shut the mill down, but a review court opened it again. Finally, in April 1977, the Minnesota Supreme Court unanimously confirmed a district court decision ordering the state to issue permits allowing for an on-land waste disposal facility. Thus ended what was stated to be the largest civil case in U.S. history. And the newspaper headlines read, "B.C. Firm Helps Save 3,000 Minnesota Jobs."[3]

Klohn Leonoff Consultants designed all of the new tailings facilities. According to Klohn, coming from afar may have been an advantage in this case:

"We were the only consultant of Reserve who was completely acceptable to the state, because we had no axe to grind and we were meticulous about remaining neutral. The state hired three other consulting firms to check our designs, and they all concluded that the proposed dams could be safely constructed."

Construction of the $370 million project, which would be the most expensive single pollution control ever built, began in the fall of 1977.[4]

The Reserve Mining tailings project is designed as a giant holding basin located in a broad valley seven miles from the mill. The dimensions of the ultimate reservoir are immense, covering 3,000 acres and holding more than 600 million cubic yards of tailings. Two major dams block each end of the valley, and two saddle dams bridge low spots along the valley wall. Upon completion, the largest dam will be 195 feet high and 2.5 miles long. The coarse tailings are efficiently utilized for the 55 million cubic yards of material needed to construct these dams. As well, diversion dams and canals divert the flow of two creeks, while several dykes criss-cross the basin to allow dumping of coarse tailings by rail car. The fine tailings slurry, comprising 60 percent of the waste, are pumped into the reservoir. The deal made with the state was that all tailings would be discharged and stored under water to prevent dust from blowing into Silver Bay. The valley, containing a level floor covered with a thick impervious layer of clay and glacial till, is an ideal basin site, essentially watertight. But, as an added precaution, seepage recovery dams built downstream would retain any seepage that might occur, and this would then be pumped back into the tailings pond. Eventually vegetation will be planted on the exposed tailings, leaving only a small lake of clear water surrounded by parkland as evidence of the forty-year enterprise.[5]

Measures were also designed and built to stabilize the old tailings delta built into Lake Superior. With the aid of hydraulic model studies, KL developed a graded-rock, protective apron over the delta face, allowing natural wave action to sort the rock into a stable beach profile.

Ironically, Reserve Mining was well into the new program when the company was caught in the recession of the early eighties, went bankrupt and into receivership for a number of years. However, the company is now operating again on a reduced scale, and KL continues to act as consultant to the receiver and new owner.

Despite its prominent role with Reserve Mining, KL was under no illusion as to the highly competitive nature of the geotechnical field in the United States. A number of medium- and large-sized firms were more than adequately serving that market. As well, before the recent advent of "free trade," U.S. immigration policy was extremely restrictive in allowing nonresident Canadian

Reserve Mining tailings project, Minnesota, 1978–79 – Seepage recovery dam construction.
Photo: Thomas Harper

consulting engineers to enter the country. In fact, on at least one occasion Klohn had been turned back at the border when consulting on the Reserve project. (On the other hand, American consultants such as Terzaghi, Casagrande, and Peck had consulted for years in Canada without hindrance.)

With these considerations in mind, it was decided that the company would open an office in the U.S. Initially, Minneapolis was looked at as a possible site for a permanent United States office but, with an eye toward the geographic range of the U.S. mining industry, Denver, Colorado was selected as the optimum location. Denver, situated similarly to Calgary in the eastern foothills of the Rocky Mountains, is central to the mountain states of Montana, Idaho, Wyoming, Utah, Nevada, and California, over which the great bulk of western mining activity was spread. Additionally, the head offices of the mining companies and the mining divisions of the oil companies were largely located there. And, again like Calgary, Denver was seemingly replete with entrepreneurs, promoters, developers, businessmen, and professionals (many of them Canadian), and was experiencing an unprecedented business and development boom. In fact, so many high-rise buildings were being constructed by Canadians in the downtown business core of Denver that it came to be known by the nickname "little Canada."

From the fall of 1978 through the summer of 1979, Cyril Leonoff and Earl Speer made a number of visits to Denver, initiating the necessary business contacts with public accountants, bankers, attorneys, insurers, realtors, and government bureaucracies.[6] In a November 1978 report to the Management Committee, Speer gave his initial appraisal:

"Cursory market assessment for mining engineering, specifically relative to tailings disposal facilities, indicates a good potential for this company. The market is probably tenfold that of Canada; however the competition is also much greater. I was encouraged by the general respective attitude of Americans to sales and to our expertise. This was particularly true when I mentioned our involvement for Reserve Mining Company."[7]

Berenbaum & Weinberger, a long-established Denver law office, was chosen as the firm's attorneys. Klohn Leonoff Consultants Inc., wholly owned by the Canadian company, was incorporated in the State of Colorado on March 12, 1979.[8] Officers of the company were Earle J. Klohn as chairman of the board, Earl W. Speer as president, and Cyril E. Leonoff as vice-president and secretary treasurer. Joseph Berenbaum, senior member of the law firm, took a personal interest in the fledgling company and its principals, often helping the "green" Canadians, Speer and Leonoff, to become oriented in Denver and acculturated to a new society. By spring, a telephone answering service had been installed on behalf of the company in the attorneys' office.[9] (Berenbaum & Weinberger and its successors have remained KL Inc.'s corporate attorneys to the present day.)

Reserve Mining tailings project, Minnesota, 1978–79.
Photos: Thomas Harper

Vibroller compaction of starter-dam fill.

Settlement plates and standpipe piezometers.

Speer and his wife took up residence in Denver during July 1979, and by August 1, Earl was set up to do business. Although a lot of the mining companies working in the United States had offices in Vancouver, according to Earl, when he began work in Denver he "didn't know anybody." Speer's wife, Evelyn, is the source of a clear picture of the company's initial, home-based American operation. Each morning Earl would shower, suit up with jacket and tie, just as if he were going to the office. Otherwise, according to "Ev," he simply didn't feel businesslike. Then he would begin the arduous task of placing what eventually totalled hundreds of "cold" telephone calls to potential clients. Earl would make notes on the calls, and Evelyn would neatly file them. "I spent eight to nine months, almost a year, working out of my bedroom, making contacts," recalls Speer. At first his contacts provided little more than a knowledge of work currently under way in the area, but then, in early 1980, "things started to move in the mining area."

On July 1, 1980, a business office was opened at 3000 Youngfield Street in Denver,[10] and, from the outset, the prudence of having Americans up-front in a United States operation was recognized. The intention was that Speer would manage the U.S. office only temporarily; eventually an American would take over. Speer was perhaps the first to appreciate this need:

"Someone down there told me, 'You know, we like to deal with our own—with Americans.' Good heavens what a melting pot America is. But if you have an accent—like English, Scottish, or from down under—they really don't care for that. The British were driven out of the U.S., and it seems to stick with the latter. If you are a Canadian, you have a much better chance of succeeding. Though I think really to succeed you need an American leader who knows the lingo. And, whichever way you look at it, there is still the American old boys' network."

Thus, at the inception of the Denver office, an American, David Wilson, was engaged as vice-president and manager of the U.S. Region.[11] Wilson had obtained his Bachelor of Science in mining engineering from the University of Arizona and had taken post-graduate studies in rock mechanics, coal mining, and tailings impoundments at the University of Missouri, the Colorado School of Mines, and Colorado State University. Subsequently, he had gained twenty years of experience in mine operations and as a mining consultant, working on reserve assessments, economic and feasibility studies, joint ventures, and acquisitions analyses.

One of Wilson's earliest tasks with the company was to organize a seminar, "Design and Construction of Tailings Dams," co-hosted by the Colorado School of Mines and Klohn Leonoff Consultants Inc., and held at the school on November 6 and 7, 1980.[12]

Two hundred persons attended, and many of the papers were given by KL staff. Wilson reported on the success of the seminar in establishing KL Inc. "as experts in tailings."[13] The proceedings were published in a book edited by David Wilson.[14]

Thomas G. Harper (Chapter 9) was the technical project manager for the Reserve Mining project from 1977 to 1980. At the end of 1980, Harper moved from Silver Bay, Minnesota to Denver as manager of the Mining Division. He continued to do ongoing design work on the Reserve Mining project, at the same time overseeing the development of various mining projects out of the Denver office. By 1981 some forty projects were being handled out of Denver, and the office was employing a staff of sixteen people in addition to a number of "contract people." Then, abruptly, in the fall of 1982, the bottom dropped out of the mining market. Oil prices plummeted, and most mining companies were heavily engaged in oil-shale projects.

Denver's bubble had burst. Fortunes were lost, and that city has never returned to the frantic days of pre-1982, nor has it ever filled the surplus office space engendered during that period. Klohn Leonoff Consultants was caught firmly in the midst of the collapse, and the Denver office was closed by the end of that year, although Earl Speer stayed on for a short time to "mop up." David Wilson, now conducting his own business, was retained for six months on an "as-required" basis to represent KL Inc. in the Denver area.[15] The structure of the KL American corporation was, however, retained for a better day.

Reserve Mining tailings project, Minnesota, 1978–79 - Density testing of fill with nuclear apparatus.

Despite the collapse, returns to Klohn Leonoff from the short-lived Denver operation were not all negative. Contacts had been made in the United States which in turn brought in international assignments. One that came in 1981 was a tailings impoundment stability assessment for Minerales de Bolanos S.A./Kennecott Minerals Company at Bolanos, Jalisco in Mexico. Speer's initial contact with Amoco also provided an entrée to the gigantic Ok Tedi and Ok Menga jobs in Papua New Guinea. As well, resulting from the efforts of the KL Denver staff, there were ongoing projects and the development of new work within the United States.

The most noteworthy of these ensuing American clients has been Kennecott Utah Copper. Begun in the first decade of the 1900s, its Bingham open-pit copper mine, along with the resulting tailings deposit, is considered to be the largest man-made works by volume on the face of the earth. The tailings impoundment alone, a 17-foot-high embankment, covers an area four miles by six miles.[16] Thus, KL has been a principal consultant on the three largest tailings dams in the world: Kennecott Utah; Syncrude Alberta; and Highland Valley Copper, in British Columbia.

Following the close of the KL Inc. Denver office, in February of 1983 Earl Speer returned to Vancouver, where he became manager of the British Columbia Region and, upon Leonoff's retirement in 1985, executive vice-president in the corporate office. "Tom" Harper went to the Calgary office, where he became manager of the Mining Services Division, heading up a small team working in the coal mining areas of Alberta and Saskatchewan. Harper continued to work on mining projects in the United States as well, some involving conventional tailings disposal, but particularly on projects involving heap leaching in Montana, Idaho, Nevada, and Colorado.[17]

Early in its brief history, the Denver office had become involved with the Pegasus Gold Corporation in the Zortman and Landusky Mines heap-leach operations located in the Little Rocky Mountains region of northern Montana—one of the very early gold and silver heap-leach facilities in the U.S.[18] Heap leaching is used predominantly in the gold and silver business to recover precious metals that are of too low grade to justify the capital cost of a milling operation. First, an impervious, essentially level pad is built. The ore obtained from the open-pit mining is heaped on top of the pad. It is then leached with a solution of water and sodium cyanide. The cyanide reacts with the gold, freeing it up and forming a "pregnant" liquor, which is collected by a drainage system beneath. The liquor is then passed through a small plant where the gold and silver are extracted by precipitation. As any cyanide leakage could be fatal, the "barren" solution is then returned back to the heap, maintaining a closed circuit.

In mountainous terrain the pads are often constructed on steep side slopes, involving extensive cut and fill construction. The geotechnical design involved must ensure the stability of both the leach pads and the ore heaps. Initially, bentonite clay or shale pads were used, but plastic membranes have since evolved, sometimes alone and at other times in conjunction with clay. The process had been in operation for a few years before KL Inc. was engaged, but, according to Harper, the company soon advanced the technology considerably:

"The engineering input was pretty cursory 'cookbook' design. We can reasonably claim that we were pioneers in the geotechnical aspects, applying the standard soil mechanics approach, but then extending it into the field of plastic membranes to the point where it became a science. The questions of stability and shear of materials with low friction angles and prevention of stretching and puncture of liners under big heaps were solved with dramatic results. I think that we as a company understand the relationship between plastics and earth materials and have the in-house capability of doing geosynthetic engineering as well as anybody in the world."[19]

To date, KL Inc. has been involved with some 800 acres of such heap-leach facilities, and its staff have written a number of technical papers on this subject.[20]

As this work progressed, however, it became increasingly difficult to work in the United States from a Canadian base of operations. Staff members crossing the border became familiar to American immigration officials, and they were often harassed. In one case, Harper went through a one-hour interrogation.

Partially because of these difficulties, but more directly as a result of increased business in the United States, in 1987 the company decided to reopen a KL Inc. office in the United States.[21] Once again the question of the optimum office location was considered. The mining work in which the company was engaged was scattered throughout the western United States, so that there was no particular central area. In the end, the Seattle area was chosen, in part because it has a large airport with good connections to all points in the U.S. and which, unlike the Denver and Salt Lake City airports, suffers few closures from winter weather. But the primary reason for the choice of Seattle was that the city is within a two hours' drive of KL's Richmond headquarters. This fact meant that the Seattle office would be able to bring down personnel from the B.C. office for work on various American projects. (And, somewhat unexpectedly, since the Seattle office's inception, the reverse process has also resulted, with a number of Americans working, from time to time, on Canadian-based projects.)

Thus, in August 1987, Tom Harper as manager, Robert T. Tape, and J. Andrew Leach, moved to Kirkland, Washington to open a Klohn Leonoff Inc. office in the metropolitan Seattle region.[22] Tape, an M.E. (civil-geotechnical) from the University of Alberta, had been a project engineer with Ripley, Klohn & Leonoff from 1971 to 1973. Afterwards he gained considerable project and management experience with other firms in northern British Columbia and Alberta. In 1985 he had rejoined KL as a senior geotechnical engineer. Leach, who had been with KL since 1981, was a Ph.D. graduate in engineering geology from the Universities of Manchester and Leeds who had worked with Harper in the Calgary office doing pit-slope and heap-leach designs.

Landusky heap-leach, stage II construction, Little Rocky Mountains, Montana, July 12, 1991.
Photo: Roy Mayfield

In 1988, its first full year of operation, the new U.S. office generated a gross revenue in excess of $1 million.[23] Full-time staff increased to six in 1987, to fourteen in 1988, then to twenty-one in 1989. This moved the regional manager to report at the beginning of the latter year that, "A dedicated and enthusiastic team of professionals is being developed in Seattle with an eye to client service, quality, and business development."[24]

And, at the end of 1989, the chairman reported to the board:

"Our Seattle operations, under Tom Harper, have become far more successful than we had originally expected, although they are still highly vulnerable to swings in the mining industry, as this is the major client. Steps are being taken to diversify . . . , but this will take time and hard work."[25]

At the outset, as indicated by Klohn's remarks, the Seattle office was heavily dependent on the mining industry. But the lesson learned from KL Inc.'s Denver operation—the danger of relying on a one-industry base—was not forgotten. In 1987 a water resources capability was added to the team with the hiring of Robert A. Montgomery, a civil engineering master's graduate from the University of Washington with three years of experience in hydraulic and hydrologic engineering. This work was in turn backed up by Ernest Portfors, who in 1988 spent an appreciable amount of time in this Western Region U.S. office.

Indeed, the U.S. mining industry did soften in mid-1990.[26] In order to diversify into a broader civil field, Clifford N. Williams was engaged as division manager of Civil Engineering. A graduate of the Royal Military College Kingston (1966) with a M.E. from the University of Alberta (1970), Williams has twenty years of experience in water resource, municipal, and construction engineering, five years of this experience in California.[27]

Another staff change occurred at the end of 1990 when Andrew Leach, manager of the Mining Division, returned to his native England. He was replaced by Roy T. Mayfield.[28] Mayfield, after obtaining his bachelor's degree in civil engineering from UBC, served as a geotechnical engineer with KL from 1980 to 1984 and returned to the company, after experience elsewhere, in 1988. He has had a dozen years of experience on earth dams, waste impoundments, heap leaching, road embankments, landslide remediation, building foundations, and seismic studies in British Columbia, California, Montana, South Dakota, and Washington.

With a staff ranging from fifteen to twenty people, the U.S. operation has been successful in developing a diversified range of jobs in mining, water resources, geotechnical, and general civil engineering, as well as providing services in environmental and reclamation work.

What are the advantages and problems for a Canadian-owned corporation working in the United States? Ernest Portfors views it as a mixed prospect:

"My attitude is that we cannot afford not to be in the U.S. British Columbia especially is subject to its wild ups and downs. Having an office in the U.S. helps us to provide a hedge to points in time when the Canadian market is not very good. There is lots of competition; nevertheless the western United States is still a very large market, California alone being as large as Canada in population. Our success in the States has been largely in working for international mining companies. In fact a lot of them are Canadian companies that are now working on properties in the States. So that has not been a problem. But the U.S. operation takes a lot of effort. Even between Vancouver and Seattle [135 miles] the cultural differences are really amazing—the attitudes of people are different and we have different accents. For us to succeed in general work in the States means that we have to have more Americans on staff. And if we are going to truly succeed, my personal viewpoint is that we have to have an American president of KL Consultants Inc."

Tom Harper, originally a New Zealander but someone who has spent twenty-two years of his working life in various regions of western Canada and the United States, provides perhaps a broader, more neutral outlook:

"I'm a Johnny-come-lately Canadian. A lot of Canadians, perhaps a majority, seem to have a prejudice against the U.S. and what goes on there; and it's largely an uneducated prejudice. Yet the Canadians, I think, suffer from being little brother next to the big brother of the United States. When I've lived in the U.S., people I have dealt with on the job and off the job, as neighbours and so on, are as friendly and nice and supportive a bunch as you'd ever want to work with.

"The longer that you live in the United States, the more you realize that there are enormous differences across the country—all sorts of different ethnic backgrounds and, to some degree, all the extremes of politics that you could find anywhere in the world. The immigrant population there is a high percentage of the total population, but the U.S. 'melts down' all of these people into being American. Whereas in Canada a lot of people remain in ethnic enclaves.

"People have a preconceived notion that the United States is bigger, and faster, and better. I think the U.S. people, by and large, are a little less conservative and more apt to take risks than Canadians are. But I don't believe that there are a lot of differences at all. The only drawback in being a non-local is simply lack of local knowledge and local contacts with people. The differences between living on either side of the border are really not great and, if anything, it's more a matter of philosophy. I've had to ring a few bells to wake people up to the fact that hey, we in Denver and we in Seattle are in a different country, and things are done a little differently, and if we don't do it exactly the way it's done in B.C., it's not because we're striving to be different, but because we're striving to look more American. This may sound funny coming from a New Zealander, but we have to try hard to fit into the market that we're in and service the clients who are in a different country and not try to impose Canadian standards on them. It's not a big issue, but it's a subtle thing and we have to keep working at it."

Chapter Thirteen

REORGANIZATION AND RECESSION

The years 1980–81 witnessed the most vigorous period of growth in Klohn Leonoff's history until that time. The total volume of work handled during 1980 grew to \$6.5 million, up from \$3.9 million in 1979, an increase of 67 percent. In 1981 there was a further increase of 52 percent, bringing the total of work billed to \$9.9 million.[1] By year's end the number of staff exceeded the 200-person mark. The expanding work load and the increased complexity and scope of the projects were placing severe demands on the company's business operations. At this time, too, in order to survive in an increasingly competitive and sophisticated marketplace, the company's principals recognized that the firm would have to change from a small, close-knit group having a human face, to a more impersonal corporate enterprise with greater emphasis on efficiency and "the bottom-line." Consequently, accelerated plans were begun to restructure management, revise accounting procedures, and develop a completely new computerized Management Information System (MIS). Although expensive, the new system was considered necessary to provide the base for a larger, more diversified, efficient and profitable company in future years. Symbolic of the changes, in June 1980 the corporate name was condensed from Klohn Leonoff Consultants Ltd. to Klohn Leonoff Ltd.[2]

An initial step in these changes was the striking of an Accounting Computerization Committee.[3] The existing ten-year-old accounting system was outdated and unable to provide the up-to-the-moment financial information needed to effectively manage the company and its diverse projects. What was envisioned and eventually achieved is called an "Integrated Project Management-Time Accounting System." From an operational perspective this system provides the project managers with all the financial information (time, disbursements, overhead) they require in order to complete their projects within the budgets contracted with clients. Simultaneously, once the input data has been entered, the system provides the accounting information (accounts receivable and payable, and general ledger) and financial reports that management requires to control the assets of the company, and to report to legislative authorities.

The organizing meeting of the Accounting Computerization Committee was convened on December 6, 1978, and the first working meeting was held January 24 and 25, 1979. Members of the committee were C. E. Leonoff, R. P. Benson, M. T. Olsen, E. A. Portfors, D. M. Davison, and R. S. Melling, representing the executive, engineering, management, and accounting functions of the company. Melling was appointed chairman and secretary. Dr. Herbert Spencer of Western Management Consultants, a computer systems specialist, was engaged to do the conceptual design for the new system. After a series of meetings with the committee and other key staff members, and a review of the company's operations lasting several months, Spencer's report was completed and submitted to KL management for review in November 1979. The principal subjects he had studied were project cost and schedule control, accounting functions, and management information reporting. Other topics considered were present and future technical computing requirements, marketing activity, word processing, and records-keeping. One of the options considered was the use of an "off-the-shelf" time-accounting system, a program already available in the marketplace. The implementation of such a system might be quicker and less costly. However, on the project management side, a system tailor-made to the requirements of the firm was considered a preferable choice.[4] The projected start-up date for the new system was January 1981, with complete implementation by December of that year.

Concurrently, the Engineering Committee, under the supervision of Robin Charlwood, the company's in-house computer specialist, was undertaking engineering program development and considering hardware options that would involve an appreciable investment in an engineering computing system.[5] In order to provide an independent assessment and co-ordination, Charlwood was asked to review Spencer's report, and thereafter he also took an active role in the work of the Accounting Computerization Committee. Ronald F. Grigg, a staff member and UBC civil engineering research assistant, was named "computer systems co-ordinator" and asked to prepare standard input forms and output reports, under the guidance of Melling and Charlwood. On December 19, 1979, in a brief to the company's Management Committee, Charlwood presented a general computer systems development plan, concluding:

"I believe that the recommended plan, which is basically an implementation of the recommendations of Dr. Spencer, will achieve the company's objectives. The development plan has minimized the capital investment . . . and spread the development of the software systems for both management and technical computing over a two-year period in order that it can be affordable.

"These recommendations clearly represent a major investment . . . both in terms of direct expenditures and in terms of temporary diversions of senior staff resources. I have therefore summarized . . . an overall cost benefit analysis of this proposal. It appears that the Management Systems will lead to considerable cost savings, although not of the magnitude suggested by Dr. Spencer. From a technical point of view I believe there is a very strong incentive to proceed with the plan in terms of maintaining market competitiveness."[6]

Following Charlwood's presentation, the Management Committee tabled the report for further consideration.[7] And under "other business" Klohn advised that an "Executive Committee" had been formed "to co-ordinate and maintain tighter control of the company's operations."[8]

The first meeting of that Executive Committee was convened on February 4, 1980, and it was composed of Earle J. Klohn, president and chairman; Cyril E. Leonoff, executive vice-president; Ray P. Benson, vice-president, engineering; Earl W. Speer, vice-president, business development; and Don M. Davison, vice-president, Alberta. John H. Saldat, a senior man with thirty-five years of civil engineering experience would soon assume the position of vice-president of project management and would also join the committee.

The Executive Committee was to meet monthly, and it was to act as the management vehicle to direct and control all facets of KL's operations in Canada and the United States. Klohn hoped that the committee would provide a decision-making body that could take action quickly "as required for the efficient and effective running of the company's affairs," and that it would co-ordinate and monitor all offices "to ensure that the company policies are followed." Further, admonished Klohn:

"The Executive Committee is intended to provide a forum for frank discussion of all aspects of the company's operations and performance . . . and ensure that all senior company executives are pulling together towards well-defined common objectives. Differences of opinion are expected and indeed are invited. However, once a consensus has been achieved, all members of the committee will be charged with giving their full support to the group decision."

The Executive Committee was to be directly responsible to the Board of Directors "for all its actions and its performance."[9]

Recognizing the need for high-level accounting input and tighter budgetary control, especially with the impending design and implementation of the MIS system, one of the first acts of the Executive Committee was the unanimous passing of a resolution "that the company hire a controller who would be responsible to C. Leonoff."[10] Until a controller was on board, it was felt that the launching of the new computer system should not proceed too far. Nevertheless, it would take a full year before a suitable candidate was selected and in place.

At this point in time, Klohn Leonoff had definite plans to expand even further—geographically, in dollar volume, and in the scope of its activities. Tentative steps had been taken to manage this growth—review of the accounting and computer systems, and the formation of the Executive Committee—but was this enough? For the first time in its three decades of history, on the recommendation of Leonoff, the company sought an outside, independent review of "the organization[al] structure and approach of management to ensure that [they] will be effective for an expanded organization." In May 1980, John C. Witt, managing director of Western Management Consultants, was engaged to conduct this review.[11] The terms of reference for his assignment included interviews with all members of the Executive Committee and other key members of the organization. Such interviews would be "aimed at obtaining an objective impression of the way in which the organization functions now, any inadequacies that exist, and any improvements required to prepare . . . for future growth."

On October 7, 1980, Witt presented his preliminary report to the Executive Committee, who accepted in principle the corporate structure it recommended, a structure which was to be in place on January 1, 1981.[12] The gist of Witt's recommendation was that the corporate and regional office functions be separated. The corporate officers would be Klohn, Leonoff, Benson, Speer, and Saldat. Joining the corporate officers on the Executive Committee would be the regional managers. These were to be Don Davison of the Calgary office, David Wilson, who in June had been hired as vice-president and manager of the Denver office, and Ernest Portfors, manager-elect of the Richmond office. On October 30, 1980, KL's Management Committee was formally disbanded, since the functions formerly handled by that committee had been taken over by the Executive Committee.[13]

At this same meeting, a five-year growth target for the company was established. By 1985 Klohn Leonoff was projected to comprise a staff of over 400 persons. The distribution of said staff was to be 200 in Vancouver, 100 each in Calgary and Denver, and 20 in the corporate office. KL would concentrate its activity on the resource centres of western North America, where the company had established offices. Secondary consideration would be given to developing work in the remainder of North America, and offshore on a selective basis.[14]

Four general "goals and objectives" for Klohn Leonoff were articulated. First, the company would seek to enhance its stature and reputation as a high-technology engineering organization by continuing to update and improve staff and facilities. Secondly, KL would continue to provide clients with the company's traditional, specialist consulting services in geotechnical engineering. Thirdly, the firm would endeavour to expand its engineering practice to encompass larger projects where the firm would act as project manager, providing a wide range of services which included investigations, designs, preparation of contract documents, and supervision of construction. Finally, KL would try to operate as a self-sustaining organization with a congenial working environment, thereby providing individual staff members with opportunities for professional and personal growth, challenge, and competitive income.[15]

Witt would continue to work with the Executive Committee in the ensuing months to define responsibilities, prepare job specifications, set standards of performance, and arrange accountability sessions for the committee members and divisional heads. The organizational structure of the regional offices was also revised. The largest, the B.C. Region, would be comprised of seven divisions: Office Services, Geotechnical, Water Resources, Mining Services, Special (Technological) Services, Heavy Civil, and Major Projects. The divisional managers, in addition to their engineering knowledge, would receive training in accounting, business development, and interpersonal skills.

In January 1981, regular division managers' meetings were instituted, with their respective regional managers attending, in order to define management regulations at the regional and divisional levels and to develop responsibility matrixes similar to those developed for the Executive Committee.[16] Today these meetings continue within the B.C. Region on a weekly basis, acting as a communicating, co-ordinating, and problem-solving forum. In turn, there are divisional staff meetings at the engineering-operating level.

Another organizational change made at the time was that key technical people (Olsen, Morrison, Maartman, and Charlwood) were relieved of their line-function duties and designated as "staff consultants"; this so that they could devote all of their time to in-house technical advice and review.[17] By May 1981, Witt could advise that "the new management organization was generally in place."[18] And in December, the president was able to report to his Board of Directors that, "In future no-one will be able to hide from success or failure. . . . People's job responsibilities are becoming increasingly clearer. Future production will have considerable effect on salaries. Benefits will go to the producers."[19]

The management structure established in the early eighties by KL's senior principals in consultation with John Witt has remained basically in place until the present, with only minor adjustments made from time to time as staff has changed, and the company has continued to grow.

By any measure, 1981 was a milestone year for Klohn Leonoff. During May and June, open houses were held in both the Richmond and Calgary offices to celebrate the company's thirtieth anniversary.[20] In a year-end message to staff, Klohn declared that "the year . . . was a turning point for the company with regard to corporate structure and organization." Klohn called for a strengthening of the company's three principal offices—Calgary, Richmond, and Denver—and concluded his message by stating, with considerable justification, "It is evident from the dramatic growth of Klohn Leonoff over 1981, that we are on the right path."[21]

Robert Hart
Photo: Cyril Leonoff

During the same period, implementation of the engineering computer programs was proceeding apace; Ray Benson reported to the Executive Committee in May 1981 that fifty-three programs were in place, along with user manuals.[22] At the end of the year, a company "Computing News" report stated:

"Considerable attention has been given to our engineering computing. Computer use has increased . . . as facilities and support services have improved and as engineers have become more familiar with the PRIME system.

"Our hardware capabilities have . . . been upgraded with a second terminal for engineering computing. This seems to have greatly reduced the frequency of shoving matches outside the terminal room door. These terminals are on a dedicated line to the PRIME, but can also be used to access computer bureaus such as Multiple Access or UBC via the Data-Pac Network. Our Printronix printer spews out results at the astonishing rate of 300 lines per minute, eclipsing all previous company records. It can also do high-resolution plotting. We are setting up an interactive plotting program so that anyone will be able to produce a custom plot of their data in short order. Better than squinting over a sheet of graph paper!"[23]

Klohn's approval of the "right path" being taken by KL during 1981 had one notable exception. The Accounting Computerization Committee and its advisors had barely limped through the previous year. In sharp contrast, by March 2, 1981, when the new controller, Robert H. "Bob" Hart, came on staff, the two "frontline" systems were already well advanced. The conceptual design for the project information system had been virtually completed, and a lot of the programming done. The conceptual design of the overhead system, that is the program that would provide management with the costs of running the business, was well under way.[24] The accounting input was long overdue and would now be provided by Hart.[25]

Upon the accession of Hart, Bob Melling became manager of the Office Services Division, but then left the firm in mid-1983 during the economic downturn.

Robert Henry Hart, like most of the principals of the company, has deep Prairie roots. His grandfather, born in Quebec of French (Alsace Lorraine) ancestry, had come west in the late 1880s to become one of the original settlers in the Red Deer district of Alberta. Robert's maternal grandfather, born in New York, was part of the great Irish immigration to the Eastern United States in the mid-nineteenth century and, in the 1890s, settled as a coal miner in the Crowsnest Pass of Alberta. Robert's father, who became a CP railway engineer (engine operator) was born in Red Deer in 1904, as was Bob in 1943.

Bob Hart completed his university entrance requirements while still in Red Deer. His initial career choice was law, but he had taken some accounting courses in high school and liked them. Checking with some local accounting firms, he found that rather than taking a university program (commerce with an accounting option), he could go the "slave route," working for a public accountant firm during the day, completing correspondence and evening courses after work. His parents "didn't have an awful lot of money," according to Hart, and, under the circumstances, he found the "earn while you learn" program very attractive. So, says Bob, "I decided to pursue that [course]. Been doing it ever since." Prior to this decision, Hart had played hockey "quite seriously" in the junior hockey league in central Alberta, seriously enough that he thought of applying for a hockey scholarship and furthering his education in the United States. However, given the intensity of the chartered accountant program, Hart was obliged to drop out of hockey. He later coached a minor league team in Alberta, and resumed playing when he came to the West Coast, at first competitively, later in recreational and "old-timers" hockey.

Hart spent five years articling with two public accounting firms in Calgary, obtaining his C.A. in Alberta in September 1967, and in British Columbia in March of 1968. After graduating, he moved to the Okanagan office of one of these firms:

"I was interested in public accounting and knew that I still had an awful lot to learn. It was a small practice, working for small businesses and exposed me to working directly with clients. Looking back, it was good for my career development—very, very difficult to make a living in the Okanagan Valley in those times, but good experience."

Seeking advancement in his work, for the next two years Hart worked for a large international accounting firm based in Vancouver, but in the end didn't feel that public practice was his optimal career.

Unsure what to do, he tried industry, and for the next eight years he worked for a steel manufacturing and construction firm. Enjoying it but seeking a different long-term career, through Western Management Consultants, Hart came to Klohn Leonoff:

"What attracted me, first of all, was that it was a good medium-sized firm, about 175 people, an aggressive expanding firm growing very rapidly at that time. But more than that, I was looking for a career in industry where we were masters of our own destiny, where we, not somebody else, were making the decisions that affected our future. And I thought KL provided me that opportunity, and looking back, it has."

Upon his arrival at KL, Hart found that, with a few exceptions, "the quality of the people in accounting was poor." The systems were "seriously out of date," although the firm was acting to correct that situation. In expediting the new MIS there was an organizational problem of "too many cooks." The Executive Committee, especially the regional managers who would be using the information, were fussy about the kind of output data produced. (Eventually the system would spew out over 100 accounting, project, and financial reports.) The designers of the system, Spencer and Charlwood, were "good conceptual people," but not accountants or managers. The accounting staff had little computer experience, and they, along with the programmers, were charged with implementing the system.

Nevertheless, by mid-1981, the new accounting organization was basically set. The Computerization Committee was chaired by Hart, and his committee members were Judy C. Matilda, the accounting supervisor, who had joined the KL staff in 1978 following previous employment as office manager of a major British Columbia contracting firm, and Keith B. Funk, an engineering technologist engaged in the application of computers to engineering analysis. The chief programmer was Sue Rhodes, a contract employee.

There were, however, several questions yet to be resolved. Chief among these was whether the accounting system should be centralized in the corporate office or decentralized in the regions.[26] The regional managers were opposed to centralization because, as stated, this was "contrary to the intent of the new management system." In reality they feared losing any degree of control to accounting. Hart strongly favoured centralization in the corporate office:

"At the time I came, they were decentralizing the accounting. Within the head office there were both a corporate accounting group and a region accounting group. Calgary had its own accounting group. Denver, which was a very small office, really didn't have much of anything, but the objective was that if it were to grow, then it would have its own accounting group. I felt that the new system, combined with centralization and an upgrading of the competency of departmental staff, would permit us to perform the function with fewer people and at a lower cost. If there was any blessing to be gained from the [following] recession, we down-sized to a central core group—myself, two other ladies, and a few clerical people. As we built back up, we stayed with the centralized nature of the beast and added quality people. And I think we've become much more efficient and cost-effective in doing that."

Hart was correct. At its peak, accounting staff totalled twenty-three persons in three offices. Today, with the MIS operational and a staff of eleven, half the people handle twice the business. No accounting is done in the regions now, with the exception of one employee in the U.S. office who does some project work and billing because of the different laws operating in that country.

Even with Hart on board, eighteen months were to pass before the MIS was fully operational. Time and again throughout 1981, the completion date was delayed. That December, the president reported to the board that, "The MIS computer system has been a source of constant annoyance and disappointment for the whole year because of cost over-runs."[27] In January of 1982, because the Computerization Committee was having difficulty reaching decisions, and management of the project was considered poor, Cyril Leonoff was made project director, with Spencer directly under him as project manager. By the beginning of April 1982, Leonoff was able to report to the board that "the management group of MIS had been completely reorganized," and that "tremendous progress has been made."[28] Under the new committee structure, implementation and operation of MIS had become a corporate responsibility directly under Hart. Judy Matilda had been named implementation co-ordinator. In-house user-training sessions had been established. Beginning in May, the MIS was brought on-stream in stages and was fully operational by October 1982 when Leonoff finally reported to the board, "We have reached the light at the end of the tunnel."[29] Initially, the MIS was run using an off-premises, time-shared service, but at the end of 1985 an in-house PRIME 2250 computer was leased and continues to process the MIS data today.

On April 1, 1988, Judy Matilda became the company's controller responsible for providing all financial information within the firm. Under Matilda are the financial accounting group headed by Eileen Smith, the corporate accountant, who came on staff in October 1981 after experience with a construction firm, and the operational accounting group headed by Caroline Lewis, which does the project-related work. There are also a number of data input clerks for the MIS.

There is no doubt that the birth pangs of the MIS were painful and the costs high—half-a-million dollars, about equally divided between outside and internal costs. It was a huge expenditure for the firm, particularly since implementation of the system came at the beginning of the deep recession of the eighties. The basic structuring of the system is complex, requiring a substantial amount of clerical and machine time to input and process data, and thus the high fixed costs, especially at reduced staff levels. (Designed to serve a staff of 300 to 500 people, it is more cost-effective at higher levels.) But ten years later, the MIS has proven its worth, continuing to effectively serve the organization with up-to-date financial information of all types.

In October 1982, a "Corporate Committee" composed of Klohn, Leonoff, and Benson was established[30] to meet on an "as required" basis. Speer joined this committee in July 1984 when he became manager of the B.C. Region.[31] This was the genesis of what became the senior policy-making body of the company. In 1987 this committee would be reconstituted, expanded, and formalized to meet on a regular schedule.[32]

In 1987 Robert Hart became vice-president of finance as well as secretary-treasurer of the company.[33] Hart sits on the expanded Corporate Committee, at the senior level of the company, responsible for the financial side of the firm. (He also serves on the Executive Committee, which remains the senior operating committee within the firm.) His role is to ensure that all the financial aspects of the operations are attended to, which can range from working with managers in setting project goals, to meeting capital expenditure requirements, to ensuring adequate returns to shareholders.

Engineers have traditionally been wary of people who are not knowledgable in their particular field of expertise. How has Hart, a professional accountant operating at the upper echelons of the company, gained the confidence of an engineering group?

"They're a tough, demanding group to work for. Generally they are very skilled, very intelligent people. But many of them are not good communicators. And they are unique in feeling that they want to handle all aspects themselves. The key to working in an engineering environment is that one must prove [his/her] worth. When you say you're going to do something, you must do it on time and it must be done correctly. You don't get too many second chances. If you don't do it quickly and well, they'll reject you and simply bypass you.

"I think I have the respect and the trust of the senior people within this firm and the majority of engineers at the middle-management level as well. I believe I also have good communication capability with them. And given that, I have a certain amount of freedom to do what I think needs to be done within the accounting and financial side of the firm. And they respect my abilities and permit me to do that, accepting that I will keep them informed and seek their approval when I feel it's necessary."

On July 1, 1981, recognizing that the 1980s would be a decade of rapid change, a strategic planning group was convened, composed of Klohn, Speer, and Benson. The group's focus was to be on long-range planning, which was considered to be of increased importance as the company expanded into large multidisciplinary projects. Consequently the company intended to take a more structured approach to planning than had been done in the past. Klohn proposed to extend the concept into overall business development planning, and into yearly plans for each region.[34]

In January 1981, Douglas James Watts had been appointed as an interim "outside" member of the Board of Directors, a position confirmed at the ensuing Annual General Shareholders' Meeting (AGM).[35] However, effective November 1981, Watts also accepted the position of vice-president of marketing in the corporate office,[36] replacing Earl Speer, who had been vice-president of business development and who was now fully engaged in the U.S. operations. Watts's terms of reference included responsibility for strategic planning, assessment and general development of markets, and monitoring of the marketing program. Day-to-day business development would remain the responsibility of the regions, although Watts would assist on "major opportunities." Earl Speer had done the "door knocking" in Calgary and was doing so now in the Denver office.[37] In the B.C. Region, Keith Douglass had done the business development work through the 1970s until his retirement, and he had been succeeded in this role by George Mathias, a retired contractor, and John Austin, a professional engineer and former B.C. government employee.

With his broad marketing experience, in consultation with Klohn and Witt, Watts was charged with launching the program during 1982. In mid-February 1982, Watts presented the framework of a Strategic Management Plan, which received approval in principle from the Executive Committee. Strategic management was defined as "a systematic process, planned and executed by general management, involving all responsible line and staff managers, which assures future continuity, survival, and profitability of the firm." The three basic ingredients necessary for fulfilment of the plan were to be sound planning procedures, effective organizational structure, and good internal and external "intelligence" systems. The plan would be tailored to fit the company's "mission," as well as the "personal values of senior management." With the worsening economic situation, in addition to addressing long-range planning, action plans were organized for "immediate attack on all sources of work."[38]

Watts proceeded with this operation through 1982. However, with the downturn of the economy, towards the end of the year strategic planning was "de-budgeted" and indefinitely postponed, such that marketing dollars could be concentrated on "the short-term."[39] After closure of the Denver office, Speer returned to Canada at the beginning of 1983 as vice-president of corporate marketing. And Watts remained on the board as an outside director.[40] At the end of 1984, the Strategic Planning Committee was reconstituted under Speer, with representation from the regions.[41]

With the Executive Committee now operational, in October 1981 it was agreed "that the Board [of Directors] generally should remove itself from day-to-day operations and act as a policy-setting and review group."[42] The board, elected by and responsible to the shareholders, retained the formal responsibility of electing the corporate officers.

In May 1982, a Buy-Sell Agreement, drawn up and trusteed by the company's legal firm, had been executed by the company and the major stockholders to define the conditions, terms, and method of valuation of Klohn Leonoff

Ltd. stock in the event of termination, retirement, or death of a stockholder.[43] And, later that year, the other stockholders signed Subscription Agreements to the original agreement.[44] With the increased number of common shareholders (there were thirty on record at the AGM of April 5, 1982), to allow more flexibility in transferring of shares under the B.C. Companies Act, KL was changed from a non-reporting to a reporting company. (A reporting company can approve any change of status in stocks by a majority vote of shareholders, rather than the approval of every shareholder required in a non-reporting company). Section 211 of the Act required that a reporting company appoint, from among its directors, "an Audit Committee composed of not fewer than three members, the majority of whom are not officers or employees of the company." Because Watts at this time was an "inside" director, another "outside" director was needed on the board. Consequently, in 1982, Washington Derek Wilks was elected to the board. Until his retirement in 1979, Wilks had been Manager of Sales, Pacific Region for Canadian Pacific.[45]

In December 1982, the board appointed J. W. Burrows, W. D. Wilks and C. E. Leonoff to form the Audit Committee,[46] with Burrows as chairman. The committee first met on February 21, 1983. The principal "watchdog" role of the committee was to review the audited financial statements of the company and to recommend their acceptance to the board.[47] The committee was also intended as an arbiter between management and auditors on questions such as financial reporting, and, indeed, one of the first acts of the Audit Committee was to recommend opening the audit to competitive proposals.[48] As a result of that recommendation, in 1983 Thorne Riddell (now Peat Marwick Thorne), under its Richmond audit partner Malcolm F. Clay, became the company's auditors,[49] replacing Deloitte Haskins & Sells, who, along with their predecessor the Winspear Company, had been the company's auditors since its inception. Because of changes to the B.C. Companies Act requiring more onerous reporting, in 1989 Klohn Leonoff reverted to a non-reporting status. Nevertheless the Audit Committee has been retained. Wilks retired from the board in April 1986, and current Audit Committee incumbents are J. W. Burrows (chairman), D. J. Watts, and the executive vice-president, E. W. Speer. In the period 1989 to 1991, Patrick Kinsella replaced Wilks on the board as an outside director.[50]

In 1984 the Board of Directors was streamlined to include three inside directors—the company's chairman, president, and executive vice-president—and the three outside directors.[51] The shareholders' director (who had been consecutively, K. R. Gillespie, L. E. Rodway, and M. L. Parsons) was dropped, because it was considered that shareholders had their own forum for input at the AGM and other ad hoc meetings. The vice-president of finance serves as secretary to the board. Thus the current board is evenly weighted between the inside directors, whom chairman Earle Klohn effectively utilizes as a sounding board for the company's goals, and the outside directors, who serve as contacts to the general community in the company's business, marketing, and political strategies.

When a company is in a growth mode, the requirements for office space become a critical element in the forecasting process. KL management over thirty years had seen many swings in the economy, with resultant rapid increases in work load, often followed by equally rapid decreases. From 1978 onward, expansion in the mining, water resource, and highway sectors required the leasing of more bays, as they became available, in the existing building at Airport Executive Park. As of December 1, 1980, 22,000 square feet were occupied, about double the original space.[52] In January 1981, office renovations were completed at a cost of $200,000 for building and furnishings.[53]

In 1981, however, additional space was suddenly required to accommodate the design teams for two newly won major projects, the Quebec-Cartier mine and the B.C. Rail Tumbler Ridge line, and again the question arose as to whether the company should proceed with the purchase or leasing of a new building. The Executive Committee prudently decided to "attempt to expand within the present building," or to "rent temporary space."[54] A project office of 8,200 square feet was leased in an adjacent building,[55] resulting in Klohn Leonoff then occupying some 30,000 square feet. In 1983, in the midst of the recession and with these projects nearing completion, the company was able to renegotiate with the landlord to terminate the lease on this extra space, confirming management's wisdom in not committing the company to fixed long-term premises.

Charles Ripley, office Christmas party, 1953.
Photo: Lars Anderson

KL Ninth Annual Golf Tournament, 1987 foursome, from left: Myles Parsons, John Burrows, Beverley Schroeter (guest), Steve Ahlfield.
Photo: Brian Leach, Rich Colour

At the APEGGA Annual Meeting, Banff, Alberta, May 1980, from left: Earl Speer, Don Davison, Earle and Lorna Klohn, Dorothy and Ken Gillespie, Evelyn Speer.

Santa and his elves, from left: Manon Deshaies, Malcolm MacFadyen, Sharon Dulmage, Bruce Broster, Richmond, December 17, 1982.

Former Winnipeg office staff members, from left: Alex Kuluk, Elsie Leknes, Paul Janzen, Chris (Andrusiak) Scott, Mike Saxton, celebrate the marriage of Elsie and Paul, Winnipeg, 1988.

During this same period, social and recreational activities were not neglected at KL. Company Christmas parties are of record as early as 1953. In 1979 the first golf tournament was organized at the instigation of Ray Benson, the company's all-time golf champion, and Letta Lewis, its newest recruit. However, as the company grew in size, these activities became more formalized. In September 1980, the Executive Committee authorized Leonoff to proceed with formation of the Social Club,[56] which in December 1981 became the responsibility of the B.C. Region.[57] Events sponsored by the Club soon included a curling bonspiel at the Richmond Winter Club, the third annual KL golf tournament, the first annual company picnic in Ladner, the first annual KL Hallowe'en extravaganza, and a children's Christmas party, held in the Richmond Inn. Evenings of softball during the summer gave way to the 'CyKlohns' hockey team and evenings of social skating during the winter.[58]

After a period of dormancy, owing to the recession, at the beginning of 1989 the Social Club was rejuvenated. The reason was reported to the board: "Judging from the old days the Social Club had a very positive impact on employee morale and working atmosphere, and its activities served very well as a vehicle through which the company personnel could get to know each other."[59] Today, according to B.C. Region manager Peter Lighthall, the Club's "spirit still exists" on an ad hoc basis, including the annual golf tournament, and softball, volleyball, and soccer games. The traditional year-end dinner and dance is arranged and sponsored by the corporate office.

Social activities in the Calgary office were highlighted by the annual Christmas dinner dance and the summer barbecue held at "Don's Ranch" outside of the city.

Five major projects were to dominate the first half of the 1980s for Klohn Leonoff: B.C. Railway's Tumbler Ridge Branch Line tunnels in northeast British Columbia; Quebec Cartier Mining Co. tailings disposal near the Quebec-Labrador border; the Maduru Oya reservoir in Sri Lanka (Chapter 11); Ok Tedi tailings disposal in Papua New Guinea (Chapter 11); and the Forty Mile Coulee Irrigation Reservoir in Southern Alberta. The decision that Klohn Leonoff had made in the seventies to expand the scope of its engineering services from "specialist" to "generalist," and to diversify geographically, had borne fruit, and indeed served to carry the company safely through the worst recession experienced in its history.

With Japanese contracts secured to buy 6.5 million tonnes of metallurgical and 1.5 million tonnes of thermal coal per annum, early in 1981 the governments of British Columbia, Canada, and Japan made the final decision to proceed with development of the coal fields in northeast B.C. The $3 billion development involved two coal mines, a 129-kilometre B.C. Rail branch line, the town site of Tumbler Ridge, and loading facilities at Prince Rupert, making the project the largest industrial undertaking in the history of the province. Governments believed that this visionary scheme would open up one of the last wilderness regions in the province, create much needed long-term jobs in the coal mining and shipping industries, and ultimately impact beneficially on the logging and metal mining industries as well.

The Tumbler Ridge Branch Line was to be only the third rail crossing of the Canadian Rocky Mountains, and the greatest engineering challenge of the project was the tunnelling necessary to lay track through some of Canada's most arduous terrain. Not since completion of the Connaught Tunnel in the Selkirk Mountains in 1917 had the railroad industry in Canada undertaken such an ambitious project.

In January 1981, Klohn Leonoff Ltd., as lead consultant, in association with Canadian Mine Services Ltd. and Dolmage Campbell & Associates (1975) Ltd., were engaged to undertake final design of the tunnels. High mountain field work (to heights of 2,000 metres), which involved helicopter-supported geological and diamond drill crews, was completed in 1980, and confirmed that of seven alternate locations the Table/Wolverine alignment was the most economical and expeditious route. The two main tunnels along this line would be the nine-kilometre-long Table Tunnel and the six-kilometre-long Wolverine Tunnel; as well, there would be two shorter tunnels 252 and 352 metres long. Predicated on the need for quick coal delivery, an unyielding construction-completion date of December 1983 was set, only two years after the start of final design.

The geology of the area is composed of sedimentary rock, mainly limestone, dolomite, and quartz, greatly faulted and folded. Therefore, design of the tunnels depended on sound geological interpretation of the complex stratigraphy, combined with a heavy dose of savvy drawn from extensive engineering experience. Problems anticipated during construction were snow and mud slides, major thrust faults, water-bearing rock, highly stressed rock, and the presence of hydrogen sulphide (H_2S) gas (owing to the proximity of sour-gas fields).

Completion of the project within the tight schedule called for some innovative design and contractual methods. To encourage flexibility, construction methodology was left open to the contractors, and all contractors on the tunnels wisely chose drill and blast methods, using high-speed hydraulic drilling technology. Although tunnel boring machines (TBM) could have been effectively used, they were rejected on the grounds that, given the absolute completion deadline, any major breakdown or other difficulty with a TBM could have led to unacceptable delays. The first blast took place in mid-March 1982. With the aid of custom-built drill jumbos equipped with pairs of hydraulic drills operating at three levels, a maximum advance rate of 59 feet was achieved in the best day, and 345 feet in one week.

B.C. Rail Tumbler Ridge Branch Line, Wolverine East Tunnel, 1983.
Photo: Raymond Benson

Although geological conditions encountered underground were similar to those predicted from the surface investigations, progress of the work was occasionally impeded by zones of water-bearing karstik limestone. In cases where this condition led to large inrushes of water, gravity drainage, combined with pumping, was used. Bolting, grouting, and shotcreting were applied intermittently to the tunnels where faulted and fractured rock was encountered. Steel sets were installed at the portals and in weak ground. As well, one kilometre of highly stressed rock that produced bursting conditions required special excavation and support systems. Noticeable amounts of H_2S gas were encountered in excavating the Wolverine Tunnel. This required use of gas-detection monitoring devices and special ventilation for workmen's safety. Although some 800 men participated in the construction, not a single life was lost in the tunnels.[60]

An interesting sidelight to the tunnel design was the ventilation system. The initial design stage included a traditional tunnel ventilation system for cooling, and to flush out diesel exhaust fumes generated by up to six 6,000-horsepower locomotives pulling ninety-eight coal-hopper cars.[61] However, after studies, B.C. Rail opted instead to electrify the tunnels and to use diesel/electric motive engines. Thus the Tumbler Ridge Branch Line became the first heavy (50 kV) electrified line in Canada, and only the third such railway in the world.

During construction of the tunnels, a comprehensive project schedule was prepared and monitored on a regular basis. Klohn Leonoff's A. R. "Sandy" McDonald, with thirty years of experience on heavy civil engineering projects, many of them located in remote areas involving difficult logistics, was the project director. The tunnels were completed in November 1983, on budget and one month ahead of schedule. Ray Benson, KL's principal-in-charge of the project, received a personal letter from Premier Bill Bennett inviting him to participate in the official opening in June 1984:

Province of British Columbia

April 11, 1984

Mr. R. Benson
Klohn Leonoff Ltd.
10180 Shellbridge Way
Richmond, B.C.
V6W 2W7

Dear Mr. Benson:

In February 1981, contracts were signed which set in motion the largest industrial and transportation initiative in British Columbia's history: the North East Coal and Transportation Development.

In less than three years, this massive construction project was completed. Coal was being shipped from two new mines across new and upgraded rail lines to a new port. Over 3,000 people were living in the new town of Tumbler Ridge and new highways and power systems were in place.

During the first week of June, people from around the world are invited to join with the many participants in marking this achievement. For those of us in British Columbia, it is more than an official opening. It is an integral part of a determined international thrust to earn our way by competing on world terms.

It is my sincere hope that you will be able to attend.

Yours sincerely,

W. R. Bennett
Premier

Parliament Buildings Victoria British Columbia V8V 4R3

On October 6, 1984, Sandy McDonald was in attendance at a "gala awards ceremony" in Ottawa, accepting the Canadian Consulting Engineering Award of Excellence.[62] The award was presented by Governor General Madame Jean Sauvé, and Sandy accepted on behalf of the designers of the B.C. Rail Tumbler Ridge tunnels.[63]

Gala awards ceremony

Sandy McDonald, P.Eng., accepts the Award of Excellence for Klohn Leonoff's work on B.C. Rail Tumbler Ridge Tunnels. Presenting the award is Governor General, Madam Jean Sauve at the Annual Gala Awards presentation in Ottawa. Klohn Leonoff Ltd., founded over 30 years ago in Vancouver, has emerged as a premier tunnelling consultant with an international reputation for tunnel engineering. One of the company's most recent successes in Canada is the Tumbler Ridge branch line tunnel — a vital access route to British Columbia's northeast.

Governor-General Jean Sauvé presents the Canadian Consulting Engineering Award of Excellence to Sandy McDonald on behalf of the designers of the B.C. Rail Tumbler Ridge tunnels, Ottawa, October 6, 1984.

Credit: The PEGG, February 1985

In July 1978, Earle J. Klohn issued a memorandum to staff concerning the Quebec Cartier Mining Company (QCM):

"I am pleased to confirm that Klohn Leonoff have recently obtained a major engineering assignment to investigate, design, and supervise construction of a major tailings facility in the Labrador area of Quebec [at Mount Wright]. The project is . . . [of] the same general order of magnitude . . . as our current Reserve Mining assignment in Minnesota.

"Your company is extremely pleased with being selected to carry out this work and believe that it is a further indication of our growing reputation in this field. . . ."[64]

The procurement of a major job in Quebec was indeed a breakthrough for a British Columbia firm.

The concentrator at the open-pit mine, which began operation in 1976, was designed to wet-process 123,000 long tons per day of iron ore—50,000 of this as iron concentrates. At this rate, ore reserves would be ample for some eighty-seven years of production. Once milled, the concentrate is transported by rail to Port-Cartier on the St. Lawrence River. The remainder is tailings in the form of fine to medium sand, with a small fraction of the fines extending to colloidal sizes. An important feature of this mine is that the colloidal fraction of the tailings imparts a red colour to water, even in diluted concentrations. The Mount Wright area drains into relatively fast-flowing rivers that enter important salmon spawning streams such as the Moisie River, a tributary of the St. Lawrence. Although the water colouration is not toxic, the mine is required to precipitate the red colloids from any water that is released downstream.

In this remote region, the original tailings disposal scheme was, to say the least, rudimentary. The tailings were simply pumped to the top of a nearby hill and permitted to discharge down the natural slope. It was anticipated that the tailings would deposit at a stable, but relatively steep angle of repose. Below the toe of the deposition area is Hesse Lake, used to store runoff water from the tailings. Although the mine process reclaims as much water as needed from the lake, there is a net surplus of water which must be stored in the lake by a low dam at the outlet, clarified, then released downstream at a controlled rate. However, by the time KL arrived on the scene, the site was a mess, with the uncontrolled tailings running down the hillside into the lake, thereby reducing its storage capacity.[65]

John Saldat, right, KL's project manager, with Earle Klohn, reviewing design drawings of Quebec Cartier Mining tailings facility at Mount Wright, Quebec, ca. 1980.

Initially, conceptual and economic studies were commenced to provide solutions to the dual problems of confining the tailings and storing the water over a twenty-five-year period. From 1980 to 1983, Klohn Leonoff was engaged to undertake the management of four separate works. First of all, to confine the tailings, a 25-metre-high, 4,000-metre-long tailings dyke was constructed incrementally on an annual schedule, using hydraulic sluicing methods. Secondly, the Hesse Lake Dam, a closure dam to confine the tailings runoff water, having final dimensions of 38 metres in height and 1,600 metres in length, was also built incrementally to meet the storage requirements of the rising tailings pond. While this is a conventionally constructed earthfill dam, for reasons of economy, the bulk of the earthfill is composed of tailings sand. As well, a reinforced concrete, gated, skimming-type outflow structure was designed and built to handle rising levels and seasonal surface ice on the water storage pond. Finally, there was the construction of a 400-man camp and catering facility.[66]

John H. Saldat, KL's project manager was well equipped to manage these jobs. A 1946 mechanical engineering graduate of the University of Saskatchewan, he was a former president of Crippen Acres Ltd. in Winnipeg who supervised numerous major power and heavy industrial projects, and a project manager for Atomic Energy of Canada Ltd. on nuclear power plant construction in Argentina.[67] (Saldat retired from the company in December 1987, but continues to act as a staff consultant.) Walter Shukin, experienced in tailings disposal, was the project engineer. At the apex of the design work in 1980, the QCM project office in Vancouver had a bilingual staff of thirteen, supplemented by a field staff of half a dozen, along with a survey crew. All documents were prepared in both English and French.

The "political" aspects of the assignment were as arduous as the technical problems, as attested to by Bryan Watts:

"I worked on that exciting project for a couple of years. We were still looking at how we were going to develop the tailings deposit. So we had to deal with these challenging technical problems. But there was also the challenging issue of getting along with our Quebec client, who really resented having an English-speaking group give them advice on a mine in Quebec. Their attitudes have changed greatly since then, but at that time nationalist feelings were running pretty strong in Quebec.

"I regret that I'm not bilingual, because I could have used it to advantage in Quebec. In high school I took four years of French (including one year of conversational French), but our French training in high school doesn't serve us very well—certainly it doesn't allow one to be bilingual. It wasn't that much of a handicap, because most of the people there were bilingual. But I think we would have got along much better on the job had we had a French person in a prominent position. A lesson to be learned perhaps."

Quebec Cartier Mining Company Tailings Dam A, upstream view showing outlet box, Mount Wright, Quebec, June 1, 1989.
Photo: Victor Sowa

Progress on the job was somewhat erratic. Most of the design and initial construction work had been completed when the recession hit and QCM began to cut back. They maintained a working relationship with Klohn Leonoff long enough to complete KL's portion of the project. In 1983 KL was virtually expelled from the project, and the client brought in another engineering group from Montreal to do much of the site work. However, in 1985, QCM returned to KL in nearly penitent fashion, asking the B.C. company to become involved again because of ongoing problems on site. Since then Klohn Leonoff has continued its involvement in the project on an annual basis, reviewing the progress and safety of the completed works.

For Klohn Leonoff, the year 1981 may be paraphrased as the "best of times" and the "worst of times." By any measure, it was an unusual time. The company began the year in the midst of strong economic growth, but ended the year caught squarely within an economic downturn that would result in the most severe recession in North America since the end of World War II. While 1981 was a busy year, in which the total volume of work rose from $6.5 to $9.9 million, conversely, it was also a year in which large expenditures were needed to do extensive staff recruitment, to expand plant facilities, and to restructure the management systems. While revenues had increased by 52 percent, these extraordinary costs, amounting to nearly three-quarters of a million dollars, reduced net profitability by 68 percent.[68] The remaining profit had to be returned to the company as retained earnings to help finance operations. By the end of 1981, the steps taken to consolidate the company's position in the marketplace, steps instigated by managers in an expansive, optimistic mood, had, with scant warning, suddenly placed the company in distinct jeopardy.

In the president's year-end message to shareholders, Earle Klohn placed the blame squarely:

"Entering 1982, we are faced with a Canadian economy that is in a stage of severe decline. . . . During the last few months of 1981 Canada's economy remained volatile, responding erratically to the many forces acting on it. These included such items as: a faltering world economy, particularly in the U.S.A.; high interest rates; [and] continuing high inflation rates. . . . Finally, as year-end 1981 approached, the Canadian economy collapsed, unable to withstand the combined negative impact of the National Energy Program and the Federal Budget, and headed into a serious nosedive that is still under way. . . ."[69]

On the operational side of the company, Ernest Portfors, managing the B.C. Region, at the first board meeting of 1982 expressed his recriminations:

"August 1981 was a big month, September and October much the same, but the slide downwards started in November. We did not respond quickly enough . . . when we saw what was happening. This was a serious management error. We should have seen it sooner. We had been through an extremely busy year. We had hired a lot of staff at considerable recruitment costs, and were reluctant to start chopping. At that time no-one realized that the recession was coming as quickly or going to be as deep as it has turned out to be."[70]

On the other hand, Don Davison, manager of the Calgary office, was more sanguine:

"The economy in Alberta is stumbling but has not yet reached the proportions experienced in B.C. . . . Calgary is looking forward to a good year in 1982, providing we concentrate on the areas where financing is available. . . . The principal market areas, which are strong, are the provincial and municipal governments, and the coal mining industry. . . . We are receiving several local contracts for light-rapid-transit (LRT) construction [including] foundation investigation and materials inspection. We have submitted a number of proposals in the coal industry, and have been successful in obtaining a feasibility study for [a] tailings dam siting and water supply . . . for Fording Coal. . . We are doing some work . . . in the tar sands area, involving dam siting and storage of wet and dry tailings. . . . Our major . . . project is Forty Mile, which is provincially funded. There was a major scare last week . . . a controversy between Alberta Environment and the St. Mary River Irrigation District regarding who was going to purchase the land. This has . . . been resolved and Alberta Environment can now proceed to approve the final design of the project. We have built a . . . good project team and . . . will be transferring staff from the B.C. Region to reinforce the team."[71]

The Calgary staff had reached a peak of forty-five people and, with the addition of six to eight B.C. staff members, was bucking the general trend.[72] The Heritage Fund, created in part for such a "rainy day," was pumping money into the Alberta economy and undoubtedly mitigating the effects of the recession, at least temporarily. The Forty Mile Coulee irrigation project, on which Klohn Leonoff would do the design and construction management, would prove to be one of the largest projects in the company's history, lasting (with some delays) for the remainder of the decade.

Similar to Alberta, there was some optimism still being felt in the U.S. operations. The Denver office was unusually busy during early 1982, submitting proposals for several projects. This optimism was, however, soon to fade. By October the projected work load was "dropping dramatically," needed staff had plunged from twelve to four people, and the operation was "hanging on by [its] little finger."[73] A decision to close the office by the end of the year was made in November "because of the worsening economic picture in the U.S. mining industry."[74] Only a "shell" would be retained in the United States for "potential future work."[75]

The most extensive company cuts were required in the largest operation, the B.C. Region. With the very survival of the firm at stake, management had no choice but to be ruthless in controlling costs, and particularly in terminating people who, in a professional services business, represent the highest cost. Discretionary spending was halted, but fixed items such as office space, equipment, and cars could only be reduced over a period of time. All staff were ranked as to their value to the company, and the "soul-wrenching" experience of laying people off began. The assessment was made that the region could reduce to a core of fifty people without seriously impairing the long-term technical capacity of the firm, and by the end of 1982, B.C. staff was reduced to half of its 1981 peak.[76] By applying such drastic measures, at year-end, the president was able to report a small profit to the directors:

"We have survived a very difficult period and have maintained our financial integrity. . . Because of our cost-cutting measures we have developed a more efficient and cost-effective organization which will increase our competitiveness. Management have clearly demonstrated that they are capable of 'biting the bullet' and instigating the necessary cutbacks to prevent large capital losses . . . during the economic low."[77]

The nadir for the company came during 1983. Leonoff set the tone when he pointed out to the board in April that "1983 could be a very tough year. . . In 1982 we had work carried over from the previous year, but [this year] there is a lag effect between old work petering out and obtaining new work."[78] Indeed the company's work on Quebec-Cartier had been largely terminated, the Tumbler Ridge tunnels would be completed by the end of the year, and the Maduru Oya project in Sri Lanka (Chapter 11) would soon be winding down. Additional work on the Forty Mile Coulee project was delayed pending a decision by the Alberta government to proceed with construction.

The company took further extraordinary measures to reduce expenditures. There was a continued reduction in discretionary expenditures; leases were renegotiated to reduce fixed overheads; further reductions in staff ensued (from a peak of 235 in 1981, to 81 during 1983); salaries were reduced (members of the Executive Committee took the largest cut, to half-salary), as were fringe benefits; and the work week was shortened.[79] Despite these efforts, income dropped by 35 percent from the previous year, to $6.2 million, resulting in the largest net loss in the company's history—$389,000.[80] Klohn, in his annual message to shareholders, explained the reasons:

"As anticipated, 1983 has proved to be a very difficult and frustrating year for the consulting engineering profession in both Canada and the U.S.A. As the year progressed it became evident that although the recession had technically bottomed-out and general economic conditions were improving, this was having little effect on workloads for consulting engineers. . . . Large debt positions, coupled with high interest rates, did irreparable damage to many companies. . . . Industrial capacity was greatly underutilized during the . . . recession [and] most organizations have placed their top priority on using any profits . . . to reduce debt rather than expand plant. Unfortunately for consulting engineering companies, who depend heavily on capital investment for their workload . . . from the resource sector (mining, oil and gas, pulp and paper, hydroelectric developments, etc.) . . . this has meant a continuance of very poor markets for their services, despite a recovering economy."[81]

With an unemployment rate hovering at close to 40 percent throughout the recession, consulting engineering in British Columbia seemed to be the worst hit of all the professions.

The bottom of the cycle was reached by the end of the "disastrous" first quarter of 1984—books were showing a $200,000 pre-tax loss in the Canadian company.[82] With a touch of humour gained only in hindsight, Ernest Portfors has recounted his stewardship of the B.C. Region during this period:

"When I took over the job as manager, the region had 100 employees. In August of 1981 we peaked at 156. And when I left to go off and do project work in 1984–85, we were down to 55 [just above the worst-case scenario total of 50]. So I was infamous as being responsible for adding 50-odd people to the payroll, then taking off about 100."

Don Davison, managing Alberta, was in a similar dilemma. He was working a three-day week and participating in the UI workshare program, with a staff total reduced to sixteen—an operation not large enough to generate sufficient fees to cover salaries and operating expenses.[83]

Portfors, now (1991) the company's vice-president of engineering, compares his 1981 stint as people manager to that of his later role as project leader:

"When you are leading a project team, you have technical goals to meet and you say this is what we have to do, and you get on with it and do it. Being a manager, I personally think is a very difficult job. You really have to be attuned to personnel-related problems. It is one thing to go out and hire people. But when you have to cut them out of the payroll, knowing that for a lot of them it is really a personal crisis, it is a darn tough job. I did it but I can't say that I liked it. . . .

"In retrospect, I think Klohn Leonoff did well. It was painful for everybody. We cut a large number of staff, but we kept the majority of the key staff we wanted to keep. We cut everybody's salary and the management people, of course, [were] cut more than anybody else. But we held [the company] together and, when things started to improve, we still had our core of people that enabled us to carry on and expand again."

At the beginning of 1984, President Klohn told the shareholders that he was "cautiously optimistic" that an economic upturn would occur during that year:

"Everyone should realize that once the bottom of the cycle is reached the company still faces a difficult . . . recovery from the losses of both staff and revenue suffered on the way down. Moreover, we are not anticipating a return to the halcyon days that preceded the current recession. Rather, we expect competition for engineering assignments to remain very keen, with only the most innovative and efficient companies succeeding in a very cost-conscious environment. This means that . . . survival in the changed marketplace will require continued effort from both management and staff to reduce operating costs and increase efficiency. . . . It also means that we must continue to strive for technical excellence and remain near the leading edge in those technologies that relate to our marketing strategies."[84]

The years 1984 and 1985 marked a watershed period for Klohn Leonoff. While annual income leveled off at $5.1 million—the low point of the decade—the efficiency measures had taken effect. Through the remainder of 1984, the company was able to make up the first-quarter loss for a near break-even year,[85] and in 1985 to show a profit that recovered three-quarters of the 1983 loss.[86] The turn-around in the company's fortunes came as a result of international work, which Klohn and Leonoff had pursued so actively in the early seventies. This time, however, such work came about not through planning, but virtually by chance.

In January 1984, Klohn received a communication from Amoco (a U.S. firm) asking KL to propose a tailings scheme for a mine on the Ok Tedi River in Papua New Guinea (Chapter 11). The contact with Amoco had been made by Earl Speer in Denver. Klohn Leonoff responded by sending a team of senior staff to the site, and by July, Klohn was able to report to his board that a contract was won for the first stage of investigation and design:

"This is a very high profile project and everyone [around the world] knows about it. Our success relates to our expertise in sand cycloning. [Also] we were successful in getting the job because we had the senior staff available."[87]

Reinforcing the mood of cheerfulness, director John Burrows remarked, "We appear to be getting ready to ride the next wave."[88]

By October Klohn was more confidently able to predict that "the worst is over for Klohn Leonoff, but . . . recovery will be very slow and difficult [and] survival will require running a very efficient and cost-effective operation over the next several years."[89] For KL the Papua New Guinea job was the turn-around point of the recession, and indeed for the survival of the company. Representing 30 percent of the revenue for the B.C. Region in 1984,[90] by the time of completion in 1987, the project had brought in some $7.7 million in fees. It represented the most significant component of a trend within the company whereby, as the domestic work load diminished, Klohn Leonoff expended more and more effort in developing foreign work to fill the gap. These efforts were rewarded to the extent that 60 percent of the total revenue in 1985 was generated outside of Canada—10 percent in the United States and 50 percent in foreign work outside of North America.[91]

On March 31, 1985, fundamental change again came to the stewardship of KL when Cyril Leonoff ended thirty-three years of service to the company. The previous five years had been particularly gruelling for all the company managers—unprecedented growth, management reorganization, and a great recession had followed hard upon one another. But by the spring of 1985, the company was emerging from the recession. Leonoff had just passed his sixtieth birthday and had always intended to retire at that age. There were other interests in life that he wished to pursue, including photography, a university course in history, and a writing career. He had also served on two Vancouver civic advisory boards—the City Planning Commission, and the Development Permit Advisory Panel—and he was at the time chairman of the Heritage Advisory Committee. The new management structure was in place and operating efficiently. Leonoff's successors, Earl Speer in management and Bob Hart in finance, had been carefully chosen and were well prepared. To Leonoff, it seemed the appropriate time to leave.

The customary retirement presentations were held in both the Richmond and Calgary offices. Later, at a company reception attended by the directors and members of the Executive Committee, Earle Klohn spoke to the assembled crowd:

"We have gathered here tonight to honour Cyril Leonoff, a founding partner in our company. . . . In his early years . . . Cyril was involved almost exclusively in the technical side of our practice, utilizing the training he had received at the University of Washington, where he had earned his master's degree in civil engineering. However, as the consulting practice expanded, Cyril became more and more involved in the business management and development aspects of our work. . . . Most [present] members of the Board of Directors associate Cyril with the business end of our [firm] and his incisive criticism of those of us who sometimes lost track of the fact that the practice of consulting engineering is, after all, also a business.

"Cyril was also noted for his dry sense of humour, which he displayed in fine form at a recent Vancouver office get-together held in his honour. At that time, Cyril outlined some of the record achievements he had set during his many years with the company. As I recall . . . two of these . . . were:

"Most late morning arrivals at the office—a record already being challenged by one of our senior staff members.

"Most lunches with girls from the office—a record which I believe is unlikely to be ever beaten.

"Whereas I can't really disagree with these claims to fame by Cyril, I do think that I would be remiss if I did not touch on a few of his other achievements [in] legal, financial, civic, and political matters. These ranged from partnership agreements to articles of incorporation . . . and included such things as pension plans, insurance of all kinds, staff and client contacts, [and] civic affairs. For many years Cyril . . . pleaded our case with the federal government, and I might add often with success.

"Whereas all of these achievements are important, from my personal point of view, Cyril's most important contribution to the company's success was his constant availability to me as a friend, advisor, critic and confidant on all aspects of our consulting practice. Needless to say Cyril, I will dearly miss you in these areas."[92]

And it could be truthfully claimed that, over three decades of a close working relationship, the two partners had never had a serious dispute.

After five years of dissociation, Leonoff returned on assignment in 1990 to research and write the story of Klohn Leonoff. In 1991, he was elected to a seat on the board as an outside director.[93]

By the beginning of 1985, there were stirrings of new work in British Columbia: low-level radioactive waste containment in the municipality of Surrey and at the CN Rail yard near the Port Mann Bridge; waste management on Indian reserves; geotechnical investigations on the Coquihalla Highway, a major new route through mountainous terrain into the south-central interior of British Columbia; and, later in the year, preliminary engineering design on various tunnel and open cut alignments in connection with upgrading of the Squamish Highway along the precipitous mountain slopes of Howe Sound. Minor assignments continued for different mining companies: Cominco, Brinco, Lornex, Placer, Quebec Cartier, and Teck Corporation. Yet the volume of domestic work continued to be small, and the B.C. Region was largely sustained by overseas work.[94] Financially, 1985 concluded as a profitable year,[95] but only because of the strict cost control measures that had been applied to all facets of the operations.

The Alberta Region was the first to break out of the domestic recession. In 1985 the Calgary staff doubled to thirty-five people. Ten of these people were working on materials testing projects, including two Light Rapid Transit (LRT) lines for the city of Calgary. Five Calgary staff were attending to the jobs of the Western U.S. Region, which included Reserve Mining, and six heap-leach projects.[96] But the major work was in the water resource sector—the Old-

At the official opening of B.C.'s Coquihalla Highway, Premier William R. Bennett, left, presents a citation to Ernest A. Portfors, president of the Association of Professional Engineers of British Columbia, acknowledging the contribution of professional engineers to the design and construction of the highway, May 16, 1986.

man River and Forty Mile irrigation projects.

The Oldman River Dam[97] is located near the town of Pincher Creek, Alberta, where the dam provides flow regulation and on-stream storage of a dependable water supply for irrigation and multipurpose uses. The reservoir, 24 kilometres long and 2 kilometres in breadth at its widest point, has a surface area of 2,420 hectares at full storage and operates through a drawdown depth of 54 metres. The reservoir area, adjacent to the Rocky Mountain Foothills on the west, is in the Alberta Plain physiographic region of rolling hills.[98] Geologically of the upper Cretaceous and Tertiary ages, the site is composed of gently dipping, interbedded sandstones, siltstones, and claystones which contain weak, presheared bedding planes. The Oldman River and its tributaries have cut down through these relatively soft rocks to form steep-sided valleys.[99] Another significant feature of the site is that it is located in one of the windiest parts of North America, with gale velocities reaching 150 kilometres per hour.

Klohn Leonoff's sub-consulting assignments on this project have all concerned various aspects of the reservoir's stability. The company was first asked to establish the "boundary line" around the reservoir—that is a safe line beyond the perimeter of the reservoir which defines the limits of the land that could become waterlogged, unstable, or erodible. The banks of the reservoir are under high shearing stresses during rapid water drawdown. As well, they are subject to erosion by high waves generated by fierce winds. For these reasons, the area of land between the high water line and the boundary line was to be purchased by the government.

Link-H Bridge over Oldman River, Alberta, summer 1989.
Photo: Thomas Murray

A second assignment related to the bridge crossings of the newly formed reservoir—four in all, plus a pipeline crossing. Two of the bridges were to be constructed, each at a cost of $10 million, the existing CP Rail bridge was to be relocated, and the provincial Highway No. 3 bridge crossing required stabilization. The latter was a particularly tough geotechnical challenge. Under the new conditions formed by the reservoir, because of the residual pore-water pressures in the abutment slopes during rapid reservoir drawdown, and the presence of the weak bedding planes in the underlying bedrock strata, the factor of safety for the existing bridge abutments was inadequate. Anchored retaining walls were chosen as the means to stabilize the abutments. Multi-strand anchors, complete with double erosion protection, were grouted into the bedrock to anchor the retaining walls at the base level of each abutment.[100]

In 1991, no sooner was the $350 million Oldman River Dam completed and the water rising in the artificial lake behind it than it became a "reservoir of trouble." The Alberta government was accused of "the unnecessary destruction of a wild river" and a "single-minded commitment" to manage the Oldman runoff for irrigation and water storage purposes without due consideration for the ensuing environmental and socio-economic damage. The evident beneficiaries of the new dam are the city of Lethbridge—Alberta's third largest population centre—and its surrounding irrigation district, which are now guaranteed a predictable year-round water supply. The apparent losers are the Peigan Indians, whose land and water claims remain unsettled.[101]

In June 1990, Bill C-78, the Canadian Environmental Assessment Act was introduced into the federal parliament. The bill requires an environmental assessment for any project where the federal government is a proponent, provides financial assistance or federal lands, or where there are interprovincial or international implications.[102] Although the Oldman project was virtually completed, as a result of the complaints, a review by a federal panel was commissioned to assess the environmental and social impact of the project. In an appeal by the government of Alberta, with intervention from a coalition of five environmental groups, the Supreme Court of Canada ruled that the federal environmental assessment rules are constitutional. This far-reaching decision means that federal screening will proceed in more than $40 billion worth of projects—dams to pulp mills to roads—across the country.[103]

A far less controversial project, the Forty Mile Coulee Irrigation Reservoir is located between the communities of Bow Island and Foremost in the southeast corner of Alberta. Part of the historic Palliser Triangle, it is one of the most arid regions of Canada. The project derived from the Oldman River Basin studies of the late 1970s. Owing to its unique geographical location and natural topography, the coulee was selected as a giant off-stream reservoir site, storing 87 million cubic feet of water, to serve the needs of the eastern portion of the St. Mary Irrigation District.

The reservoir is formed as a result of the construction of two 28-metre-high, 600-metre-long earthfill dams—West Dam and East Dam—built 10 kilometres apart in the coulee. In addition to guaranteeing water supply for existing multipurpose uses, it allows irrigation of a further 35,000 acres of farmland. Cyclic draught patterns of water flowing into the adjacent St. Mary main canal are evened out by the reservoir. During low demand periods, unused water is directed into the reservoir; during peak periods, water is pumped back into the canal by means of Canada's largest pump station—ten pumps each draw 20 cubic metres of water per second (264,000 imperial gallons per minute). An inverted syphon, composed of twin-barrel, prestressed concrete pipes, carries irrigation water 750 metres (2,500 feet) across the coulee, replacing an old wood-stave syphon. The pump-station, inlet gates, and syphon are computer controlled and can be remotely operated by touch-tone telephone.

Commencing in 1980, over a ten-year period, Klohn Leonoff was responsible for the various phases of the project: feasibility, project planning, preliminary and final design, contract documents, construction management, commissioning, and performance monitoring. Design was carried out in association with W-E-R Engineering Ltd. and Associated Engineering Alberta Ltd.

Foundations at the dam sites are comprised of soft lacustrine clays up to 35 metres thick at the West Dam, and 60 metres thick at the East Dam. Because of the thicker and more plastic foundation soils at the East Dam, its construction was of greater concern. In fact, such a large structure built over such a thickness of compressible foundation was virtually unprecedented in Canada. Based on field investigation, laboratory testing, a test fill, and conventional "effective stress" analysis, the dam was conservatively designed with gradually sloping sides at a ratio of 8 horizontal feet to 1 vertical foot. Settlements in the order of 3 metres (10 feet) were expected, but it was considered that the resulting strains could be safely absorbed by the glacial-till dam without rupture.

Construction of the dams was staged over a two-year period, from 1986 to 1987, and the reservoir was filled to full supply level in 1989. During construction, the West Dam performed as expected, but the East Dam proved more problematic than anticipated. However, precautions against such an occurrence had been taken. One hundred and seventy-six internal and sixty-six surface monuments were installed and monitored continuously as the dam and reservoir were raised, measuring pore-water pressures, as well as vertical and horizontal movements of the dam and its foundations. Don Davison, the principal in charge of the dam, was able to react in calculated fashion:

"I don't think this dam could have been built fifteen years ago with the soil mechanics knowledge of that time. You do your investigation and come up with a design, believing that you have done it all right. But the key is that last step of getting the field data during construction. The soil was much more plastic than we thought and the pore pressures so high that the centre of the dam was essentially floating on water. The field instrumentation picked that information up for us. By correlating the dam analysis with the measured performance (using a finite element computer program), we could determine remedial methods by such means as raising the dam and reservoir more slowly, flattening the slopes, or building stabilizing berms."

As a result of the observational methods, berms, which act as buttresses or counterbalances, were added during construction to both the upstream and downstream toes of the dam. These enabled safe raising of the embankment and reservoir to full height on schedule and on budget.[104]

The $55 million project was operational and commissioned in 1988. Don Pettey was the project manager and Bill Chin the resident engineer responsible for performance monitoring. For Klohn Leonoff, it was the company's largest project undertaken in Alberta, with fees amounting to $7.7 million.

Unlike its Oldman Dam counterpart, and unlike the earlier Dixon project, the Forty Mile reservoir, funded by the Heritage and Savings Trust Fund and administered by Alberta Environment, has been a model of co-operation among government, the local residents, the general public, and environmentalists. From the beginning, local residents have been consistently involved and have worked hard to support the fulfillment of the project. According to Davison: "We had absolutely no problems with any of the farmers and landowners. They really wanted this project. They were always interested, would come around to see the construction and would bring their neighbours and relations who were visiting."

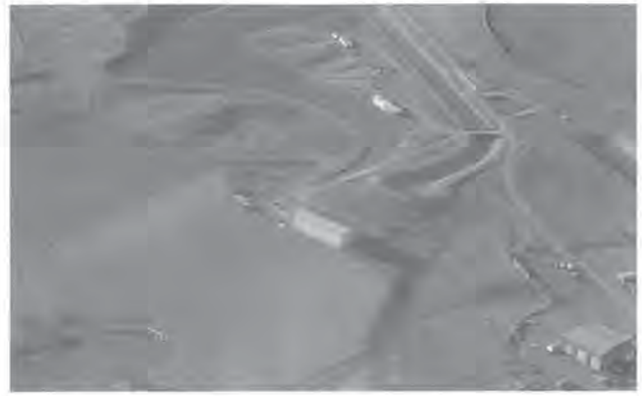
As explained by Davison, the reasons are not difficult to discern:

"Before irrigation, with dryland farming and using hardy wheat, they were lucky to get one annual crop off. Now they are getting two and three crops of alfalfa, they're growing beans, they're growing corn, and a variety of other crops on this land. So the dollars that they are making per acre have increased tremendously. A farmer will pay '*X*' dollars per acre, is allowed so much water for that, and can take the water off whenever he wants [to obtain the optimum crops]. There is a lot more work for the farmers because irrigation is a pretty intensive operation. But some of them have more time on their hands than they used to. It has turned out even better than they had hoped for. An added feature is a good recreation lake—the only lake in that area. I was down there a couple of times when the lake was forming, and there were also people from Lethbridge and Medicine Hat there, to boat and fish in the lake."

Indeed the intense green of an irrigated field of alfalfa now stands in sharp contrast to the nearly moonlike features of the previous landscape. And the Forty Mile Coulee Irrigation Reservoir offers other attractions to local residents

Forty Mile Coulee Irrigation Reservoir, St. Mary Irrigation District, Alberta, commissioned 1987–88.

Inlet Chute showing the first flow into the reservoir from the St. Mary Canal.
Photo: Donald Pettey



Pump Station. Water enters the intake structure, left, where it is lifted by ten pumps to the outlet canal, right.
Photo: Paul Ardell

Inverted Syphon. Twin-barrel prestressed concrete pipes carry irrigation water 750 metres across the coulee, under construction August 1984.
Photo: Donald Pettey

and visitors beyond the storage and management of water. A viewpoint provides visitors ample opportunity to observe the site. A 7-metre-high recreation dam forms part of a park facility on the south shore of the reservoir which includes a boat launch, swimming area, as well as camping and picnic facilities. Environmental enhancement includes increased habitat for migratory waterfowl and the construction of a walleye-rearing pond to facilitate the creation of a viable sport fishery in the reservoir. The mapping and excavation of archaeological sites have also been undertaken throughout the project area. And an interpretive centre is planned, which will focus on the history and growth of irrigation in southern Alberta.[105]

During the mid-1980s, in order to diversify an economy heavily dependent on oil, the government of Alberta set out to establish a world-class forest industry. Projections called for world demand for paper products to double within the next twenty-five years, especially in Pacific Rim countries like Japan. While traditional sources of wood pulp were dwindling world-wide, central and northern Alberta were blessed with 350,000 acres of boreal forest containing tamarack, spruce, pine, poplar, and aspen, species which hitherto had been regarded as "weed trees." (The United States and Japan had developed the technology to economically convert hardwoods, such as aspen, into lightweight coated paper.)

An aggressive marketing campaign by Alberta to attract investment resulted in numerous offers from international corporations to install large-scale pulp/paper facilities. Four of these proposals were accepted by the government, together with expansion programs for three existing pulp mills. The seven projects and future expansions, in concert with significant investment in new sawmills, lumbermills, strandboard and fibreboard plants, are expected to eventually (over a twenty-year period) generate $3.5 billion in private capital investment, $2.2 billion in forest production, $1.5 billion in taxes and royalties, and 12,000 jobs. Owing to its international expertise in this field, Klohn Leonoff has participated in six of these projects as geotechnical subconsultant to the prime contractors.[106]

In 1990 three key staff members of Klohn Leonoff retired from the Calgary office: Ken Gillespie and Lloyd Rodway, both at normal retirement age, and Don Davison. Davison was only fifty-seven years of age at the time, yet he had been with the company for thirty-six years (1954–1990). Starting out as a technician, Don had eventually achieved the position of vice-president and manager of the Alberta Region:

"I went from one field assignment to another field assignment. I was quite happy getting those, even at the sacrifice of personal things, because of the challenges and the experiences. When I reached a goal, I was given new, more challenging work. The last one was Squaw Rapids Dam—very interesting geotechnically, with a variety of precedent-setting problems. And being in Saskatchewan, far from home base, I had a lot of responsibility.

"From there I went on to Winnipeg. I have often wondered whether I got Winnipeg because no one else would go. I was only thirty-one at the time, which is relatively young to have that responsibility. There I was given the opportunity to manage an office—not just management of staff, but also management of projects. So it was a good combination between engineering and management. Being in the Prairies has allowed me to do that. I consider myself a very conservative manager. Probably my staff and others think that I am too conservative. Right from the beginning in Winnipeg, I found out that break even in those small offices is very sensitive. If you gamble the wrong way, the company can lose money. When you have a large staff, you can gamble a little bit more. But you have to make a profit; otherwise they close offices.

"I resisted going to Alberta, but in retrospect I wouldn't have done anything different. I spent twenty years there—

the longest I have stayed in any one place. And I helped build the organization there from one of strictly foundation engineers to one doing big civil engineering projects. I also enjoyed the northern work. That you might say was a different culture—certainly different from the southern.

"The way I look upon it, I'm a practical engineer. I have never been strong in theoretical analyses. But I recognized that fact and always got help when I needed it. There are many good engineers that this company has attracted. And working with them is one of the key reasons that I have spent my career here. Forty Mile was probably the most complex project around. While I wasn't doing the design, I was co-ordinating the staff who were doing it and reviewing their work. In the end, I feel that I have been involved in very interesting and challenging jobs. I set goals for myself and feel that they have now been accomplished. So it is time to retire."

While working at KL, Don, a bachelor, lived on an acreage south of Calgary. After he left the company he moved to a property near the northern end of British Columbia's Lake Okanagan, taking up the life of "something like a country squire."

The nearly simultaneous retirement of three of the four senior principals in the Calgary office (Pettey remained as manager of major and special projects) resulted in a hiatus which led to the complete restructuring of the Alberta Region. Don Davison, who retired on March 16, 1990, was replaced by Greg P. Stevens, a civil engineer and community planner who had served as a member of the Alberta Legislature. Owing to the loss of Rodway's expertise, marginal profitability, and the investment required to update its equipment, the Materials Testing Division, which since 1968[107] had been an integral part of the Alberta operation, was discontinued on June 1, 1990.[108] Following completion of the Forty Mile and Oldman irrigation projects, the $62 million Willow Creek/Pine Coulee and Little Bow River dam-reservoir projects were proposed to follow,[109] but were instead "on hold" indefinitely pending the results of environmental reviews. Nevertheless the new manager reported, perhaps over-optimistically, that "consulting engineering in Alberta remains competitive, but is alive and well and we intend to obtain our share."[110]

In the fall of the year, Stevens resigned for personal reasons and was succeeded in the spring of 1991 by L. Douglas Keil. A civil engineer trained in applied mechanics at McGill University, before joining the Richmond staff of Klohn Leonoff in August 1990 Keil had twenty-eight years of experience in geotechnical, water resource development, waste management, and heavy civil engineering projects in Manitoba, central and eastern Canada, and in Central and South America.

During this interim 1990 period, work load for a staff of less than twenty people in the Calgary office was sustained by a variety of projects. The Canmore trenchwater study involved a methodology for making municipal utility excavations in a gravel floodplain area. Five hydroelectric projects on the Taltson and Snare Rivers were inspected for safety for the Northwest Territories Power Corporation. A 13-metre-high concrete arch dam on Mark Creek supplying town and mill water for the city of Kimberley, B.C. was designed, as was the Mark Creek flume for Cominco. In addition, groundwater assessment was done for the city of Calgary, and floodplain mapping was completed for the town of Turner Valley.

Douglas Keil

Donald Pettey

Construction proceeded on Alberta pulp and paper mills built upon sites with a variety of foundation conditions. Miller Western Pulp required dynamic compaction of loose floodplain gravels. A mill for Daishowa Canada Co. was founded primarily on a gravel terrace, but some of the heavy structures had to be supported on steel H-piles driven through clay layers to bedrock. Alberta Newsprint Co. (ANC) required assessment of the dynamic properties of the foundation to support a high-speed newsprint machine on a compacted gravel pad. And Alberta Pacific Forest Industries (ALPAC) involved the placement of 1,700 cast-in-place belled caissons each measuring 1 metre in thickness and 10 metres in length.[111]

Final design of the Roseau River Dam for the St. Lucia, West Indies, Water and Sewerage Authority proceeded in 1991, and was also delegated to the Calgary office. The principal components of the work are a concrete-faced rockfill dam with plinth and parapet wall 40 metres high, together with development of the associated quarry; a diversion tunnel 200 metres long with portals and closure gate; water supply intakes with a spillway and flip bucket; and the associated project infrastructure, including office, yard, and haul roads.

Under the new management, Alberta staff has increased to thirty-two people. A strategic business development plan has been formulated for the Calgary office covering the three Prairie provinces, the Northwest Territories, and the East Kootenay Region of British Columbia. As well as services in the company's traditional fields of geotechnical and water resource engineering, the Calgary office now offers environmental engineering services in such areas as contaminated site redevelopment and recreational property improvement.[112]

Chapter Fourteen

DIVERSIFICATION

Klohn Leonoff came out of the early-eighties recession into an unprecedented period of growth and diversification—revenues began to increase steadily, from $8.5 million in 1986[1] to over $20 million in 1991.[2] The company experienced a "solid and profitable" year in 1986, with work loads remaining high throughout the year and cost controls continuing to be effective. In British Columbia the principal resource industries of pulp and paper and mining were heading into another expansion cycle. In Alberta the province was still suffering badly from low world prices for oil and gas, but with work continuing on the Forty Mile and Oldman projects, KL was doing more governmental consulting work in the province than any other firm. Most of the work in KL's U.S.A. office came via the heap-leach gold mining industry. The company's 1986 work load was constituted by projects that were 40 percent Canadian, 10 percent American, and 50 percent overseas.[3]

The same trends continued through 1987. However, with work on the two major projects, Ok Menga hydroelectric in Papua New Guinea and Forty Mile Coulee Reservoir in southern Alberta, nearing completion at the end of the year, Klohn Leonoff embarked on an extensive marketing and expansion program "to further diversify the engineering services it offers and develop a broader base of engineering work."[4] The effect of these actions would reflect positively on the company's fortunes in 1988 and beyond. By mid-year 1987, Klohn could report with some accuracy to his board meeting in Calgary: "I believe that it is correct to say that Klohn Leonoff has shaken off its small specialist company image, and is now being conceived of by both clients and competitors as a rapidly expanding, major force in the civil engineering consulting field."[5]

In order to handle the company's increasing growth and responsibilities, the corporate structure was enlarged and strengthened. Officers elected for 1987–88 were: Earle J. Klohn, chairman and chief executive officer; Raymond P. Benson, president and chief engineering officer; Earl W. Speer, executive vice-president and chief operating officer; Robert H. Hart, vice-president finance and secretary-treasurer; Donald M. Davison, vice-president, Alberta; and Ernest A. Portfors, vice-president, special projects.[6]

The management committees were also defined in 1987 and redefined as of January 1, 1991. The Corporate Committee, meeting weekly, is the senior management group that reviews all aspects of the company's operations and sets the company policies. Goals and objectives, short- and long-term planning, marketing strategies, and the overview of the company's financial operations are all within the purview of the Corporate Committee. The committee is chaired by Klohn, and its other members, as of 1991, are Benson, Speer, Hart, and Portfors.

The Executive Committee, meeting quarterly, is the senior operating group, ensuring that the company's plans and policies are followed. It is responsible for co-ordinating operations between regions and for recommending budgets, staff policies, salaries, employee benefits, major capital purchases, and any other matters for decision by the Corporate Committee. This committee is chaired by Benson, and is comprised of the members of the Corporate Committee, other corporate officers, and the regional managers.[7]

To allow Speer sufficient time for his corporate operating and marketing duties, in the fourth quarter of 1986 Myles Parsons was made manager of the British Columbia Region,[8] and in 1988 Parsons was elected as vice-president of the B.C. Region.

Expansion and diversification of Klohn Leonoff's operations took several forms. What would become the most significant long-term move came in March of 1988—the establishment of Klohn-Crippen Consultants Ltd. to serve as the firm's hydroelectric arm.

Crippen Wright Engineers Ltd. was founded in British Columbia in 1954 as a private consulting firm in the hydroelectric power development and water resources fields. Its president, Glenn E. Crippen, had worked for the B.C. International Engineering Company, a firm which had completed post-war power developments for the Alcan Kemano project and the B.C. Electric Company. Klohn Leonoff and its predecessors became involved with Crippen as geotechnical consultants on such projects as Seymour Falls Dam, the Iona Island Sewage Treatment Plant, and the Squaw Rapids Hydroelectric Development. Like KL, the company was owned by its principals and senior employees.[9] However, by the late 1970s when KL became involved in water resource project work, and Crippen had developed some in-house geotechnical capacity, an intense if friendly rivalry had developed between the two companies.

In an attempt to diversify from its sole reliance on the pulp and paper industry, H. A. Simons Ltd. had over time acquired an interest in a number of engineering, economics, and environmental firms in B.C., Alberta, Quebec, and the southern United States. By the end of 1977 these acquisitions included Crippen Consultants. The "Simons Group of Companies" aimed at providing "complete consulting services for resource development projects."[10] Their initial thrust was to develop overseas work, but if this paid off, the group would also be utilized in the future for domestic assignments. Rather than a "loosely knit" group of companies, which had proved ineffectual, the plan in 1977 was that this cluster of companies would become a separate corporation or perhaps form a legal partnership among the companies involved.

In February 1978, Klohn Leonoff was invited to hold exploratory talks with the management of Simons and Crippen to ascertain its interest in, and possible terms for joining the Simons Group. Heretofore completely independent, KL was put under considerable pressure to join a group that had, as described frankly by Klohn, "lots of money, lots of people, and lots of selling power."[11] (Simons had a staff of 2,000 people at that time.) The choice for KL was clearly delineated—either join the group or be left, in Klohn's words, "out in the cold."

For management at Klohn Leonoff there was no problem with H. A. Simons Ltd. After all, KL had a long-standing and mutually compatible relationship with Simons that spanned a quarter century, mostly in providing geotechnical services on their pulp and paper mill projects. The real problem was the overlap between Klohn Leonoff and Crippen—there were substantial areas where both companies offered clients similar services. This applied especially to Alberta, where KL had gained entrée into water reservoir projects. As well, Western Canada Hydraulics Laboratories, Ltd., a subsidiary of Crippen, had recently established a laboratory in the Denver area, and KL, too, was incipiently opening an office there (Chapter 12), so that the two companies could conceivably be competing for water resource projects in the U.S. market.

To resolve the problem, a joint negotiating committee was established to explore "possible benefits and potential conflicts" that would result from a close working relationship between Klohn Leonoff and the Simons Group (Crippen Consultants in particular), to sort out the "trade-offs," and to clearly define the scope of services and geographical territories for KL and CC. The conclusion of the committee was that the joint "technical capabilities" of the firms would make a strong combination, and that potential "mutual benefits" could be derived for geographical diversification into the U.S., Alberta, and overseas markets.[12] The negotiations resulted in the execution of a joint "working relations" agreement by Crippen and Klohn Leonoff in February 1979.[13] Thereafter, monthly business development meetings were held by the management of the two firms. The only tangible benefit, albeit a major one, to come out of this agreement was the joint venture on the Maduru Oya Reservoir project in Sri Lanka (Chapter 11).

Concurrent with the Crippen-KL negotiations, Simons wished to consummate the relationship by acquiring a "common thread of ownership" among their group of companies. After protracted negotiations,[14] a draft agreement was drawn up in which Simons would purchase 20 percent of the common shares of Klohn Leonoff[15] (although they wished to eventually acquire more). However, in the end, the agreement foundered on two points. The old-time pulp and paper group of Simons felt strongly that, for reasons of liability and responsibility to clients, they should not have a direct corporate tie with the company doing their foundation work. As well, some of the younger principals at KL were ultimately lukewarm to the agreement, feeling that they could lose control of their own destiny if a sizable block of shares was held by an outside corporation.[16] By the end of 1980, the proposed Simons agreement was shelved and the intended resource company stillborn. At this time, too, the Crippen-KL working agreement was terminated, with any future work together to be done on an "ad hoc basis."[17] The Maduru Oya joint venture, of course, continued to the conclusion of that project.

In 1986, however, a new window of opportunity was to open and bring Klohn Leonoff and Crippen together into a more binding relationship. By then Crippen Consultants was a wholly owned division of H. A. Simons Ltd.

Following KL's work on the Ok Menga project (Chapter 11) in Papua New Guinea the company felt, for the first time, that it had the potential to become a prime consultant on domestic hydroelectric developments. The British Columbia economy was emerging from the recession, and in order to meet projected domestic power needs after the year 2,000, it was apparent that the planning of new hydroelectric facilities would soon have to begin. Klohn Leonoff's strategic planning group identified this as an excellent opportunity "to build a strong hydroelectric consortium owned and operated by B.C. consulting engineers." A highly skilled, innovative, and progressive team would be required in order to compete with the established hydroelectric engineering companies concentrated in central Canada. The only other local firm with a credible track record in the hydroelectric field was Crippen Consultants, which was backed by the resources of the then 3,000-person Simons organization. Crippen-Simons management were approached, were agreeable, and the seed of Klohn-Crippen Consultants Ltd. (KCCL) was sown. In August 1986, Earle Klohn was able to report to his board that, "We perceive a real opportunity to build a prominent hydroelectric organization in British Columbia."[18]

By June 1987 British Columbia had a new premier, William "Bill" Vander Zalm,[19] and B.C. Hydro had a new chairman and CEO, Larry Bell. In order to confirm the perceived opportunity, Klohn Leonoff approached B.C. Hydro officials and the Honourable Jack Davis, energy minister in the Vander Zalm government and himself a professional engineer.[20] Left with only the remnant of a once dominant engineering department, and in view of the government's privatization policy, it became clear that Hydro was modifying its approach to future hydroelectric projects in the province with a commitment to support the province's private sector engineering professions.

Klohn-Crippen Consultants Ltd. was incorporated in March 1988.[21] The company is owned equally by H. A. Simons Ltd. and Klohn Leonoff Ltd. The stated purpose is "the business of providing engineering and project management services for hydroelectric and other electric utility power regulation, generation and transmission projects . . . in Canadian and international markets."[22] The elected officers were: chairman, Tom A. Simons; president and CEO, Earle J. Klohn; vice-presidents, Doug A. McIntosh (of Simons) and Raymond P. Benson; and secretary, R. H. Dewar. Klohn, as chief operating officer, would be devoting the bulk of his time to organizing and running the new company. In January 1989 office space was leased in downtown Vancouver to serve as the corporate headquarters and engineering offices for Klohn-Crippen.[23]

In 1988 B.C. Hydro issued a call for statements of qualifications from B.C. engineering firms interested in entering a competition for selection of the corporation's "prime hydroelectric consultant." The selected consultant would begin engineering studies and investigations in order to make "shelf-ready" B.C. Hydro's two suspended dam and power projects—Site C on the Peace River and Keenleyside on the lower Columbia River. Eleven responses were received and three candidates were short-listed. Klohn-Crippen submitted a detailed proposal in which Shawinigan Integ Inc., who have particular expertise in power plants, participated as a one-third subcontractor. The final decision in favour of Klohn-Crippen was announced at the end of October 1988.[24]

Beyond the immediate work assigned to KCCL was the "Team BC" concept, an entrepreneurial game plan whereby Hydro and Klohn-Crippen would use their combined skills and experience to win contracts abroad.[25] Larry Bell, chairman of B.C. Hydro, announced the strategy:

"The winning consortium, Klohn-Crippen Consultants Ltd., convinced us that not only could they provide Hydro with the private sector services we require for the future, but also that they will make their mark in the international field. . . . As our prime consultant in developing hydroelectric power projects, KCCL will work closely with Hydro's engineering staff sharing expertise and techniques which will enable them to become a strong competitor in the international marketplace. . . . [Indeed B.C. Hydro is prepared to work as a subcontractor, making available their

Signing of the B.C. Hydro, Klohn-Crippen Prime Consultant Agreement, from left: Tom Simons, Larry Bell (chairman, B.C. Hydro), Earle Klohn, Vancouver, B.C., October 31, 1988.
Photo: B.C. Hydro

extensive experience and knowledge of hydroelectric engineering and utilities operation.] This is a most significant boost to the consulting engineering profession of this province and we hope it will provide a stimulus to economic development here."[26]

Earle Klohn, president of KCCL, was equally confident: "With Canada moving rapidly into its important position as an industrialized and creative world leader in energy matters in the twenty-first century, British Columbia will assume a leadership role in western Canada. It will also serve as a marketing focus for the entire Pacific Rim area. KCCL and Team B.C. will create a world-class hydroelectric engineering company in Vancouver for the benefit of the whole province and for Canada. . . . We mean to ensure that B.C.-based subconsulting companies will play a significant role in providing services to KCCL so that we can share the work among the engineering profession of B.C. Also another of our corporate strategies will be to put as much work as possible into the hands of B.C. contractors and fabricators to help with their growth and technological advancement."[27]

At the end of 1988, Earle Klohn made it clear that he felt the company had succeeded in establishing itself as a major participant in the hydroelectric engineering field:

"Although we were already engaged in small hydroelectric projects such as Ok Menga, Porgera, and Tortum, the big break-through was our success in obtaining a significant portion of the Kemano Completion Project from Alcan. This was followed by Klohn-Crippen winning the competition to become the designated hydroelectric engineering designer for all future B.C. Hydro work. All in all, a very exciting year for your company."[28]

Another potential, if controversial, future demand for hydroelectric development in British Columbia is for the export of power to the energy-starved United States, particularly California. This prospect has become more credible in recent years in view of the advent of free-trade, and the dismantling of the National Energy Policy by the Conservative government of Brian Mulroney.

While it will take many years to fulfill the potential of the Klohn-Crippen organization, its four years of operation have seen considerable progress. KCCL continues to be the prime engineering consultant to B.C. Hydro, with the current contract extending to March 31, 1994. The company presently employs a staff of forty-two persons in Vancouver, but the work has been scaled back from the original projections due to several factors, chief among them a general slowdown in industrial developments in the province. As well, environmental studies on Site C by a joint federal-provincial task force have been ongoing; energy and resource conservation programs such as "power smart"[29] and "resource smart"[30] have been instituted by Hydro with noteworthy success; and co-generation with the private sector (see Kemano Completion below) has emerged as a significant development. KCCL has carried out preliminary studies on several Independent Power Producer projects in British Columbia, including a small hydro project in northern B.C. for Yukon Electric, but none have as yet come to fruition. The firm has also been working on dam safety upgrading of Cleveland and Seymour Falls dams for the Greater Vancouver Regional District. Work in the international field has progressed slowly, with a small hydroelectric job obtained in Thailand.

Major success did come in 1991, however, with the winning of Ontario Hydro's "Miscellaneous Hydroelectric Engineering" package by a joint venture named KST Hydroelectric Engineers in which Klohn-Crippen have the majority interest.[31] This enterprise, employing a current staff of forty-five persons working out of a Toronto office, has a minimum duration of nine years. The project entails dam safety and rehabilitation of existing hydro facilities throughout central Ontario. Ten to fifteen projects will be carried out each year, of which half a dozen are expected to carry forward into the construction phase.[32]

Klohn Leonoff's involvement with Alcan's Kemano-Kitimat power and smelter project dates from the company's first year—1951—when Charles Ripley was engaged by Alcan as a soil mechanics consultant. His principal assignment was at the Kitimat smelter site, and Ripley had only a passing role on the power phase of the project at Kemano. The power project involved the construction of Kenney Dam on the Nechako River, a headwaters tributary of the Fraser River (Chapter 4), and the diversion of a portion of the water westward through a 16-kilometre tunnel to an underground powerhouse on the Kemano River, with discharge into a fjord of the Pacific Ocean. To supply the energy for an eventual increase in smelter capacity, project planning and water licenses provided for future expansion of the generating facilities.

In the late 1970s and early 1980s, Alcan began to look at "Kemano II," that is developing the remaining power potential of the Nechako Basin before the lapse of their water license in 1999. By this time, however, environmental and native issues had reached an order unheard of in the 1950s, and Kemano II would prove to have immense geographical, environmental, economic, and human implications.

Crippen Consultants, with Ray Benson acting as an additional consultant, was commissioned to do a study on expansion of the existing power facilities, as well as a diversion of part of the Nanika River, to the north, a river which was also included in Alcan's water license. At the same time, Klohn Leonoff was asked to investigate a new smelter site near Vanderhoof that would utilize the power generated by the expanded facilities. However, the federal Department of Fisheries and Oceans objected to the Kemano II project on the grounds of adverse impacts on salmon stocks. Years of controversy and environmental studies followed. Finally, in 1987, a compromise "Settlement Agreement" was reached whereby Alcan would develop an

Breakthrough by Tunnel Boring Machine (TBM) of Kemano power tunnel, June 25, 1991.
Photo: Alcan

additional 540 megawatts of power (less than initially envisioned) from the Nechako Reservoir, but the Nanika River would be left undisturbed. Alcan also agreed to make scheduled releases from the reservoir to achieve fisheries' objectives downstream on the Nechako River. By 1987, however, Alcan had developed smelter capacity elsewhere and abandoned the Vanderhoof project. Instead the company opted to develop the power at Kemano and sell it to B.C. Hydro for a specified term, after which it may be used for additional aluminum smelting.

Thus, in 1988, Alcan Smelters and Chemicals Ltd. embarked on the $1 billion expansion of their power facilities now called the Kemano Completion Project, asking for statements of qualifications from private sector consultants wishing to provide the engineering services. Bechtel Canada Ltd. was appointed the project manager. Because of the enormity of the development, it was to be split into a number of packages: site services; camps and roads; environmental engineering; surveying; geotechnical engineering; the power tunnel; the powerhouse and penstocks; power transmission; and a group called reservoir structures, which included the water intake into the power tunnel, and the facilities to release water into the Nechako River. Ernest Portfors would be the principal in charge of KL's portions of the project:

"Representatives of Alcan from Montreal and Bechtel hydro people from San Francisco came to interview us at our office. We spent a day with them going through the statement of qualifications that we had submitted. Thirty of our senior technical people sat around the table and we had a bit of input from them all. We said frankly that some of the packages, such as site services and transmission, where we had no capability, would best be done by others. We truly expected that we would get the geotechnical package. [After all, the company had served as geotechnical consultant to Alcan for thirty-seven years]. We really hoped that we would get the tunnel package. A few weeks later, we got a call saying that they were giving us three packages—the geotechnical, the tunnel, and they threw in the reservoir structures as well. So we were pretty ecstatic about that."

Klohn Leonoff began geotechnical investigations in July 1988. Detailed design and construction documents were prepared for a new 5.7-metre-diameter power tunnel to carry water through the coastal mountains, from the Nechako Reservoir on the eastward flank of the divide, 16 kilometres westward to Kemano. Located in the West Coast Batholiths that begin near Vancouver and continue as far north as Alaska, the tunnel is in very "competent" granite rock and is unlined except for some soft filled-in shear joints which have been shotcreted. Two tunnel construction methods were investigated—the conventional drill, blast, and muck method, and driving with a Tunnel Boring Machine (TBM). To evaluate performance of recently improved TBMs in high strength granitic rocks, a world-wide investigation was conducted for precedential construction examples. The search also included a measure of the tunnel wall roughness coefficients resulting from the use of the particular TBM. Based on the results of laboratory tests and evaluation of the performance of a TBM with relatively high torque, use of a TBM for the Kemano Power Tunnel was considered to be a feasible and economical method. Using a TBM specially built for the project, tunnel construction began in June 1990, and breakthrough of the first half came precisely a year later. The work also involved design of the water intake structure at the reservoir end of the tunnel and a large dredging program at Tahtsa Narrows.

The Kenney Dam Release Facility, part of the reservoir structure package that was also the design responsibility of Klohn Leonoff, was to become a much more complex and interesting challenge than originally expected. The 1987 Settlement Agreement required that two conditions be met in the release of water from the Nechako Reservoir. Firstly, a minimum, base flow of water was to be maintained all year round. Secondly, cooling water was to be released during July and August to protect the sockeye salmon spawning downstream in the Nechako River. The resulting $70 million multipurpose water-release facility at Kenney Dam is, in Ernest Portfors's words, "on the leading edge of technology—probably the most complicated structure that any of us has seen." By allowing for withdrawal and mixing of the deeper cooler water in the reservoir with warmer surface water, the facility maintains suitable flows, temperatures, and dissolved gas pressures for the spawning salmon.

The design problems were multiple. First, the structure had to be built around the existing dam. Because the reservoir was already filled, two 4.2-metre-diameter pipelines had to be constructed 60 metres below the water (to draw cold water from the bottom of the reservoir), with control gates to release the required amount through a spillway system into the downstream river. Then, surface water had to be released through the same facility. Finally, in order to maintain the minimum base flow during the winter, and avoid freeze-up when temperatures drop as low as minus forty degrees centigrade, water had to be released into an existing diversion tunnel and then into the river.

As this is a "fish water release," the problem is to achieve simultaneously the required temperature and gas pressure of the water. To protect the migrating sockeye in July and August, when the river warms up quickly, the water must be cooled. But the cooler water situated at the reservoir bottom is very high in nitrogen and low in oxygen, a condition which could have an adverse effect on the fish. Thus the quality of the water must be improved, and a conventional flip-bucket spillway could not be expected to provide adequate improvement. Instead Klohn Leonoff designed a special 18-metre-wide spillway that has in it a series of baffle blocks from top to bottom, such that the water passing through the spillway tumbles down a chute over and around the baffles. This tumbling action not only dissipates the energy, but also aerates the water, bringing the oxygen level up and reducing the nitrogen level. The gas pressure is very close to equilibrium when the water is released downstream into the river, as verified by hydraulic model studies conducted by Northwest Hydraulic Consultants.

At the height of its design work, Klohn Leonoff had thirty persons working on the project, and over $12 million in consulting fees had been expended. Then, midway through the project, in June 1991, construction work at Kemano was suspended, and the 840-strong work force laid off. A Federal Court had ordered a review after ruling in favour of the case presented by the Rivers Defence Coalition and the Carrier-Sekani Tribal Council. The court had ruled that the federal cabinet broke its own laws by exempting the Kemano Completion Project from the environmental review process.[33] Alcan, convinced that the project was environmentally sound, and the Department of Fisheries and Oceans both appealed the order, and the lower-court ruling was subsequently overturned. Meanwhile, pending any further appeal, the project continues to be suspended, and it is estimated that 2,000 local jobs and millions of dollars in business have been lost in the neighbouring communities of Kitimat and Terrace.[34]

The president of the Kitimat Chamber of Commerce, stressing the need for an economic boost for the area after heavy job losses during the 1980s, has expressed the business community's view on the impasse:

"The loss of the project [is] an opportunity we are missing [and] has left people feeling let down. . . . People don't feel confident in our economy [nor] that there will continue to be growth. It's [a] very pessimistic [outlook] right now."[35]

Alcan, stuck with "a $500 million hole in the ground," has threatened to sue the federal and provincial governments to recover the incurred costs if they are prevented from completing the project.[36] And of course, B.C. Hydro is anxious to receive the promised power, which may otherwise have to be developed elsewhere.

As it was with the Kitimat-Kemano project, Klohn Leonoff's work as a geotechnical consultant in the Yukon began in the company's first year. In fact, upon opening his Vancouver consulting practice, Charles Ripley's second paying job, in collaboration with R. M. Hardy, was a review of "bridges, earth slides, and stream erosion" along 1,200 miles of the Northwest Highway System, the Canadian section of the Alaska (Alcan) Highway. The 1,500-mile road from Dawson Creek, B.C. to Fairbanks, Alaska, through the Yukon, had been built by American and Canadian soldiers and civilians in 1942–43 as a wartime emergency measure.[37] The Hardy-Ripley investigation was the start of a long-range program to upgrade the highway and its 133 bridges (6 metres or longer) to contemporary standards. The fundamental problem was the riverward displacement and rotation of bridge abutments, and in some cases of bridge piers, as a result of movements in the foundation soils and approach fills. These movements had produced some major structural damage. Also, numerous landslides had occurred along the highway in similarly treacherous soils. The initial investigations spanned the period August 1951 to March 1954.[38] Later investigations at specific bridge sites requiring major repairs or replacements were carried out by Ripley, Klohn & Leonoff during 1968 to 1970.[39]

As well, at different times, RKL's Yukon work has consisted of consultation on such mining projects as the Cyprus Anvil lead-zinc mine at Faro, and the Clinton Creek asbestos mine northwest of Dawson City.[40]

In January 1986, the Department of Community and Transportation Services of the Yukon territorial government authorized Klohn Leonoff to provide consulting services on the "Dawson City Dyke Improvement Project." This work, of considerable historic interest, was ultimately to establish the company as a permanent presence in the Yukon.

Dawson, Canada's most glamorous town of legend and folklore (as immortalized by writers Robert Service and Pierre Berton), sprang up in 1896–98 as the commercial centre of the last great placer gold rush to the American continent's northwest. Fronting the confluence of the Yukon (an Indian word for "Big River") and Klondike rivers, it became the trans-shipment point for men and materials destined for the Klondike gold fields.[41] At the peak of the gold rush, in the summer of 1898, Dawson had a reputed population of some 30,000.[42] In the twentieth century,

Structural damage of the Gardner Creek Bridge, Mile 358.4 Northwest Highway System (Alcan Highway), due to movements in the foundation soils, August 1951.
Photo: Charles Ripley

however, the introduction of more sophisticated mining technology eventually drove out the independent hand-shovel and sluice-box miners, and Dawson's population dwindled to less than 1,000. The great gold era may be said to have come to an end in 1966 when the Yukon Consolidated Gold Corporation shut down the last of its giant placer dredges, although there remained about seventy small- to medium-scale bulldozer and backhoe operations by men (and women) who continued to, in Service's words, "moil for gold."

Bypassed by the Alaska Highway during World War II, Dawson subsequently lost its hegemony as the mercantile, service, and territorial capital of the Yukon to Whitehorse[43] (current population 21,000), 530 kilometres to the south. Next came the end of Dawson's utility as a river port, the result of the completion of the Klondike Highway connecting it with Whitehorse, and the drydocking in August 1960 of the last of sixty steamboats that had plied the Yukon waters. By the early 1960s, it was apparent that Dawson's economic future would be largely dependent on tourism.

Revitalization of Dawson as a national historic site and tourist attraction commenced in 1960 when the federal government, with the co-operation of the territorial and city governments, initiated a long-term restoration program.

With its location on a floodplain at the northeast corner of the junction of the two rivers, Dawson has been subjected to periodic flooding throughout its history, usually the result of ice jams during spring breakup. While piecemeal dyking to protect the city's waterfront had been built up over the years, it was of uneven quality and crest elevation and inadequate to hold back a major flood. The latest and largest flood on record occurred in May 1979, incurring damages in excess of $10 million. In January 1986, the Yukon territorial government, Department of Community and Transportation Services, engaged Klohn Leonoff as their principal consultant on the Dawson City Dyke Improvement Project.

Work on the dyke project was guided by a steering committee composed of representatives from the three levels of government. Because of the large number of tourists visiting the city each summer, an important design consideration was that the new dyke be aesthetically pleasing and not obstruct traditional access to the rivers. Klohn Leonoff worked closely with Parks Canada and the city of Dawson to develop a plan for walkways and picnic areas along the dyke that would supplement the existing community parks.

Klohn Leonoff's initial assignment was comprised of a river engineering study and flood frequency analysis,[44] preliminary designs for dyke rehabilitation, an estimate of construction costs, and a cost/benefit analysis, that is a comparison of the cost of dyke construction and maintenance versus the estimated cost of damages which would be caused by flooding if protection was not provided. The

Construction of the Dawson City flood protection dyke, 1986–87 – Fill placement and compaction.
Photo: Edward Falloon

The aesthetically pleasing dyke protects the S.S. Keno National Historic Site, July 1988. The Keno was the last sternwheeler to ply the Yukon River, from Whitehorse to Dawson City on August 29, 1960.
Photo: Robert Lorimer

latter analysis was carried out by Gary K. Bowden, a resource economist. The studies proved positive. A 2.4-kilometre-long earth-fill dyke would protect against a 200-year flood occurrence and could be justified on the basis of the economic analysis. Portions of the dyke crest would also be used to carry vehicular traffic.[45]

Following approval of the feasibility study, KL prepared final design drawings and specifications, evaluated tenders, and provided construction management and site supervision for the $3 million dyke. Building of the dyke included some interesting "firsts." The rich gold-bearing bottom gravels of the Klondike River and its tributaries, sporting exotic names such as Bonanza Creek (where the gold was first discovered) and Lovett Gulch, owe their presence to the fact that the valley was never glaciated. Named "white channel gravels" because of their high quartz content, they have been worked and reworked by placer mine, dredge, and bulldozer for ninety years, yet still contain some gold particles. Plentiful, durable, clean, and well-graded sandy gravels, these deposits were found to be an ideal construction material for the main body of the dyke. Hence it may be claimed that the dyke is literally constructed of gold. By comparison, nearby material from the "Moosehide Slide" was rejected because of its unproven consistency and the presence of asbestos particles, which could prove hazardous to health. Riprap erosion protection against the action of currents on the riverside of the dyke was obtained with the deposit of quarried rock and de-rocker tailings (coarse gravel and rock rejected from the placer operations). In order to ensure that the city would be protected during the spring breakup, cold-weather construction of the dyke was carried out between September 1986 and June 1987—an unusual happening in such a northern climate. To mitigate against the effects of freezing, special construction techniques were employed involving a continuous loading, hauling, filling, and compaction operation.[46]

The Dawson City dyke project required full-time resident staff on site. Via the project, Klohn Leonoff was establishing a good reputation with the Yukon government. Furthermore, decentralization was in vogue with the federal government of the day, which was moving its various northern affairs offices to Whitehorse and Yellowknife. As a matter of policy, companies established in the North were likely to be given preference for federal consulting work. In the private sector, mining activity was beginning to increase somewhat. And there was the eventual probability of the construction of a gas pipeline that would pass through the Yukon. With all these considerations in mind, Earl Speer was given the responsibility of assessing whether enough work could be developed to justify a permanent northern office.[47] As a result, Klohn Leonoff Yukon Ltd. was incorporated in June 1986 and an office was established in Whitehorse. (Peter E.) Thomson & Iles Ltd., Whitehorse surveyors who had been working with KL on the Dawson Dyke, were included in the new firm as a minority partner.[48]

In February 1987, Robert J. Lorimer joined the firm as manager of the Yukon office. A 1973 graduate of McGill University, prior to his hiring he had fourteen years of experience on a variety of civil engineering projects in Canada and overseas. Of particular import in his engagement was the fact that half of this experience was in the North. In the Yukon, Lorimer had worked on supervision of dam construction, reconnaissance of potential hydroelectric sites, and on the Aishihik hydroelectric development for the Northern Canada Power Commission. In the Arctic islands he had been supervisor of field investigations for marine portions of the proposed Polar Gas Pipeline. Early in his career, "Bob" Lorimer had been attracted to the beauty and mystique of Canada's North, and it is in this environment that he has found his engineering niche.

With Lorimer's presence in the KL Whitehorse office, considerable success in business opportunities was realized by the spring of 1988.[49] Between 1986 and 1991, some 250 projects have been carried out by the firm in the Yukon, most

Beaver dam, Fox Creek, Teslin wetlands, June 1988.
Photo: Owen Quinn

in the small- to medium-sized category. Annual fee revenues range from $400,000 to $500,000, and staff averages three persons—relatively small by company standards. Nevertheless, the Yukon office achieves several objectives. It keeps Klohn Leonoff's northern experience current. It conforms to the company's stated policy of broadening its range of civil engineering projects. As well, the Yukon work has enabled KL to become involved in several new, non-traditional areas of work, some of these at the frontiers of engineering practice. The two most outstanding examples of this are the ground contamination clean-up at the Department of National Defence Cadet Camp, and the Teslin Wetlands Sewage Treatment facility.

The DND Whitehorse Cadet Camp had suffered a long-term leak from fuel storage tanks, thereby contaminating the campground beneath several buildings and threatening a nearby salmon-bearing stream. KL's advice was sought on a solution to the problem. Studies concluded that the only viable option was by means of bio-remediation, that is by introducing the growth of natural soil bacteria that consume hydrocarbons—the first such application in cold-climate conditions. A high remediation has in fact been achieved in the first year of this scheme's operation.[50]

In 1988 a village of 450 inhabitants situated on the shore of beautiful Teslin Lake retained Klohn Leonoff to assess the feasibility of, and develop a conceptual design for a sewage disposal method that would be an economic, practical, and environmentally superior alternative to conventional systems. The need for such a superior system is particularly acute in this case since wetlands exist, or can be created, throughout the village's surrounding area.

The treatment and disposal system designed by Klohn Leonoff will deliver secondary effluent from sewage lagoons to a wetland area through a simple gravity-fed pipeline system operated during the summer months. The effluent will be released from the pipeline as a surface discharge and will be allowed to flow downslope to infiltrate through the root zone to the local water table. During the overland flow and infiltration processes, "polishing" of the effluent will occur through physical filtering, nutrient uptake by natural vegetation, and natural biological stabilization. After mixing with the natural groundwater, the polished effluent will be discharged as a component of the groundwater baseflow into Fox Creek. Further mixing, aeration, and dilution will occur in the creek before it finally discharges into Teslin Lake.

Although wetlands treatment has been developed in the United States and in a few locations in southern Canada, the Teslin facility, currently under construction, is the definitive work to date on the subject of cold-climate wetlands sewage treatment and disposal. The significance of the project lies in the application of wetlands treatment in northern communities, where low cost, simplicity of operation and maintenance, and minimum environmental impact are critical.[51]

The Yukon government has used the Teslin Lake study as a procedures guide for the assessment of wetlands treatment in other communities.[52] As well, the territorial government nominated the village of Teslin for a national Environmental Achievement Award for its leadership in pursuing the project. Work on the facility also won for Klohn Leonoff a 1991 Canadian Consulting Engineering Award of Merit for soft engineering studies,[53] and prompted Audrey McLaughlin, Yukon MP and leader of the New Democratic Party of Canada, to write to Robert Lorimer.

HOUSE OF COMMONS
CHAMBRE DES COMMUNES
OTTAWA, CANADA
K1A 0A6

OCT 28 1991

October 24, 1991

Robert Lorimer
Engineering Manager
2-203A Main Street
Whitehorse, Yukon
Y1A 2B2

Dear Mr. Lorimer:

As your Member of Parliament, I congratulate you and your firm, Klohn Leonoff Yukon Ltd. for your outstanding achievement in winning the Association of Consulting Engineers of Canada Award of Merit for your work on the Teslin Wetlands Feasibility Study.

Rarely does such recognition come in a professional career. And rare, too, is national recognition of work conducted in the North. Today, all Yukoners can be rightly proud of your successful application of innovative ideas to practical problems.

Because it is through projects such as yours that solutions will be found to many of our society's most pressing needs.

Best Wishes for Continued Success!

Sincerely,

Audrey McLaughlin, Yukon M.P.
Leader of the New Democratic Party of Canada.

Bob Lorimer is designated as the company's manager for the Yukon/Northwest Territories Region, which operates under the umbrella of the B.C. Region. He spends some 70 percent of his time in the North and the remainder in the Richmond office. The amount of work in the Northwest Territoires, and its widespread nature, has not yet justified the opening of a Yellowknife office. Traditionally, work in that area has been co-ordinated from the Alberta office, and in the case of mining projects, from the B.C. office. However, Lorimer co-ordinates the efforts of all regions working on northern projects.

RKL's professional concern with environmental issues dates virtually from the company's first year, when construction of the Wahleach Dam on a tributary stream of the Fraser River was restricted in order to prevent siltation of the river during the salmon spawning season. The Brenda Mines tailings impoundment and water reclaim system of the 1960s, designed to prevent contamination of Lake Okanagan, was the pilot "big dam" project for safe mine waste disposal in the province (Chapter 7). In a report to the

Managers' Meeting of March 1972, Klohn elaborated upon how his company works in relation to the environment:

"Environmental engineering is the application of engineering principles to the solution of environmental problems. . . The geotechnical engineer, whose training and experience are totally concerned with the physical properties and behaviour of soil, rock, and water . . . together with the plant and animal ecologists, form the ideal team for assessing and developing practical solutions to environmental problems. [The ecologist's] role is to determine how much change can be accepted without causing irreparable damage . . . [to] the delicate balance of plant and animal life. [The engineer] can advise on the designs that will cause the least physical upset to the existing environment."[54]

In more current times, Klohn has added these comments:

"On the whole, most engineers do care about the environment—they are not interested in destroying it. A large percentage of them are skiers, hikers, and campers and like nothing better than the environment. I myself have spent a good part of my career, building dams for mines, so that they don't pollute the environment.

"The pendulum goes back and forth, but right now we are in a green theme. A good example is Carmanah Valley where there is a big stand of Sitka spruce that should be preserved, but doesn't fill the whole valley by any means. That is society's choice—whether it would rather save the spruce, or cut off the wood supply to the mill. [Environmentalists] have had a material effect on engineering business and, I am afraid, are going to have more impact before it is over—on dams, pulp and paper mills, hydroelectric projects, and almost everything else.

"I don't know who is going to clean up the environment. Companies don't do things for nothing. Some people say that the government should do it, but these same people refuse to pay any more taxes. As an engineer, I find the whole exercise completely illogical."

As environmental problems moved to the forefront of public awareness through the eighties and into the nineties, resultant pressures have been brought to bear on governmental bodies and major corporations. These government and corporate entities have been asked to collectively "clean up their act," and this lobbying has created significant opportunities for engineering consulting firms, given that the engineer's role in cleaning up the environment is simply indispensable.

By the beginning of the 1980s, Klohn Leonoff was assembling a staff with considerable expertise in waste management, hydraulics, hydrogeology, and other disciplines relevant to the environment. The Special Services Division, under Dr. Robin Charlwood who had experience in the handling, recycling, and disposal of radioactive materials, carried out a number of studies on hazardous waste sites. The Water Resources Division, under David Sellars and groundwater specialist H. Rodney Smith, handled a number of multidisciplinary assignments with agricultural, socio-economic, and environmental components, specifically water quality, sewage disposal, and groundwater contamination from industrial sites. And the Mining Services Division, led by Peter Lighthall and Harvey McLeod, gained the most up-to-date knowledge possible concerning cyanide in groundwater as the result of gold and silver mining.[55]

A number of assignments during the eighties are illustrative of the expanding field of environmental engineering and KL's simultaneously increasing expertise in the field. Environmental and socio-economic assessments were made for the proposed Adanac Mine in northwestern British Columbia, where the ore contains low-level radioactivity.[56] Remediation of an industrially contaminated site in Surrey, B.C. was undertaken for Atomic Energy of Canada. An environmental impact report was prepared on the California Silver Zaca Mine in the Toiyabe National Forest, where various state regulatory requirements (for cyanide heap leaching and forestry concerns in particular) are very exacting.[57] At the Faro Mine in the Yukon an abandonment plan was developed minimizing any movement, via wind or water, of the lead-zinc tailings, and any leaching that might ensue, thereby maintaining water quality for fish habitat.[58] An environmental assessment was also completed for the Blackcomb ski resort at Whistler, B.C., as was a multidisciplinary study of proposed golf course development in the Burns Bog area of the Fraser River Delta.

Today the credibility of major projects proposed in Canada and the United States depends on the developer's successful accommodation of a wide range of technical, environmental, and socio-economic considerations. Such projects are now subject to vetting by a review process that is active at every stage of development, from planning to satisfactory completion. And this review may involve several levels of government—federal, provincial, regional, and local—as well as open participation by native councils and the general public.[59]

Coincidental with the introduction of the Canadian Environmental Assessment Bill by the Canadian parliament, with all of that bill's implications for large-scale engineering projects of every kind, the government of British Columbia introduced the Major Project Review Process. Henceforward, a provincial review process would be applied to a conglomerate of industries that includes pulp and paper production, mineral smelting and refining, chemical manufacturing, and major ports and marinas. (Mine development and energy projects are covered by other review processes.) The B.C. legislation created review panels, and, while advisory only, the role of the panels is to help in consensus-making, and their recommendations on the acceptance or rejection of projects have become increasingly difficult for governments to ignore.[60]

In 1989 Klohn Leonoff, under the direction of Dr. Myles Parsons, was awarded the contract to manage the environmental assessment study[61] for the proposed National TRIUMF[62]-KAON project located at the University of British Columbia. The existing TRIUMF cyclotron, which provides intense beams of subatomic particles, has for more than a decade been the flagship of fundamental science in Canada. The new "factory" is to be an expansion of the present facility which will include the construction of an accelerator that can speed particles to 99 percent of the speed of light, thereby creating subatomic particles called KAONS.[63] The project is part of an international network of giant machines operated by scientists in order to better understand the nuclei of atoms via the smashing of particles into smaller and smaller bits. The KAON factory will provide the highest intensity proton beam source in the world and will be at the leading edge of particle physics research.

Once operational, KAON will employ 1,900 people and operational costs will be high—up to $100 million per year in current dollars. However, studies have indicated that the spinoff in high-technology industries such as computer software and precision measuring systems, and in medical research, will provide an infusion of one-quarter-billion dollars every year into the private sector of the British

Columbia economy.[64]

This scientific megaproject, located on a 33-hectare site at UBC, where now "crows and squirrels are happily building nests in the forest and grassland," will be unprecedented. Construction statistics are awesome. Capital costs will be an estimated $1 billion. The facility will take six years to build. Seventeen thousand person-years of employment will be created. Massive amounts of concrete—143,000 cubic metres—will be poured. The Booster Synchatron, which provides the first-stage acceleration of protons generated by the TRIUMF cyclotron, will have a 214-metre-long tunnel with three below-grade concrete levels. A 1,070-metre-long arch tunnel, to be constructed by cut and cover method, will contain the rings that further accelerate the protons. An "Extraction Hall," where the particles will be obtained, will feature a 200-metre-long concrete channel with precast beams. A large "Experimental Hall" and three sub-halls will direct the particles to targets where the experiments will be performed. There will also be an administration building and more than a dozen service buildings.

Klohn Leonoff assembled a multidisciplinary team of consultants to assess the environmental impacts that could result from construction and operation of the TRIUMF-KAON facility. Any potential risks were to be identified by the team, as well as any mitigative measures that would be required. The scope of studies encompassed: vegetation and wildlife at and around the project site; aesthetic and recreational values; land use and social features; alteration of soil moisture conditions in the general area due to site drainage, excavation, and backfill; groundwater contamination by radionuclides and various chemical materials; air quality; water vapour emissions; noise from construction and operation; radioactivity; electric and magnetic field effects of the power transmission line; and risks associated with a major earthquake.

A public consultation program comprising two public meetings was carried out as an integral part of the environmental assessment. The final report was submitted by Klohn Leonoff to the TRIUMF-KAON project office in December 1989.[65]

The project had been formally initiated earlier that year by an agreement between Industry, Science and Technology Canada and the B.C. Ministry of Advanced Education, apparently with an arrangement to share the costs. In recognition of the importance of the project to international nuclear science, the G-7 consortium of leading industrial nations (the United States, Germany, Italy, France, Korea, Great Britain, and Japan) have agreed to share one-third of the capital costs. Since then the project's fate has been, as described by the press, "mired in political wrangling."[66] The British Columbia government, actively promoting the project, has taken a non-partisan approach involving the support of all the major provincial political parties. The federal government, however, has yet to provide a firm pledge to fund its one-third share, and the project has remained in limbo. The issues unresolved are the inflation factor and annual operating costs. It has been reported that the "powerful science bureaucrats" in Ottawa have "turned thumbs down" on KAON on the grounds that it is too expensive. Such a rejection would inevitably fire the debate as to the dominance of central Canada's research institutions in terms of scientific funding. (Currently B.C., with 12 percent of Canada's population, receives only 7.1 percent of federal science and technology spending.) At stake are the loss of the international funds, which otherwise will be directed elsewhere, and the dream of hosting a world-class high-tech industry.[67]

Klohn Leonoff's "plans and objectives" for 1990 included the launching of a new Environmental and Waste Management Division. In the B.C. Region alone, some twenty projects and $1.5 million in business had been done in the environmental field over the previous two years. The president, reflecting on the need for a specific division to integrate all the company's work in this field, perhaps stated the obvious in saying that, "If we are to succeed in this area, it is vital we take a strong company initiative."[68] From the perspective of technical accomplishment and management experience, the logical person to head this division was Myles Parsons. The division officially commenced operation on April 1, 1990, and Parsons was enthusiastic:

"A good lot of our traditional business has been environmental work, although we really didn't call it that. We didn't go out and sell environmental engineering or environmental consulting. We were selling hydrology and groundwater and geotechnical engineering. These things all have a significant application in what is now called environmental work. We have a pretty much open-ended mandate, but we are limiting ourselves to the things we can do best, which are in fact soil and water related. We're building on our traditional market areas—conventional work in agriculture and water resource development, soil erosion, land reclamation, and this company's well-known background in the mining industry. Klohn Leonoff has a good domestic base and a lot of international experience. So our environmental group can and must capitalize on this reputation, broaden our scope, and make good use of our existing client base."

The Environmental Division's work to date has been focused on contaminated site remediation and a whole new growth area of business called "environmental audit" work. Such an audit calls for review of established operations—industrial plants, airport facilities, hazardous waste, oil and gasoline spill sites—which may have contaminant problems in the workplace and/or in the surrounding area. The audit also applies to properties which are in the process of being redeveloped or transferred from one order of use to another. Today, present and future owners are necessarily interested in knowing about environmental problems, and what can be done about them. A good example of this type of owner is Placer Dome Inc., a major international gold producer headquartered in Vancouver who, in a merger, took over the former properties of Dome Mines, a major Canadian gold producer. KL was engaged to do an environmental audit of these properties, determining their compliance, or lack thereof, with regulations, and to assess any remedial work required.

Despite the censure of environmentalists, self-styled and otherwise, a good deal of sound environmental work has been done by engineers over the last twenty-five years on the development of mine properties. An example of this has been KL's work on rock dumps and tailings ponds. Nevertheless, certain environmental concerns have come to the fore in recent years that simply weren't anticipated in the past. Cyanide, for example, when used in the extraction of gold and silver from ores, must be controlled to prevent the contamination of water supplies. And probably the foremost environmental issue in the mining industry today is "acid rock drainage."[69] This phenomenon occurs when moisture and air at an abandoned site provide an environment for harmful bacteria, which then react with pyrite in waste rock, producing the acid. Blanketing a dump with an impervious cap, such as glacial till, to try to keep out air and water is a conventional method but, in practice, a satisfactory result is very difficult to achieve. The technology for handling this problem is still evolving.

To keep abreast, indeed at the forefront, of state-of-the-art practice in the environmental field, Klohn Leonoff has engaged a "new breed" of researcher. Serena J. Domvile, an environmental scientist and applied chemist with extensive experience in hazardous and industrial waste management, heads the environmental chemistry section. A laboratory dedicated to this section's work is currently operational on KL's premises, and a number of research projects are under way. These include an acid rock drainage study jointly undertaken with the University of Western Ontario and sponsored by the Ontario Ministry of Northern Development and Mines, Indian and Northern Affairs Canada, Echo Bay Mines, and the International Nickel Company (INCO). As well, urinalysis monitoring instrumentation has been developed, funded jointly by Klohn Leonoff and the National Research Council of Canada, to determine urinary arsenic levels present in humans as a result of exposure to both occupational and dietary sources and to differentiate between toxic and non-toxic forms of arsenic. This unique and advanced program is headed by staff member Dr. Alexis Carpenter, an analytical chemist and specialist in the development of procedures for environmental and toxilogical monitoring programs.

KL and the Science Council of British Columbia have also co-operated on the development of a solvent leach process—a soil-washing technology for extraction of inorganic (and organic) constituents from soils contaminated as a result of industrial operations. Dr. William R. Cullen, from the Department of Chemistry at UBC, is collaborating in the research on both arsenic instrumentation and the solvent leach process.

Serena Domvile conducts research on arsenic remediation, Richmond laboratory, 1990.

KL is also doing commercial development of the "Domvile Process," a patented water treatment technology designed to remove arsenic and metallic cyanides in mill effluent. The process was developed and is currently operating at the Nerco Con gold mine, near Yellowknife.

As Klohn Leonoff's business load has grown rapidly in the post-depression eighties, expansion of the company's internal management and service sectors has been obliged to keep pace. The company's long-standing policy is, whenever possible, to develop middle-management from within the organization, and the current crop of such managers has proven the wisdom of this policy.

C. David Sellars joined KL in 1981 as a senior engineer, rising quickly through the ranks to become, within three years, manager of the Water Resources Division. Born in Plymouth, England in 1948, Sellars lived most of his youth near Windsor, about thirty miles west of London. His parents followed traditional occupations. His father was a civil servant in the London post office, as was his father before him. David's mother, in addition to rearing five children, was a district nurse. David received his grade school education at a Catholic boys' school, which from an academic perspective was outstanding but from a social outlook was weak, lacking extracurricular activities like music and drama.

In contrast to the rather prosaic and stationary careers of his parents, David Sellars had a vivid imagination and a keen interest in "adventure and wilderness." He remembers, around the age of twelve, writing a school essay in which his stated ambition was to paddle a canoe across Canada, ending up at the Kemano hydroelectric project. The teacher's critique on his essay was that it was "too fanciful." But, as it turned out, David's teacher lacked vision because, years later, in his engineering practice, Sellars would indeed find himself at the Kemano project, responsible for the Nechako River flood studies of the Kemano Completion Project.

When it came to choosing a career, recalls David, "I was always interested in the physical sciences, geography and geology, and in the natural sciences. So I toyed with the idea of being a geologist or a forester or something like that." Then, in a careers brochure, he saw a photograph of a skier in the mountains of northern Persia conducting a snow survey. Interested in mountaineering, Sellars looked at the caption of the photo to see what kind of career would take him into the exotic mountains near to where Noah landed his ark, and it said civil engineering. Responded David, "Right, that's for me." Coincidentally, he learned at this time that his father had completed a year at London University, intending to choose civil engineering as a career. Instead, at age seventeen, the senior Sellars was compelled to leave the university and help support the family.

Great Britain has a number of universities with strong engineering departments, and Sellars chose Birmingham where he enrolled in civil engineering. In his senior year he became interested in hydrology, planning to take graduate training in the water resources field. A professor there gave him sound advice. He told Sellars that he would be welcome at Birmingham, but that he had already been there three years and, in order to broaden his mind, it might be better if Sellars went elsewhere, perhaps overseas. Says Sellars: "That was a good idea. I had always thought of Canada because of my interest in geography and, since I was a keen mountaineer, the Canadian mountains attracted me."

So Sellars applied to a number of Canadian universities. Queen's University in Kingston, Ontario had NRC research money and offered him a scholarship at $3,000 a year. This was an attractive proposition, inasmuch as a starting salary for engineering graduates in England in 1969 was only about £1,000 ($2,000) a year. Sellars booked an inexpensive flight across the Atlantic, travelled to Queen's, and proceeded to take his master's degree under the tutorage of Ed Watt, one of the foremost engineering hydrologists in Canada.

After completing his degree in 1971, Sellars read a newspaper advertisement for a glacier hydrologist with the federal Department of Energy Mines and Resources, and the opportunity seemed to Sellars to combine everything he was interested in. However, he didn't get that job. Instead he was offered a position with the federal Department of Environment on the environmental impact studies being conducted for the Mackenzie Valley pipelines. Sellars spent the next three summers living in a tent in Canada's Arctic, monitoring the weather and various other ecological measurements: "I was sort of working with a research group. You had to be scientifically ambitious. I was more interested in problem solving, and we didn't have real problems to solve in the federal government. They were artificial—you had to invent the problems and then solve them. I found the whole way of doing things and the [lack of] motivation didn't suit my personality. So I thought that I would be much more suited to a consulting environment."

David Sellars

In looking elsewhere for employment, Sellars's yen for the mountains was still with him, and when he learned that CBA Engineering Ltd., a small but "well-connected" engineering firm based in Vancouver, had just been awarded two impressive CIDA assignments, he was quick to apply. CBA was a technically competent company but at the time not particularly strong in the water resources field: "They needed somebody to go out to northern Nigeria for six months to find out what was happening in a river basin. And they looked at my résumé and thought this was a likely character—somebody with a sense of adventure."

The job was offered, Sellars accepted, and so began a two-year assignment that he was to thoroughly enjoy. In another of the fortuitous incidents that seem to determine the future of both individuals like David Sellars and corporations like Klohn Leonoff, Myles Parsons was the CIDA technical advisor for the project. According to Sellars, Parsons would visit the site in Nigeria, always show great interest in the work, and the two men got on exceptionally well.

Another assignment followed in Tanzania, a master plan involving water supply systems for villages and towns, hydro power, and irrigation. Sellars now describes this job as "one of the best I have ever had." He soon felt himself to be an integral part of the project team, was promoted to deputy project manager and co-ordinator, and remained for two years. Again, Myles Parsons was the CIDA representative on the project.

Following these foreign assignments, Sellars finally came to Vancouver to work for CBA on a number of projects in British Columbia. Then, in 1981, the company was bought by the Simons group and merged with Crippen Consultants. Sellars found himself feeling "very disconcerted" with the change from his role in a "nice small company where you just walked in and talked to the principals," to that of an anonymous position in a large organization with a sizable water resources group. Wanting more control of his own destiny, Sellars perceived that it was "time to make a move." As further happenstance would have it, on the street one day he encountered Myles Parsons, who was now with Klohn Leonoff. And thus Sellars came to his current position.

Klohn Leonoff and CBA had developed a keen rivalry, and the latter firm was "very upset" upon hearing of Sellars's intention to join KL. He was earnestly advised against the move. However, Sellars disregarded the advice and pursued what has subsequently become an enviable opportunity. With KL he has served as project manager for a large number of water resource engineering projects including irrigation, water supply, hydroelectric power, and mining developments. He has also been responsible for the management of multidisciplinary projects and has carried out a number of assignments having socioeconomic, agricultural, and environmental components.

Joanna Mary Barnard is a young engineer in the company's Water Resources Division who has faced many of the typical challenges encountered by the minority female intending to break into a male-dominated profession. Joanna comes from Newfoundland and trained in civil engineering at Memorial University in St. John's, a relatively small school. Her parents are health care professionals who hoped she would pursue a career of equal substance:

"They both wanted me to go to medical school, but once they realized that I was a bit too squeamish for that, they were very supportive of anything I wanted to do. I was more science-oriented and liked the maths and physics courses. I thought about just doing a science degree but it seemed a dead end. The practical aspects of engineering interested me, and I thought it would be fun. I took civil because it had the most variety and the most people-oriented work."

When her class first met, there was unusual excitement because of the presence of sixteen women—the highest percentage in any school anywhere. But that acclaim didn't last long—a number of the women dropped out along the way. When the class graduated, there remained, according to Joanna, "pretty well the standard ten percent."

Inasmuch as her marks were not affected, Barnard does not feel that she encountered any overt discrimination in what had been a male-oriented school. Nonetheless, as a woman, Barnard was not treated by her male classmates in quite the same way that they would another man. Other peoples' assignments were often circulated and discussed, but, even though Joanna had some of the highest marks in the class, she was rarely asked for help with homework. "I think because I was a female I was unapproachable," speculates Barnard. It was an attitude that was also evident at social events: "One evening at a party I'd be talking to a guy, having a good time. Next day in class he wouldn't talk to me—he just didn't seem able to relate in that situation." Each of the women in Barnard's class seemed to find her own way of dealing with her minority status. Some tended to become "one of the boys"—drinking, smoking, swearing types. "For me", says Joanna, "I wasn't that kind of girl—I wouldn't have made that kind of a guy."

Barnard did at times have doubts about engineering as a career, but it was not specifically because she was female. It had more to do with the work load, and the compulsion she and her other female classmates felt to over-achieve:

"In general the girls did get higher marks because you didn't go into engineering unless you were pretty darned sure that's what you wanted to do. There were a couple of unpleasant instances that were related to the fact that I am female, but I wasn't about to give up; I wouldn't give them the satisfaction."

Memorial University has a co-operative program which allows the student to obtain outside engineering experience along with the course work. Joanna Barnard spent two terms with Acres International in St. John's working on water resource projects and hydro developments in Newfoundland. This introduced her to hydrology and hydraulic engineering and focused her on a career in water resources engineering. Following her graduation from Memorial, and thinking that the master's program at the University of British Columbia would be enriching both academically and culturally (and that Vancouver would be "a nice place to live"), Joanna continued her studies at UBC, which has a good reputation in the water resources field. While she was the only woman in the water resources program, there were others in allied programs, and her problems with her male counterparts seemed to lessen. "I think most people have grown up by the time that they get to their master's," explains Barnard. Making good use of her experience with Acres, Joanna wrote her master's thesis on computer modelling for flood control, reservoir operation, and drainage studies, an exercise which has given her valuable expertise in this field.

Upon completion of her M.A.Sc. in the fall of 1989, Barnard joined the Water Resources Division of Klohn Leonoff. Her first assignment was the development of interactive software to simulate the operation of the Nechako Reservoir following construction of the Kemano Completion Project. Her model has become a key factor in predicting downstream flood conditions under a new hydroelectric operating regime. The results are of particular interest to the B.C. Ministry of Environment and the Nechako River Conservation Program. This work was followed by a major study to determine the probable maximum precipitation (PMP) and probable maximum flood (PMF) for the Nechako Reservoir. Barnard worked closely with John Miller of Washington, D.C. on this study, a man who is considered the world's leading authority on PMP analysis. Another assignment was a historical review to assess priorities for floodplain mapping of Indian reserve lands in British Columbia. For this task Joanna made site visits, interviewed band administrators, and wrote a series of reports.

Once a woman has completed her education and obtained an agreeable job, one might hope that problems of sexual discrimination might end. Yet, according to Joanna Barnard, there remain subtle biases that continue to discriminate against the female engineer in the workplace. While again not claiming that there is overt discrimination, Joanna does nevertheless assert that there are fixed attitudes which are often difficult for a woman engineer to overcome: "You always have to be battling to prove that you are as good an engineer as a man—that you can do the job as well, maybe not as good as other men, but better than some." And, inevitably, certain of these attitudes tend to be adopted even by the woman discriminated against. Joanna admits that, even today, she sometimes feels awkward going to client meetings where "there are seven or eight men in their grey suits, and then there's me."

Joanna M. Barnard receives the Engineer-in-Training Award from R. R. Affleck, president of the Association of Professional Engineers and Geoscientists of British Columbia, October 1991.
Credit: B.C. Professional Engineer, December 1991

There is also the general public's perception of a woman in a nontraditional field. "When people ask me what do I do," recounts Joanna, "I find it hard to say I'm an engineer without it coming out like a challenge. Because people's reactions are, 'What? You're an engineer? Isn't that a man's job?'"

Barnard is accustomed to attending a seminar where she is the only female present, or perhaps there are a couple of women: "One night I went to a seminar for engineers at UBC—it was me and fifty guys. Most of the time I don't even notice anymore. But next day I was out there for a program that they were running for high school girls to persuade them to consider engineering as a career, and it twigged on me—it's been a long time since I've been in a room full of women."

Younger women need role models. Having practising women engineers address high school classes, as Joanna Barnard has done, is useful. And more women engineering professors would certainly help. Joanna was fortunate at Acres International to work with a senior woman engineer who was recognized for her work in hydroelectric developments in Newfoundland. This woman was also active in professional affairs, chairing seminars, etcetera. "It really helped me to work with a woman engineer," states Joanna, "and to see that women are getting into visible positions."

A perplexing problem for employers, as well as for employees of both sexes, is the issue of affirmative action, which has been advocated in recent times. It is feared that employment equity for women may in fact be prejudicial to men and therefore not equal at all. Senior men already in established jobs are unlikely to feel threatened by women, but young men early in their careers may feel at a disadvantage to women peers when competing for the same job. Joanna herself has mixed feelings on this subject:

"I'm sort of leery about any kind of affirmative action program. It's quite a sore point with a lot of the guys who say you're going to get a job anyway because you're a woman. That really bugs me. I don't need to be a woman to get a job. I know that I can get a job because I'm a good engineer."

On October 5, 1991, the newly created Division for the Advancement of Women in Engineering and Geoscience (DAWEG) of the Association of Professional Engineers and Geoscientists of British Columbia held its first Annual General Meeting at Science World in Vancouver, attended by more than fifty women and men. Joanna Barnard was elected to the Executive Committee as Newsletter Editor. DAWEG hopes to address five main issues: "mentoring, school counselling, social networking, child care and career advancement."

Those attending the meeting were dismayed to hear the statistic that only 2.2 percent of the registered engineers in B.C. are women.[70] Yet the future prospects look brighter.

Following the lead of American universities such as Purdue and Washington, the Faculty of Applied Science, along with the Women Students' Office at the University of British Columbia, have embarked on a joint "Project for Women in Engineering." In 1991 the number of first-year women enrolled in the faculty was 20 percent, compared to 14 percent in the previous year. This may be compared to over 300 women undergraduate engineering majors at the University of Washington in Seattle, comprising about 20 percent of the college's enrolment. The objective is to raise the number of UBC women engineers to 30 percent by the mid-nineties.[71]

Bryan Watts

In 1991, in recognition of her engineering skills and her community involvement as a volunteer in therapy and daycare programs for disabled and able children, and as a "Big Sister," Joanna Barnard, for "showing responsibility, initiative, and determination," received the Association of Professional Engineers and Geoscientists of British Columbia Engineer-in-Training Award.[72]

Bryan David Watts, another of Klohn Leonoff's "new breed" of astute engineers, came to the firm in 1980. Watts is a native British Columbian, born in 1951 at Comox on Vancouver Island, where his father was a logger. Earlier generations of his family had settled in the Prairies. In 1909, his maternal great-grandfather, William Arthur Giggs, came over oxcart trails to homestead at Macklin, Saskatchewan, south of Lloydminster and near the Alberta border. Branches of the family remain as wheat farmers in that district today. His paternal grandfather was a United Church minister in Saskatchewan during the time that Tommy Douglas was premier of the province.

While he was still in school, Bryan's family moved to North Vancouver, and so Bryan attended Carson Graham Senior Secondary. "A very good high school," recalls Bryan, "it had a mix of academic and vocational paths, and I chose the academic of course." The school was particularly stimulating inasmuch as a number of native Indian students from the Capilano Reserve were attending, and occasionally a rather famous Indian, Chief Dan George, paid a visit: "Most of the native Indians were, in fact, in the vocational part of the school, by choice. But they seemed to mix with the others. We didn't grow up with any anti-native feelings at all. I didn't recognize those things until I got out of grade school."

In grade twelve, students at Carson Graham could choose to write examinations for university scholarships. Exams in two subjects were required, and Watts chose history and Latin, although he also had a strong interest in mathematics. When he entered university, somewhat contradictorily, he chose engineering:

"There's no family background at all in engineering . . . and, by the way, most people weren't thinking about career paths in 1970. It was a time of university upheaval and drugs and anything other than conforming to society. So those people who went into engineering at that time were bucking the trend. But I guess I did it because I had some interest in mathematics, and I wanted a strong career."

At UBC, Watts chose geological engineering with a geotechnical option. Upon taking his first course in soil mechanics, he "literally fell in love" with the subject matter. During his first summer job he conducted a gravel search for the District of North Vancouver. Ripley, Klohn & Leonoff had collected a lot of information regarding the district in connection with the Seymour Falls Dam, and Watts recalls his first contact with the firm:

"It was in the summer of 1971. I came into the RKL office on Broadway and asked for some information on the Seymour watershed. I remember that the people there were very helpful and gave me all their information. I went up to the watershed and found some gravel for the district, so it was a successful summer for me."

Watts graduated in the spring of 1974. The early seventies was a time of recession in British Columbia so, along with most of his classmates, he headed off to Alberta where the oil business was booming. Watts had worked for Imperial Oil during the previous two summers, and thus he was able to obtain a position with that firm doing geophysical exploration in the Beaufort Sea, and on the Syncrude oil sands project. But after eighteen months of such work, he wanted to return to his chosen career path in geotechnical engineering. From 1975 to 1977, Watts worked for Hardy Associates, almost exclusively on the design of the tailings dams for the Syncrude Canada Ltd. project at Fort McMurray, Alberta. At Fort McMurray, he "occasionally had the pleasure" of working with Bob Hardy.

Years later, Klohn Leonoff was to be heavily involved in tar sands disposal at the Syncrude site, supervising the raising of a centreline-constructed dam storing 1 billion cubic metres of oil sands tailings. And Bryan Watts acted as the project engineer. The Syncrude tailings are of a different kind from that conventionally obtained from crushed rock. The sand is more rounded and contains a tar sludge residue. In this case, cell-type construction is being used to maintain the stability of the dam.

Watts resigned from Hardy to take up master's studies at the University of Alberta:

"Before I went there I solicited the views of other engineers about where I should go to graduate school, and they said, 'The University of Alberta is as good as any . . . and you're already here.' So that's what I did . . . I've never had any regrets. [It] was a wonderful place to be. The fellows I met at the U of A at that time have all gone on to be successful geotechnical engineers."

Watts's thesis advisor was Dr. N. R. (Norbert) Morgenstern, an internationally renowned engineer who has continued the tradition of soil mechanics excellence at the University of Alberta established by the likes of I. F. Morrison, R. M. Hardy, and S. R. Sinclair. Watts worked for Morgenstern on a number of interesting studies, including underground mining at the Cold Lake oil sands and the freezing of water-bearing strata to maintain stability during the sinking of deep shafts. His thesis was on the Great Canadian Oil Sands (now Suncor) tarsands dyke—300 feet high and moving a few inches a year on its foundation.

Upon completing his thesis, Watts hoped to come home to Vancouver. Knowing little about British Columbia engineering firms, he sought the advice of Morgenstern, who recommended Klohn Leonoff and a few others. Watts arrived at KL for an interview, was soon hired, and then assigned to the Mining Division where he worked on a variety of major mining projects. With his contacts in the

Alberta oil industry, he also worked for six years on the Beaufort Sea artificial island program.

While Watts was in the Mining Division, KL was invited to submit a proposal on a large, already operating tailings facility that was in trouble. In making the submission, Watts was to learn the value of a dictum first enunciated by Karl Terzaghi, and later followed by many of the company's principals—"It's important to get to the truth as soon as you can, both for your sake, and for the sake of your client."

Upon investigating the seismic stability of the dam in question, Watts and two other experienced staff engineers, independently of one another, all quickly came to the same conclusion. There was a fault in the vicinity that could still be active, and the dam would fail under the maximum possible earthquake emanating from that fault. The three men went to see Earle Klohn and advised him that they thought the firm could probably land the job associated with the tailings dam. They were concerned, however, that if they informed the client in direct fashion that the dam was not safe seismically, the job might go elsewhere. Watts was impressed by Klohn's response:

"He said, 'Remember, after you're naked in bed with a woman, it's too late to tell her you came over to watch television. You're going to get screwed, so you better tell them right now that the dam's not safe. And we'll take our chances.' So we put in the covering letter that it wasn't safe seismically—and we got the job. That was a real lesson for a young engineer. Number one, do the right thing. And number two, you only want to work for those clients who want to do the right thing."

Having innate technical and leadership abilities, it was inevitable that Bryan Watts would advance in the organization. In 1989 he became manager of the Geotechnical Division, which historically has been at the core of the company. Supervising a staff of nineteen professional engineers, he has no difficulty outlining his duties: "[I make] sure that all the geotechnical work that comes through our division is executed and that the right people are doing it, that it's done on time, on budget, to correct technical standard."

As a "third-generation" geotechnical engineer who has benefited from the advance of technology via computers and more sophisticated analytical tools, Watts has the advantage of superior training. Nevertheless, Watts's chief motivation in joining KL was the practical experience he would receive from the senior engineers in the company, men who are now in the category of review consultants. Has he been well served by his choice?

"Those three fellows, Mark Olsen, Bob Maartman, and Ian Morrison are of tremendous value to this company—more value than a lot of people recognize. They keep the company out of a huge number of problems.

"Bob Maartman is just a super engineer. In fact a friend of mine from B.C. Hydro told me of a recent visit by Ralph Peck [today the pre-eminent soil mechanics engineer on the continent] to review a Hydro job—Ralph asked about Maartman, out of the blue. He had remembered working with Bob on a job decades ago and wondered if he was still practicing. So it's obvious that Bob Maartman makes an impression on people.

"I've worked with Mark Olsen extensively, both in mining and geotechnical, and enjoyed it thoroughly. We don't use him very much in geotechnical because he's in such demand in the Mining Division. He has a knack for sitting back and looking at a project in an unbiased way and picking out major flaws in the design and approach.

"I think Ian Morrison is one of the best foundation engineers in Canada—a delight to work with. And I say that having known a lot of good foundation engineers. We use him by regularly soliciting his input at different stages of the project, from proposal to final report. Unfortunately for us, but fortunately for his clients, Ian in some circumstances still likes to do the whole job. Simons think the world of Ian Morrison. Whenever there's a problem with any of their jobs where we haven't necessarily been involved, whoever the geotechnical consultant is, they bring in Morrison to review the work.

"Ian Morrison amazes me, because I know he's not as well read as I am in geotechnical engineering. But things that I was taught, he's just managed to figure out by himself through his experience and by very careful thinking. In fact he teaches me a tremendous number of things on every job. I've still got a lot to learn from Ian Morrison. He's a company treasure."

The responsibility of the company to its clients, and to society in general, is to maintain continuity, to transfer the immense body of knowledge that has been accumulated over forty years to succeeding generations. This task is very much on Bryan Watts's mind, as head of the Geotechnical Division:

"There are obviously lots of very good people out there in our group. Yet this transition is going to be more dramatic than has occurred in the past—because Ian Morrison, Mark Olsen, Bob Maartman, and Earle Klohn will all go within a few years of each other. I think I have about five years to transfer this knowledge from them to the rest of the people here. But there's no replacement for those guys. We've been given the market on a plate. Here it is. I don't have to go out and start a new company and go after the Simonses and the Sandwells and all the others. So, knowing that you can't replace them, the challenge is to keep the market. And that's the great opportunity that young engineers like me at Klohn Leonoff have."

For Watts, like the engineers who have gone before him, there arises the dilemma of ascending in management versus staying active in technical engineering. How would he view a time in the future when he might be totally immersed in management?

"I think it would bother me. It may not be possible for me, but there are some people who can maintain parallel technical and managerial careers. I take as my role models Earle Klohn and Ray Benson."

When asked point-blank, "What's your ultimate ambition within this company?" Watts's response is equally frank: "President of Klohn Leonoff."

Donna Gail Le Clair is an engineer in the Geotechnical Division. Born in Edmonton in 1956, she took all of her schooling in Vancouver, attending John Oliver High. The youngest of three daughters, Donna has come from a "very old-fashioned, traditional family," with both parents of Russian and Ukrainian descent, raised on farms in Alberta. All the daughters were accomplished at high school, but there was little support for going further. Her older sisters settled down, married, and raised families. Explains Donna: "There was no precedent in my family nor any desire from my two sisters to do anything different. I was the odd ball. I wanted to go to university, but I didn't get any encouragement. In fact my father said, 'Well, you're just going to get married and have babies. So what's the point of sending you to university?' Girls didn't do that sort of thing."

After high school Donna entered the work force, first as a secretary. Then she worked at the Grouse Mountain Ski

School and finally at the Bay. She also did a lot of travelling. Then, at the age of twenty-five, Donna Le Clair decided to do what she had originally wanted to do—go to university:

"I sat down and looked at a university calendar and thought, what can I take? I didn't want to go into the three traditional areas to which women are attracted—nursing, home economics, and teaching. I looked at the other options and narrowed [them] down to engineering or radiology. And in the end I said, 'I don't want to be a doctor because then my life will never be my own.' So it was engineering. Then it was just a matter of what sort of engineering."

She confesses her total ignorance as to the fact that engineering was a male-dominated profession: "I looked at the requirements that you needed—at the type of courses that you took. It didn't seem to me that you needed brute strength or any other type of quality that would restrict admission."

Before enrolling at UBC, Donna spent a year at Capilano College, completing her grade twelve equivalent in algebra, chemistry, and physics. Her marks were excellent. Then she entered UBC:

"Coming back to school after eight years of being away was difficult in itself. The curriculum was just another difficulty. In undergrad [engineering] we started out with nine or so [women], and in the end seven graduated out of something like ninety-four [students]. At the peer level you were pretty much like everybody else. Certainly there were obvious differences and you were treated a little bit differently, but that was OK because it just meant that people were more polite in your presence, which I was quite happy about."

Donna found her niche in geotechnical engineering and carried right on to take her master's degree in this field. And graduate work was a rewarding experience for her. There was a one-to-one relationship with the professors and few problems.

Donna had married at eighteen, and her husband has been very supportive of her career. But, even when Donna was quite advanced in her university stint, her mother was given to scolding Donna's husband as to this support. In Donna's mother's eyes, her daughter will always be better off as a housewife and mother. A further instance of her mother's intransigence came in Hawaii, where Donna was visiting her parents, who spend some time there each year: "We were driving past a construction site and they were driving piles. So, of course, I was interested. I'm like Mark Olsen, if there's a hole in the ground, I have to look in it. My husband and I were talking about something on the site, when my mother said, 'What do you know about that?' And I just said, 'What do you think I did in school for seven years? What do you think I do now?' Nothing's really changed."

Graduating in the spring of 1988, Donna Le Clair had no difficulty in finding a job. In fact, she very soon had a tempting offer from a California company, but she instead chose employment with Klohn Leonoff. In her four years with the firm, Donna has had the usual variety of field jobs—drilling investigations and inspection of foundation construction at industrial plant sites. This work has quickly given her a wide range of experience, and, on the whole, it has been work she enjoys: "So you get a little dirty. It's the nature of the work. I don't mind. There's always the shower at the end of the day." A petite 110 pounds, Donna admits that the field work can present some physical difficulties: "If I have to do a soil density test it's very difficult for me to carry the volumeter around, especially when it's full of water. Even the nuclear densometer is heavy. After I've carried [those] around for about fifteen minutes, I'm beat."

Donna Le Clair

Another problem particular to women engineers sometimes occurs on remote sites, where the only accommodation is the work site camp: "On the Iskut Road study, I was up in northern B.C. and one of the camps where we stayed . . . was just terrible. It had no facilities for women. In fact, the camp manager was quite irate that she wasn't told that the D. Le Clair who was coming up was a woman, because she was completely unprepared to have a woman in the camp. There were no women's washrooms, and in the end, the only one that I could freely use was the cook's. So if it was after about nine o'clock at night, of course the cook was asleep, and the washroom was right inside her room, so I was out of luck."

But Donna shrugs off such incidents:

"It wasn't all that bad. The one camp was not very nice. The second camp that I stayed at was fine—totally set up to handle women. They did have women in the camp so it was a little more normal.

"I was away for a month on that project. You were a bit isolated, but the weather was pleasant, which helped a lot being outdoors. That was an interesting and challenging job—going somewhere where there wasn't anything and trying to visualize something."

Indeed, 1991 was an unusually hectic year for Donna. Shortly after the Iskut Road study, she was sent for five weeks to the Celgar pulp mill construction in Castlegar, B.C., then home for two weeks, then to Uganda for a month, and shortly thereafter back to Celgar for the remainder of the year: "That was the longest stretch where I was away from home. I didn't get to come home as often as I planned. The demands of the work didn't allow me to take one week a month off, like it had been scheduled. So I just came home for a weekend every month. But my husband works on construction, and when I was in university, there were a couple of summers where he was out of town for anywhere from two to four months. We've dealt with absences before. It hasn't been a problem."

Donna's experience as KL's resident engineer at the Celgar site provided the material for a report she gave to Klohn Leonoff staff:

"After going to site in Castlegar on June 21st for a proposed one-week trip, I finally returned to the big city on November 10th. Things at site have finally wound down and the major earthwork components of the $700 million Celgar modernization project are nearing completion. I finished off the year the way I started it: installing vibrating wire piezometers (in February along the Columbia riverfront; in November around the effluent treatment lagoons).

"Our work this year varied widely, from the typical excavation and backfill monitoring, to borrow source evaluation, construction of effluent treatment lagoons, and inspection of a geogrid-reinforced slope, an anchored machine room wall, and of a shotcrete-mesh-anchor-supported excavation. We installed instruments to monitor settlement and groundwater levels, and permanent groundwater quality monitoring wells.

"The Klohn Leonoff name is well known in Castlegar now! . . . Friday, November 8th marked the 227th [and final] working day for KL staff on site in 1991. Most of the contractors on site said we'd be missed."[73]

Donna, though an obviously pleasant and likeable person, admits to a reputation gained on the job as someone who sets very high standards for herself and those she works with, standards that she expects people to meet:

"If you're going to do a job, do it right. Of course you get the usual remarks every time you walk by a group of men. You have to be confident enough in what you're doing that you can draw the strength from yourself to just ignore it. It's obvious that some of the contractors won't pay attention to what you say because they can't bear the thought of having a woman tell them how something should be done. And others, while they know you're a woman, will listen quite carefully to what you say and what your reasons are, and it's a pleasure to work with them. The other ones, those are the ones you get paid for. On the Celgar job, for instance, one area had some poor-quality material dumped there. The contractor was hoping we'd just forget about it, allow it to remain there, but I kept saying to Kevin [her male subordinate], 'No they can't do that, they have to take it out.' And this had been dragging on for quite a while. So when I got to the site [again] I saw it still wasn't done. I said to Kevin, 'Oh, they're waiting for the shift to change so that they can sneak it by me and hope I won't notice.' And he says, 'No, they know you're stricter than me.' "[74]

There is no doubt that Klohn Leonoff's experience with women engineers has been positive overall. Ian Morrison, who has reviewed the work of numerous of these women, has made this comment:

"We have several now and have had others who have moved on. The ones we have had have generally come directly from school with not much professional experience. I would say, at the level at which I have been exposed to the female engineer, she is something that the male engineer has to live up to. They are generally very meticulous, accurate, and good communicators. You get a report from them, some handwritten notes, or some drill logs—they are well organized and you can read them. The male engineers are almost exactly the opposite—you get something that you can't read and its not well organized."

David Sellars, who has two women professionals on his staff, an engineer and a geologist, concurs with Morrison's opinion, although he also acknowledges some required differences in dealing with female engineers:

"You have to be a little more careful how you treat them because they do think a little differently, and they have different kinds of sensitivities. But they also have different kinds of strengths from some of the male engineers, [and] you have to recognize what those strengths are."

Donna Le Clair, in sharing Morrison's and Sellars's views, adds her own explanations:

"Women tend to communicate more effectively than men, whether its in their written work or orally. Women communicate differently. If a man doesn't know an answer to something, quite often he'll make it up. Whereas a woman will say, 'Gee I don't know, but I can find out.'

"When women manage [a project] they tend to go for a group effort rather than an individual effort. And sometimes that's perceived as an individual weakness. But it's just a different style. And, in some cases, it's even more effective.

"How your work is perceived is different. There's less of an aggressive nature in the way women deal with problems. It tends to be more of an unconscious behaviour that we've learned from childhood. You want to excel in what you do, but there isn't that strong driving force to stand out. In some women that need is very strong, but generally it's not.

"One of the strongest lessons that I learned in university is that there is never only one right answer, and there is never only one way to do something. And that applies to a technical problem or it applies to how you manage your projects. And just because something is different doesn't mean that it's wrong."

Bryan Watts perhaps best sums up the situation vis-à-vis women and engineering when he describes the characteristics of the two female engineers on his staff, Susan W. Hollingshead and Donna Le Clair: "Definitely suited for engineering, exacting, mature, direct, and efficient."

Harvey Neil McLeod, another of David Sellars and Bryan Watts's peers, came to Klohn Leonoff in 1976, and in 1990 he became manager of the Mining Services Division. Born in Edson, Alberta, he was brought up there and in Kamloops, B.C., where his father was a train engineer at division points on the CNR. While still in high school, Harvey became interested in electronics as a hobby, building amplifiers and speakers, and he intended to enroll in electrical engineering at UBC. However his summer employment, following the first-year general course at UBC, was on a geophysical survey outside of Kamloops. That work incited his interest in engineering geology, and he graduated with such a degree in 1973.

Single and footloose like many of his university contemporaries of that period, McLeod wanted to take time off and travel. However, in 1974, CBA Engineering Ltd. obtained the CIDA Hadejia River Basin Study in Nigeria, so he joined a team of some seven expatriates on that job—in geology, water resources, economics, agronomy, and sociology—all reporting to a single project manager. McLeod was solely responsible for the geologic mapping of each dam site, as well as air photo interpretation, preliminary site selection, drilling, and conceptual design—an exceptional and challenging task for an engineer so new to the profession.

Living conditions were rugged. The site in northern Nigeria, three hours' drive from the major city of Kano, was inland and not far from the equator, therefore extremely hot. Most of the time McLeod lived in a field trailer parked in the vicinity of the dam site. Occasionally he stayed overnight in mud huts in native villages. He often found the experience utterly exhilarating: "I loved it. The job was interesting. It's quite a different country. There was a bit of a culture shock at first, but you get used to it after a while. However, after being in the bush for some time you get 'bushed,' and you're happy to leave and get back to civilization."

McLeod returned to Vancouver at the end of 1975. But not before he had fulfilled his wanderlust, taking six months to travel through east Africa—Kenya, Uganda, Tanzania—and then take a boat down to South Africa. Arriving back home, he found that there was no further work with CBA, and someone there suggested he see Mark Olsen. McLeod came to work with Klohn Leonoff in February 1976, shortly after the opening of the Richmond office.

His arrival came at the height of the local mining boom for KL, and Harvey McLeod was immediately thrust into the role of project engineer, a role which continued over the next fifteen years on a variety of mining projects—mill foundations, dams, rock dumps, and tailings storage. These included the Highmont and Lornex mines at Logan Lake, B.C.; the Afton mine near Kamloops; the Obed-Marsh thermal coal project and the Syncrude oil sands mine in Alberta; and the Bullmoose coal mine in northeastern British Columbia.

Sponsored by the company as part of a long-range plan to encourage promising young engineers to enhance their education, McLeod took a year off for studies, receiving his M.Sc. in soil mechanics from the University of London, and D.I.C. from the Imperial College of Science and Technology. In Harvey's mind, returning to school after six years of "worldly experience" made good sense: "I think if I'd done my master's right out of university, it wouldn't have been nearly as beneficial. [After] you've got a feeling for what you really need to do on a site, when you read your textbook again, it's a lot easier to focus. It meant a lot more to me." While in London, he was also able to meet a number of people from the international soil mechanics community, and thereby develop a broader base of friends within the industry.

Harvey McLeod

During the 1980s, when large overseas projects developed for KL, Harvey again directed his attention to foreign lands—construction monitoring of the earthfill dam and irrigation canal on the Maduru Oya project in Sri Lanka, project engineering on the Ok Tedi mining project in Papua New Guinea, and designing the on-land tailings storage facilities for the Titania ilmenite mine in Norway. He also worked on several gold and silver mines on the North American continent—in British Columbia, Yukon, Manitoba, and Mexico.

Through long hours and hard work, Harvey McLeod has earned his current position as head of the Mining Division. In his fifteen years with the company, he estimates that fully 80 percent of his time has been spent on mining projects. Perhaps his most challenging job to date has been the Porgera gold project, currently under development in the central highlands of Papua New Guinea:

"It's a major gold mine under construction by Placer Dome Inc. from Vancouver. The capital cost of the project is in the order of $600 million to $1 billion. It's in an area which receives about four metres of rain a year and has very unstable soils. Basically its geology is in the active process in the sense that it is being formed and eroded at a high rate even today. The whole countryside is covered by a layer of colluvium, which is sliding on top of weak mudstone. You can actually see it moving in many places. There's a tremendous geotechnical challenge in order to build things in that country.

"The major challenge is construction of the waste dump. Essentially the problem is how to put 400 million tons of waste rock on top of a landslide. We're looking at options like major excavation and replacement, ground improvement, and dynamic dumps which will fail and be eroded by river action. We have an international review board on that particular project: Dr. N. R. Morgenstern from Alberta, David Coffey and mining consultant Kevin J. Rosengren from Australia.

"Placer is phasing [the mine] in over a number of years. The first phase is complete and they just started (August 1990) producing gold. It's an extremely rich deposit disseminated in veins in granitic intrusions. Of course, if you spend a billion dollars, you'd better be going after a rich deposit. When I was down there, they had one stope (an underground cavern of the mine) that was ten metres by ten metres by twenty metres high. It had $10 million worth of gold in it—quite a pretty sight."

Maintaining slope stability in any large open-pit mine is always a challenging problem. At Porgera the technical requirement is to design a 500-metre-deep pit in highly variable rock, from sound intrusives to little more than weak mudstone.

Today, the mining industry is coming under increasing government and public scrutiny. With huge mines generating ever-increasing quantities of new conditions such as cyanide and acid rock drainage, the problems, if anything, are mounting. The technology and methodolgy to meet the requirements for safe and effective mine waste disposal are still evolving. Concludes McLeod: "There is technology developing. Whether or not we're getting a better answer, I think people can still argue. The bottom line is that practical experience and having been around the site still account for a major percentage of any design." He states categorically that, "In terms of tailings management and dam design we are as good as anyone I've seen anywhere in the world."

At Klohn Leonoff, monetary restraint during the recession of the first half of the 1980s had curtailed the upgrading of equipment and the recruitment of office staff. By the end of 1985, when the work load began to escalate, it was apparent that the service sectors of the company were badly outmoded. Those that required substantial upgrading included computing and word processing, library and records management, and human resources.

When the Board of Directors met in December of 1985, Earl Speer reported that Ian Morrison, as chairman of the Engineering Computer Committee, was "very enthusiastic" about the implementation of a computer system at the Richmond offices. Speer further recommended that a long-range Office Planning Committee be created "as technology is changing very rapidly."[75]

Ian Morrison is indeed a computer enthusiast. He was the first company engineer to apply the personal computer as a daily tool in engineering problem-solving. When Bryan Watts, fresh out of university, joined the company in September 1980, he had been trained on large mainframe computers and knew at least "the difference between hardware and software." Of course neither Morrison nor anyone else in the office at that time had formal training in the use of computers. Personal microcomputers had just come into vogue, and Watts found that Morrison, Olsen, Maartman, and Klohn, all self-taught, were struggling to master them. He thought it remarkable that the senior engineers in the company were the first ones to recognize the usefulness of personal computers. It was several years later before some junior and intermediate engineers could be convinced that computers would be of genuine use to them.

In June 1987, K. I. Morrison, chairman of the Computer

Committee, and M. L. Parsons, B.C. Region manager, tabled a joint memorandum recommending "that Klohn Leonoff's objective be to install a microcomputer system, with networking, to serve word processing and engineering functions throughout [the] B.C. Region and corporate office." The report recommended the immediate procurement of "5 micros, plus network with file server, plus laser printer." However, "if budget restraints govern," continued the memo, the networking system could be delayed.[76] As a first priority, four of the micros would replace the Burroughs Redactron word processors, in use for eleven years, which were now considered obsolete. The fifth micro would be dedicated to filing purposes. (Shelagh McKenzie, the Records Department filing clerk, in a previous memo had provided justification for computerization of all filing records in a database.) Engineering functions on these machines would be given a lower priority during regular working hours, as four engineering micros were already in use. The Board approved the budget for the system, less the networking. By the end of the year, this system was installed.

By the first quarter of 1988, twenty computer work stations were in place in the corporate and regional offices, handling word processing, engineering, and drafting functions.[77] An appropriate degree of compatibility was maintained between engineering and word processing facilities, with each microcomputer work station consisting of an IBM-compatible having only minor variations in its peripheral components. By mid-1989, the company had leased twenty-six personal computers for employees, and included in the lease an employee buy-out option.[78] Today the company owns over 100 computers, 80 of these in the Richmond office.[79] Two computer technologists in the Richmond office, Keith Funk and Burk Forrer, provide computer support services which include hardware purchase, maintenance, upgrading, training, and software development. The long-term goal remains to implement a shared network system in order to allow a common database, flexible transfer of files, and electronic mail.

In its forty years of operation, Klohn Leonoff has been steadily generating, receiving, and storing paper documentation—project files, business minutes, accounting data, and reference materials. For its size, the company has collected a prodigious amount of records. In the Vancouver-Richmond office alone, these comprise 40 million tons of file documents made up of 2 million pieces of paper covering 6,000 projects, and a 14,000-volume reference library. In addition, the Calgary office houses the records of the Prairie operations. This material represents a vital corporate resource which the company depends on as an accurate, readily available tool to assist in management decision-making, to provide a permanent projects record and historical reference, to supply engineering precedents, to document compliance with standards and regulatory requirements, and, where needed, to provide litigation support.

From the beginning, basic rules and procedures were employed to file and catalogue the documents. Initially a part of the secretarial duties, in the busy period of the late 1970s a full-time records clerk, Shelagh McKenzie, was employed, and she provided yeoman service in organizing and processing the material. As well during this period, until 1982, the library was managed by professional librarians—successively Pat Emory and Treva C. Ricou. However, during the recession of the 1980s, there was no trained librarian on staff, and the work was handled on a part-time basis by Caroline Lewis, then a college student. In the post-recession boom period, with the amount of paperwork increasing exponentially, and with a cataloguing and filing backlog clogging both the records room and the library, it became apparent that the procedures being utilized were not appropriate to the volume of material being generated. Company management recognized that the implementation of a formalized records management program, following contemporary policy and practice standards in this field, was now necessary.

In June 1987, John Michael Bolton was engaged as manager of the Library and Records Department. Bolton's technical background is of particular pertinence to the company because, prior to receiving a master of library science degree at UBC (1987), he had obtained bachelor of environmental studies and master of arts in geography degrees from central Canadian universities, thereafter spending five years as field supervisor and party manager of seismic crews on geophysical explorations in Alberta. In June 1989, Elaine C. Dawson, who had worked for a time under Treva Ricou, joined the KL staff permanently as records management assistant, replacing the retired Shelagh McKenzie. Trained as a library science technologist at Loyola College in Montreal, Elaine has had extensive experience as a library assistant and records clerk in industry and the professions.

Bolton immediately set about certain housekeeping duties—processing the backlog, records maintenance and upkeep work, acquiring shelving and pursuing the physical reorganization of the collection to provide for better access and growth, library acquisitions, and journal subscription services. But more importantly, assisted by Dawson, he began to develop and implement a long-term strategy for the creation of an efficient, cost-effective information management program, subject to review by a Library and Records Committee and final approval by senior management. This program has included the production of a new subject index and classification system for the library collection, upgrading of the project file system, and the development of a retention and weeding policy to identify essential records and avoid the storage of unnecessary material. Increased security was obtained by centralizing files in a secured records centre equipped with a fire and smoke detection system. A disaster plan was prepared to ensure that important records are saved in the event of flood, fire, and other hazards. As well, a "vital records program" has been established that will identify, locate, and safeguard all documents that are essential to the operation of the company.

A corporate archives has also been established to prepare, preserve, and house those written documents, photographs, and physical items that represent the corporate memory of the company. These materials are a valuable resource that can be used by management to review and develop corporate strategies and policies. As well, some historical project data dating back to the first days of the company (Kitimat, Cleveland, and Seymour dams for example) are still in active use. But paper documentation is subject to deterioration with age and handling, and eventually could be lost.

The indexes and finding aids for the project files and library have been automated through the use of IBM-AT-compatible microcomputers and GENCAT software. A database has been built of project records and information, augmented by the long-term loading of historical data.

Ultimately, in order to reduce volume, provide secure archival storage, and fast retrieval, the plan is to transfer all written documents and drawings to CD-ROM (compact disk-read only memory), an analog digital system. This state-of-the-art electronic technology has the capability of accepting material directly from word-processing and CAD drafting work stations (or by scanning from existing paper documents) and filing it in a compact cabinet, thereby providing access to millions of documents without the physical space and handling problems of conventional storage. With this system, retrieval and viewing of any document is possible from any work station on a microcomputer network.[80]

Traditionally the role of "personnel" manager, or in currently more fashionable parlance, "human resources" manager, was the responsibility of the company's chief executive officer. This role has included staff recruitment, setting and co-ordination of salary levels, employee contracts, conditions of employment, employee benefit plans, performance evaluations, and counselling. And it may be fairly claimed that, since its inception, RKL's recruitment policies have been equitable as to gender, race, and creed and, once the company began to formally organize, staff policies have been consistently progressive for their time and industry. Cyril Leonoff handled the human resources duties for RKL from 1962 until his retirement in 1985. As the company grew into various regions and divisions, details of this work were delegated to the respective managers, while secretarial support staff have been handled by the head secretary or office services manager.

For several decades, provincial labour codes (and professional practice standards for those having control of their own time) have governed such conditions as minimum wages, hours of work, breaks, overtime, statutory holidays, annual vacations, sick and maternity leaves, and terminations. However, in recent times, society's expectations and government regulations have expanded to include other situations in the work place such as health and safety, harassment, and employment equity.

On March 15, 1988, Klohn Leonoff Ltd. registered under the Federal Contractors Program For Employment Equity,[81] an action which is mandatory for companies having a hundred or more employees and Government of Canada contracts in excess of $200,000. Contractors are required to make a corporate commitment to achieving employment equity—to prepare an appropriate plan and be subject to monitoring as to compliance. As defined, "A fundamental principle of employment equity is the elimination of both actual and potential barriers to employment and advancement of designated group members within the organization."[82] KL is a performance-oriented company and has always selected and promoted engineering, technical, and administrative staff solely on the basis of skill. Because of this historical approach, the government equity program has simply served to reinforce the standards that the company had already set for itself.[83]

As a result of the company's growth and issues such as employment equity, in 1989 the Corporate Committee approved the establishment of a human resources function within the corporate office to "encompass all matters relating to personnel within the firm."[84] By mid-1990, this position was temporarily filled by a man who had experience in implementing the employment equity program for a federal government department. And in December 1990, Ruth Ann Manshreck was engaged as manager of the Human Resources Department in the corporate office, reporting to the chief operating officer.

Ann Manshreck graduated in 1984 with a B.A. (Honours) in English literature from Laurentian University, Sudbury, Ontario. But her work experience as a student and after graduation was in the fields of personnel administration and industrial relations, in industry and in consulting practice. In 1988 she graduated with an M.Sc. in industrial relations and personnel management from the London School of Economics and Political Science, and had relevant work experience in England before joining Klohn Leonoff.

In her tenure at KL, Manshreck has carried out a complete review of her department that has resulted in standardization of human resources policies and procedures and the redesign of the performance evaluation system. She has developed a harassment policy,[85] and an employment equity plan that successfully passed a compliance review by the federal government.[86] She has also developed a health and safety program that has met with Workers' Compensation Board approval[87] and provided information on hazardous materials in the work place to technical and engineering staff.

By the end of 1988, in order to seek out and procure, on a long-term basis, major jobs in North America that would utilize the skills of the multidisciplinary engineering firm that Klohn Leonoff had become, the Corporate Committee and the board recognized the necessity of reinstating the position of corporate marketing manager. As well, there was the need for internal organization and co-ordination of the business development functions of the individual regions and divisions. In February 1989, Arthur Alexander was hired to fill this position. A professional engineer by training, when he was hired Alexander already possessed an extensive background in the mining industry, public relations, business, and in entrepreneurial property and resource development.[88]

"Art" Alexander, born in 1937, is descended from pioneers of both the Alberta and British Columbia sectors of the Peace River district. His paternal grandfather left Scotland to homestead in the Spirit River region of Alberta where he farmed and, in the off-season, logged. His life ended as the result of a logging accident which occurred in the Mackenzie River Delta. Art's maternal grandfather built the first building in Taylor Flats, B.C. and was a lineman on the telegraph line to Alaska that went through Telegraph Creek in northwestern British Columbia. Art's mother was born in Telegraph Creek. After she married Art's father, they ran a store in Hudson Hope, B.C. (now the site of the W. A. C. Bennett Dam.) But his father died when Art was just a year old, and his mother went on to work as a civilian employee of the Department of National Defence Western Command headquarters, back and forth between Edmonton and Vancouver. As a result Art's upbringing was, in his own description, as that of a "pseudo army brat."

Like many descendants of pioneering families, Alexander sought upward mobility by attending the University of Alberta. Of the eight faculties then at the university, only two interested him—engineering and law. "For better or worse," he chose engineering. In 1959 Alexander was a member of the second class in metallurgical engineering to graduate from that institution. "Graduates were in demand in those days," says Art, "I wrote ten letters and got four job offers." He obtained employment as a research engineer with the International Nickel Company of Canada at Port Colborne, Ontario, in charge of experimental gas clean-up devices. But the technology was not that reliable, and despite wearing a mask, he was gassed quite harshly by sulphur dioxide fumes. Needing oxygen to purge his lungs, he sought a cure by working as a mill metallurgist for the American Smelting and Refining Company in the isolated north-central highlands of Mexico. With his health restored after two years in Mexico, he went right back to the smelters, working as a research engineer at Flin Flon, Manitoba for the Hudson Bay Mining and Smelting Company, then engaged in smelting copper and refining lead and zinc by electrolytic means. However, while he enjoyed the work, after having worked in the industry for six years, again for health reasons, Alexander decided on a career change.

With a wife and two young children, and thus "a need to put bread on the table," Alexander secured a job in Vancouver as an engineer-credit officer with the Industrial Development Bank (now the Federal Business Development Bank), a crown lending institution. This was his baptism into big business, which, he says, was "like taking an MBA" on the job. The job was to assess the technical-financial validity of major loan applications initiated by clients, writing up and securing approval for the loans, then monitoring the client's performance. Projects he processed included the development of storage and moving facilities for a major bulk loading terminal on the West Coast, and the financing of sea-going tugs and self-loading, self-dumping log barges (then new technology) for coastal towing companies. As an engineer working with senior accountants and vice-presidents of finance of these large companies, Alexander received a thorough education on the financial aspects of such projects:

"You worked with these seven, eight-million-dollar loan accounts. After analyzing fifty to a hundred financial statements a year, it got to the point where I could pull apart a consolidated statement of twenty-six subsidiary companies and look at what was happening, because you had to make sure that there was no skulduggery going on that you couldn't put your finger on."

After spending five years, from 1965 to 1970, on this job, Alexander concludes, "I had the largest portfolio in B.C., maybe Canada, and was uniquely placed, as I was one of only a few engineer-credit officers in Canada responsible for tracking these big loans." But promotion within the bank required a move to head office in Montreal for training, followed by a posting to anywhere in Canada. By then, "married" to Vancouver, and at that stage of life unwilling to resume an itinerant lifestyle, he resigned.

Art Alexander returned to the mining industry, this time as executive assistant to the managing director of the Mining Association of British Columbia. The Association is essentially a co-ordinating and lobby group in the areas of public, government, and labour relations, and represents approximately 100 mining companies. But, three years after assuming his new position, the Granby Mining Corporation "raided" the Mining Association and acquired Alexander to serve in the capacities of manager of corporate and industrial relations, treasurer, and assistant to the president. He was responsible for public relations, personnel, and was chief labour negotiator for the company with its 400-person workforce. Coincidentally, Granby Mining was a client of Klohn Leonoff, who did the dam design and slope stability for their Granisle mine, and the reclamation studies for their Phoenix mine, both in British Columbia. At this time, Granby had just been bought by the Zapata Corporation, an American multinational public company that was, as Alexander puts it, "run by a bunch of Harvard MBAs who emphasized the product diversification route that was very popular in the early seventies." (George Bush was one of the founders of the company.) " Zapata Granby" was to become their mining arm for properties in Canada and the United States. However, because of its majority U.S. ownership, the company came under the scrutiny of the federal Foreign Investment Review Act, and in 1979 was sold to the Noranda Mining Corporation of Canada. All senior managers were asked to leave.

Arthur Alexander

For the next decade, Art Alexander became a principal and manager of a number of British Columbia companies engaged in heavy industrial, commercial, residential, and recreational land development. His group acquired from the Anaconda Copper Company the defunct, historic Britannia Mine property on Howe Sound. Comprising a town site with 132 buildings, 2,300 acres of land which included four miles of waterfront, 25,000 acres of mining claims, an ongoing logging operation, and the tourist potential of a mining museum, this property "represented one hell of a real-estate business acquisition." For five years, Alexander acted as president and manager of the property. However the recession of the eighties set in, thwarting the partners' development plans.

One of the interesting sidelights of the terms of purchase from Anaconda was the gift of the immediate mill site, the mining museum, and an underground tunnel to the B.C. Museum of Mining, a non-profit society in which Alexander had been very active. The mine site had been discovered in 1898 by a trapper—he reported a literal "mountain of copper" along the east shore of Howe Sound, thirty-five miles north of Vancouver. Joseph Boscowitz, a pioneer Victoria businessman, and his sons did the early financing and developing of the famous "Jane" claim at level 1,050 (feet) on the property. A giant in the development of B.C.'s mining industry, by the time the Britannia mine closed in 1974, it had produced more than 50 million tons of 1.25 percent copper ore, yielding in excess of 1 billion pounds of copper for the world market.[89] In May 1989 the mine was dedicated as a national historic site.

At Klohn Leonoff, in reporting to the executive vice-president, Alexander's mandate is fourfold: to pursue business prospects in all sectors of the company and particularly in multidisciplinary projects; to assist regional and divisional managers in identification of business opportunities, presentations, and proposals to clients; to update and control all business development materials and aids (project sheets, brochures, résumés, etc.) and edit the company newsletter; and to represent the company on appropriate engineering, business, community, and political committees, and at functions.

In pursuing this mandate, Alexander has his own clear modus operandi:

"Obviously my aspirations reflect the aspirations of the Board of Directors. I see, as one of my roles, making proposals to the board on new initiatives. My feeling is that somewhere down the road we'll be a much bigger and much more diversified company, [recognized] as general engineers. I see no reason why we can't be. We're certainly able to demonstrate that in our current portfolio of projects.

"I'm a great believer in management by objectives. This involves sitting down with the division managers—high-powered, highly intelligent, highly motivated people—and getting them to agree on a common objective. Obviously they're prepared to be co-operative [if] you have clear-cut objectives, clear-cut timetables, and clear-cut ideas of how you get there. I think engineers are very suited to management by objectives, because that's what project management and engineering management are all about.

"My attitude is that obviously we have a bank of skills that we can market. But I don't see much point in chasing anything [unless] there's funding available and likely to be allocated. Who has the dollars and where are they investing them? And then, if that's a marriage with your skills, that's what you chase.

"The pursuit of major mining companies headquartered in North America, be they operating in Canada, the U.S. or overseas is a major objective. We want to be a prime contractor. Therefore we need project managers. We have to have a core group that can handle enough of the work that pops out of a major project. [Where we require other skills on a multidiscipline job], my own business background says the last thing you want to do is go out and hire these people. You want to find associates who are very strong in the areas you need, who come in under your umbrella [or joint venture with you].

"I see my job as getting short-listed. After that it's up to our professional engineers to win the job. I see, too, as part of my role the lobbying that's required on the major projects. You might get short-listed but you don't necessarily win unless you do the full lobby.

"My third area of responsibility is developing brochures and SOQs [statements of qualifications]. I think I can do the most good by initiating computerized data banks for projects—let's call it boilerplate corporate descriptions. Once you get the data bank built up, with key word search capability, anybody goes to records, picks up the disk, throws it on the machine. This'll give all the elements, and you can pull out the ones you want. And if you want to know, it'll kick out every project that we've ever worked on. Better than reinventing the wheel!"

In mid-1990 Arthur Alexander became vice-president of marketing for Klohn Leonoff. At the time of this writing he is president-elect of the Consulting Engineers of British Columbia (CEBC).

Klohn Leonoff has of course historically participated in highway, railway, and municipal transportation (surface and underground) projects, but usually in a specialist, sub-consultant role. However, with the current push towards diversification and generalization, KL has more recently striven to take a principal role, usually in consortia with established firms, in transportation-transit engineering. Four major projects, carried out in the last five years, illustrate KL's present work in this field.

In 1987–88 Klohn Leonoff carried out[90] a technical analysis, preliminary design, and cost estimate of a deep tunnel option for the Regional Municipality of Ottawa-Carleton Central Area Transitway—the first line of a rapid transit system for downtown Ottawa. Three main tunnel alignments were studied, each with combinations of twin single-lane tunnels beneath two adjacent streets, or one double-lane tunnel beneath one street. The tunnel schemes were compared on the basis of construction costs, schedule lengths, environmental impact, disturbance to traffic, and potential for future expansion.

The best overall selection was a twin tunnel scheme at a cost of $102 million (1988 dollars). The rock underlying downtown Ottawa consists mainly of sound limestone, which provides an ideal material for an underground transitway. Underground excavation, with a tunnel boring machine and a mobile miner, will not cause any disturbance to the traffic or to the public at street level.[91] To date, the work has not proceeded to the final design and construction phases.

In 1990, the Province of British Columbia, through the Ministry of Energy, Mines and Petroleum Resources (MEMPR), undertook to assist, on a cost-recovery basis, mineral exploration and development of new mines in northwestern British Columbia. A corporation was established to build and own a 96-kilometre-long resource road from Bob Quinn on provincial Highway 37 through to gold properties near Bronson and Eskay creeks. An advisory council, including representatives of the mining companies, the Tahltan Tribal Council, and the Kitimat-Stikine Regional District, was formed to help ensure that the road will meet environmental standards and other regional needs. The road, located in the Iskut River valley in the Coast Mountains of northwestern British Columbia, running in a southwesterly direction, parallels the south side of the Iskut River between Ninqunsaw River and Bronson Creek, tributaries to the Iskut. The Eskay Creek branch, paralleling Volcano Creek in a southeasterly direction, climbs out of the Iskut Valley into alpine terrain.

At the beginning of August 1990, MEMPR, co-sponsored by Cominco Metals (SNIP Bronson Creek property) and Corona Corporation (Eskay Creek property), commissioned Klohn Leonoff, under project manager Robert T. Tape, to lead a multidisciplinary team of engineering, environmental, and archaeological specialists in carrying out the Iskut Road study. Complying with the terms of reference for urgency, the field work—route reconnaissance and surveying, aquatic and wildlife studies, archaeology and heritage site investigations—was fast-tracked from August through October, before winter set in. Final reports on the study, road design, and cost of construction were issued in seven volumes by the end of March 1991, after review and comment by government environment, forestry, and fishery agencies, and a technical/permitting committee.

The Iskut Road was designed as a single lane, 5-metre-wide gravel road having a nominal design speed of 60 kilometres per hour. The mountainous terrain, however, will require increased width and reduced speed at several locations. Passing turnouts are to be provided at regular intervals. Nine major bridge crossings were identified. Additionally, three smaller bridges were recommended to accommodate fisheries concerns. Measures recommended to mitigate effects of the road on wildlife include buffer zones around sensitive areas, limiting road access and sight-line distance, as well as wildlife monitoring and management programs. No new archaeological and no heritage sites were found within the road corridor.[92]

In January 1991, Klohn Leonoff Ltd., in association with Buckland & Taylor Ltd. and Graeme & Murray Consultants Ltd., was awarded a contract by the B.C. Ministry of Transportation and Highways (MOTH) to carry out a functional design for 28 kilometres of provincial Highway 99 between the Caulfeild Interchange in West Vancouver, and Furry Creek, just south of Britannia Beach. This section of highway is the most mountainous part of an overall intended upgrading, to four-lane expressway standards, of the 100-kilometre-long "Sea to Sky Highway" running from Metropolitan Vancouver to Whistler, a world-class ski and recreation resort.

Opened in 1959, the existing two-lane highway follows the eastern coastline of Howe Sound from Horseshoe Bay to the community of Squamish, at the head of the Sound and 60 kilometres southwest of Whistler. Probably the most precipitous highway terrain in North America, this coastal corridor is characterized by the rugged, steep, forested slopes of the Coast Mountains ascending abruptly from the shoreline to elevations in excess of 1,000 metres. These mountains experience high annual precipitation (averaging 1,600 millimetres or 63 inches) in the form of rain, sleet, and snow. More than sixty small watersheds drain directly into the sound via high-gradient creeks. Creek flows range from very shallow during periods of low summer rainfall, to torrential floods caused by high runoff mainly in the fall and winter seasons. The combination of these conditions presents a unique set of natural hazards for highway traffic—rockfalls, debris flows in the creeks, floods, limited visibility, and slippery driving conditions, all of which have contributed to high maintenance costs, traffic closures, injuries, and fatalities over the years.

The highway is of considerable economic significance since it provides access for resource extraction (chiefly mining and forestry), tourism and recreation, as well as for commercial traffic and commuters from small communities such as Squamish and Pemberton. The route has special scenic interest in that it provides spectacular views of Howe Sound and its surrounding mountains, and access to Garibaldi Provincial Park, in addition to the major resort destination of Whistler.

The alignment of the existing two-lane highway is characterized by numerous sharp curves and limited sight distance, allowing maximum speeds of only 50 to 80 kilometres per hour. Although local improvements have been carried out over the years, potential closures owing to blockages and dangers to the public are of ongoing concern. With ever-increasing traffic volumes, it is essential that a safe highway be provided that is available during all seasons.

Reconnaissance along the Horseshoe Bay to Squamish Highway (B.C. No. 99), from Tunnel Point to Loggers' Creek, from left: Ray Benson, Mano Walia, Clifford Tsang, Mark Olsen, June 1988.

The proposed "Sea to Sky Highway" design by the KL group, under the direction of Mano Walia, would provide a standard four-lane expressway having a design speed of 90 kilometres per hour. It would require an unprecedented combination of bridges, viaducts, rock cuts, retaining walls, debris basin structures, and tunnels. Major structures include nine bridges, four viaducts, and five twin tunnels 14.5 kilometres in length. Overall cost is estimated to be $600 million. Since this is the only direct route to and from Vancouver, KL has designed a unique "temporary tunnel," which will allow the traffic flow to continue safely while the rock cuts and highway construction are proceeding. As part of this commission, an alternate corridor along Indian Arm was investigated, but was found to be just as hazardous and costly.[93]

On August 20, 1991, a Klohn Leonoff-led team, in competition with ten major engineering companies, was retained by the Canadian National Railways to carry out a feasibility study and cost estimate for upgrading of the St. Clair River Tunnel, crossing between Sarnia in Canada and Port Huron in the U.S.A.[94] The study coincided almost exactly with the tunnel's centennial (the inaugural train made the first official trip through the tunnel on September 19, 1891), making it one of the few engineering works in North America that has served its original function, virtually unchanged, for 100 years. Built by the Grand Trunk Railway to connect southwestern Ontario and eastern Michigan, replacing an earlier ferry, this historic tunnel has provided Canada with its primary link to Chicago, centre of the North American railroad universe.

In 1891, during the heyday of this continent's railroad building era, the construction progress of the St. Clair Tunnel was daily news, widely reported in trade journals around the world. The project was considered an engineering marvel, given that the bore was being driven through perilous soft clay beneath the riverbed. In the twentieth century, however, until its history was published[95] and the current CN initiative arose, the tunnel has been largely forgotten by the public.

To build the original tunnel, a company was incorporated, and Joseph Hobson, a Canadian engineer born in 1834 at Guelph, Ontario, was appointed chief engineer responsible for the design and construction (Chapter 1). Two previous attempts at driving a tunnel beneath the St. Clair River had failed, but now Hobson's "combination of daring, tenacity and engineering knowledge" seemed to provide just the right ingredients for the success of such a demanding project.[96] Test borings taken in 1888 showed that the riverbed consisted of a thin layer of "treacherous blue clay" above a black shale bedrock. The 21-foot-diameter tunnel would be bored through the clay, leaving a minimum 10-foot-thick clay liner over the bedrock, to prevent gas generated in the bedrock from intruding into the tunnel. The clay layer above the crown was so thin—only 10 to 12 feet—that, while digging the tunnel, workers claimed that they could hear the bands playing aboard steamers passing overhead. To contend with the combination of soft clay, water pressure, and gas encountered in the driving, "shield tunnelling" was chosen, then a relatively new technology developed for tunnels under the Thames River in England. With this method, a steel shell is moved through the earth to protect the tunnel head from collapsing until a permanent lining can be put in place.

Hobson set about designing two huge cylindrical shields—they would work concurrently from the Canadian and American sides. The largest of their type yet produced, weighing 80 tons each, they measured 21 feet 6 inches in diameter and 15 feet 3 inches long. Fabricated from 1-inch steel plates, bolted together through flanges on the inside, they presented a smooth surface to the "slippery blue clay" through which the knifelike leading edges would be driven, "like a giant cookie cutter." The steady propulsion of the shield was to be gained by means of twenty-four hydraulic rams spaced at equal intervals around the circumference of the shield. Both shields were produced by the Hamilton Bridge and Tool Company, since, surprisingly, Hobson was unable to find a U.S. manufacturer willing to build a shield. This meant that he was obliged to pay duty on the shield used on the American side. The job of removing the tons of blue clay—men using hand shovels and spades—was described as "brutal back-breaking labour every inch of the way." Compressed air was used in the shields under the river in order to reduce the amount of material that crept into the excavation. The "spoil" was removed by light four-wheel horse-or mule-driven rail cars holding 1 cubic yard each. The hydraulic rams could be worked independently, allowing the surveyors to correct for any misalignment—even a small error could have rendered the tunnel useless for rail traffic. When the two shields met edge to edge, they were exactly in line horizontally, and out only a quarter of an inch vertically.

To permanently line the tunnel, in order to overcome the forces of the semi-liquid clay, the Grand Trunk managers decided that something sturdier than the usual masonry was required. They chose a series of rings made up of cast-iron segments bolted together. The castings were poured at the Grand Trunk shops in Hamilton and at the Detroit Wheel and Foundry Company works. A special crane was designed to set them into place as soon as the shield moved forward. Contract for the stone masonry retaining walls of the approach cuts and decorative portals was let to Wm. Gibson, MP, of Beamsville, Ontario. Several landslides delayed this work, requiring widening of the cuts and enlargement of the retaining walls. The final cost of the tunnel was $2.7 million, of which $375,000 was a subsidy from the Canadian government.[97]

Having survived a century of active service, the St. Clair River Tunnel remains a testament to the skills of its engineers, surveyors, and builders. The construction of the first international tunnel in North America also marked a variety of other "firsts" in tunnel engineering: first subaqueous tunnel in North America; first major use of hydraulic rams to move a shield; first large-diameter tunnel to use a segmental cast-iron lining; and first design and use of a "segment hoist" erector arm to place the liner segments. Several of the techniques utilized in digging the tunnel are still used in the modern tunnel boring machine, and numerous of the construction practices employed are now regarded as standard.

The St. Clair Tunnel was made obsolescent not by any failure in its engineering, but by modern traffic requirements. Currently some 200,000 rail cars cross the St. Clair annually. "The way of the future" is inter-modal rail systems, such as double-stack container cars and tri-level auto cars, which require increased clearance. The old tunnel is simply too small to allow their passage. Since their introduction in recent years, such units have had to be decoupled from trains, moved across the river by barge and tug, then recoupled on the opposite bank—a costly and time-consuming operation.[98]

Klohn Leonoff's assignment was to determine the most practical and cost-effective method of improving the capacity of the crossing. Possible options included enlargement of the existing tunnel, a new parallel tunnel, a deep-rock tunnel, a water-submerged tube, and a bridge. As well, the validity of the null (do nothing) option would be considered. For this study, which was to be fast-tracked to allow CN to make a decision by December 1991, KL in association with Giffels Associates Limited of Toronto assembled a team of engineering, tunnelling, and environmental specialists that had worked on more than a hundred tunnel assignments throughout the world. Principals in charge of the project were Ray Benson and Ernest Portfors, while Sandy McDonald, who will be remembered for his work on the B.C. Tumbler Ridge Branch Line tunnels (Chapter 13), returned to the company as project manager. Tragically, after completion of the assignment, Sandy died as the result of an accident in Ghana.

In early October, KL presented to CN an "Assessment of Options" report. Evaluation of the various alternatives identified that a new larger tunnel, driven approximately 100 feet north of the existing one, would be the least costly and safest solution, also causing the least rail traffic disruption and environmental damage.[99] KL was then authorized to proceed with a detailed feasibility assessment of the recommended option. In December the KL project team again reported to the CN Board of Directors and Grand Trunk Western (representing the U.S. side of the

St. Clair Tunnel Company 0–10–0 engine emerges from the Sarnia Portal "amid a cloud of steam and smoke," ca. 1900.
Photo: Lambton County Library

tunnel).[100] Their recommendations were accepted, and the following news release was issued in December 1991:

"Canadian National Railways announced today it will build a new $155 million tunnel and associated infrastructure to increase CN's international competitiveness and streamline the flow of rail freight between Canada and the United States through the Sarnia-Port Huron gateway.

"Ron Lawless, CN president and CEO, said the new tunnel will be open for business in [September] 1994 and will save 12 hours in transit time for freight which now moves through a smaller railway tunnel and by river barge across the St. Clair River.

"The new 6,000-ft tunnel will have an overall dimension of 31-ft. It will be large enough to handle all types of rail traffic, including double-stack container trains and multi-level auto carriers, and to accommodate future advances in railway transportation and technology. . . . The project is the latest in a series of moves by CN to reinforce its strengths in the North American freight transportation and distribution market. . . .

"The new tunnel . . . was recommended as the most cost-effective and environmentally-compatible option in an engineering review which CN commissioned by international consultants Klohn Leonoff Ltd. . . . [who] assisted CN in preparing necessary engineering drawings for the project and related documentation for regulatory and participating agencies in both countries."[101]

Like its illustrious predecessor, the new tunnel will be driven through the St. Clair clay, passing above the bedrock surface, with a minimum 15 feet of cover (for safety) between the tunnel crown and the riverbed. However, in the century between, construction techniques have greatly advanced. Chief among these is the tunnel boring machine (TBM) with rotating cutters in the head, a device that eliminates hand digging.

In order to ensure that the most appropriate state-of-the-art technology is utilized, a world-wide survey of suitable TBMs and liner systems was made. (Soft-soil TBM technology is most advanced in Germany, Austria, Japan, and Canada.) The tunnel will be excavated by a closed-face TBM and simultaneously lined with segmented and gasketed reinforced concrete. Liner production will require a sophisticated manufacturing operation with a specific plant set-up, and could come from either an international or Canadian supplier.

Summit to summit, the length of the project is over two miles (12,497 feet). Enlargement of the approach cuts on both the Sarnia and Port Huron sides will involve excavation of 1 million cubic yards of material, the construction of retaining walls and drainage systems, and extensive landscaping. Recalling the landslides which hindered the construction of the approaches to the original tunnel, this time a geotechnical program is recommended to develop designs that ensure stability of the cuts, retaining walls, and portals.[102]

Unlike the original construction, where environmental concerns were minimal, licensing today involves, amazingly, approvals of more than fifty agencies in Canada and the United States. As part of the feasibility study, an environmental evaluation report was prepared which identifies potential impacts on the natural and socio-economic environments, and suggests mitigating measures.[103] Initial contact with the interested agencies has not revealed any strong resistance to the project nor any possible consequences that can not be reasonably tempered. Nevertheless, since such approvals are critical to the construction scheduling, KL has maintained a staff of five persons on the job to handle environmental, regulatory, and native issues.

The feasibility study included a capital cost analysis and project schedule. Various contractual approaches and their project schedules were considered, including traditional tendering and "design-build." In consultation with CN, the Negotiated Compressed Process (NCP) was selected, involving an accelerated project schedule of thirty-three months.[104] To implement the NCP, a Technical Advisory Committee, chaired by Ray Benson, was struck in order to pre-qualify contractors for competitive bidding on both the TBM and the liner. The TBM, which requires a delivery time of twelve to fifteen months, is the most crucial item on the critical path. Based on technical considerations, costs, and delivery, Lovat Tunnel Equipment Inc., a Toronto-based firm, was selected over its European and Japanese competitors. The contract is valued at about $15 million, with delivery scheduled for early 1993.[105]

To avoid traffic disruption, the existing tunnel will be kept in service until the new one is in operation, then abandoned. The century-old stone masonry portals on both the Canadian and American sides will be preserved as historic sites.

As a result of the St. Clair job, in September 1991, Klohn Leonoff opened a long-awaited Toronto Metropolitan office in Don Mills, Ontario.

Chapter Fifteen

REFLECTIONS

In its first decade, Ripley and Associates was among the earliest to introduce the relatively new science of soil mechanics into general practice in British Columbia. Particularly the firm pioneered in the sphere of industrial plant site foundations on soft settling soils, and in the techniques of earthwork construction of water storage and hydroelectric dams. The end of the decade witnessed the adoption of soil mechanics (later geotechnical engineering) as a conventional tool in civil engineering design and construction.

In the second decade of its existence, Ripley, Klohn & Leonoff expanded the geographic area of the firm's operations into the Prairie region of Canada. During this period, the company pioneered in the design of sand tailings dams to safely store the spoil generated by the huge open-pit mining operations that were beginning to proliferate in British Columbia. This expertise led to the securing of future North American and overseas assignments.

In its third decade, Klohn Leonoff was gaining expertise in northern construction, oil and gas pipeline and transportation routes, and materials searches in the permafrost region of Canada. In the latter half of this decade, KL was developing a water resources capability in the disciplines of hydraulics-hydrology. Combined with the company's earth dam experience, this led to assignments in the planning, design, and construction of major flood control and irrigation projects, particularly in the south-southeastern dry belt of Alberta.

During its third and fourth decades, KL achieved international repute and further assignments in the fields of earth and tailings dams, mine and hazardous waste disposal, materials searches, and water resource projects. By the end of the third decade, the company had established a United States corporation and business office. By the fourth decade, KL's services had diversified to provide project management in the fields of rock and tunnel engineering, transportation and highways, hydroelectric generation, heavy civil engineering works, environmental engineering, and international community development.

In celebration of the fortieth anniversary of the company, the management and staff of Klohn Leonoff Ltd. hosted an open house at their Richmond office on Wednesday, September 25, 1991.[1] Over 400 guests attended including clients, associates, suppliers, public officials, spouses, and friends. The event, convened by Art Alexander and corporate secretary Patricia Hunter, featured an office tour through various and ingenious displays which reflected "the hidden talents of those who labour quietly but effectively in the myriad nooks and crannies of the Richmond office."[2]

A circus-sized hospitality tent was erected on the parking lot on that warm, sunny day, where the official ceremonies were held. Earle Klohn and Cyril Leonoff jointly made the first cut of the anniversary cake. Present were a number of staff veterans of the fifties: Charles Ripley and Mark Olsen (1951); Bill Richards, Earle Klohn, Frank Pells and Cyril Leonoff (1952); Lars Anderson (1953), Peter Wiens (1955), and Ian Morrison (1956). Appropriate addresses were made by Chairman Klohn and President Ray Benson on the history, progress, and current status of the company.

The anniversary also gave pause for reflection by senior principals on their lifetime career and on their profession as a whole. Earle Klohn had few regrets to sully any of the rejoicing:

"I think, without hesitation, that I would do it again. I might do it a little differently, [not] as dumb as I started out the first time. [But] I have no regrets. I don't think I would have had the opportunity to be heading up and running a company like I am right now if I hadn't gone through what we went through. At one time I thought maybe I would go and get that Ph.D. that I had been looking at for umpteen years, but it is probably just as well that I didn't. . . . Life is a tortuous trail. You never know where the road is going to end until you get there. That's the long answer. But the short one is that I still love engineering. I am very happy with what I am doing."

Despite the success he has enjoyed, however, Klohn was frank about some of the personal sacrifices he has had to make:

"In all honesty, you pay a pretty heavy price along the way, because obviously you cannot be all things to all people. . . . In my own case, that problem is not a problem anymore. Unfortunately twenty-five years ago it was a hell of a problem, because I was working all the time. I [could not] control the travelling imposed upon me. I got so far behind that when I [returned] I was working every night and weekends. That's probably my fault and nobody else's. On the other hand, I suppose if I hadn't done that, I wouldn't have developed this much background . . . or experience. I think the primary [sacrifice] is your children. They are grown up before you find time to spend with them. It's too late for me to worry about that now."

Charles Ripley, in his comments, was able to easily articulate some of the reasons why Klohn has risen to the top of his profession and his company:

"I think Earle is a rare person, that he does combine remarkable characteristics. First, he is a leader. He sets a good example for men with regard to his technical capacity and obviously his administrative capacity. People like to work for Earle and he sets a high standard for them. Second, Earle has the ability to come into a new technical problem that he hasn't dealt with before, to look at the literature, to concentrate, to get on top of it very quickly, and to become authoritative in that subject. That showed up [at the beginning] with respect to the pile foundations at Port Alberni. . . . And that, to my recollection, happened with his introduction to [tailings] dams, [which] was to lead into project engineering, in a major way, for the company."

In looking retrospectively at his own career, and the company, from the vantage point of retirement, Ripley was his ever-positive self:

"To me, I have had a wonderful life. At university I had the opportunity to have [superior] teachers in undergraduate and at Harvard. On [our] work I had the opportunity to become acquainted with people like Simons, Dr. Dolmage, and Lazenby, also . . . to know well Dr. Terzaghi, Dr. Casagrande, and Dr. Peck, and many others in the United States. The work was so interesting. My philosophy is that a person is very fortunate if, through some way, he or she learns to love their work. We have twenty-four hours of every day to spend. Eight of it is sleeping, eight of it is eating and leisure time, and eight of it is in work. If you really take joy from your work, the other sixteen hours are [also] likely to be enjoyable. . . .

"I take a great deal of satisfaction in watching the progress of the company since I left it. And I have particularly enjoyed its success and its stature nationally and internationally. At the same time, I sometimes ponder the problems that there are in managing a much larger, more diverse company than the one we managed in the old days. And I realize that, while the young fellows now may not think in terms of the problems faced as the company evolved and grew, they face very serious problems in working in the environment of a larger company. . . ."

Klohn Leonoff Fortieth Anniversary open house, Richmond, B.C., September 25, 1991. Earle Klohn, left, and Cyril Leonoff cut the anniversary cake.
Credit: The Grapevine, Airport Executive Park, December 1991

While not denying the current problems defined by Charlie Ripley, Bob Maartman, in his reflections, wished to emphasize what he saw as the basis for KL's long-term success:

"The approach taken by the company is first rate. They bring people out and make them work harder. Young fellows come in here and they all learn eventually that the company's policy is to tell the truth. And if the client doesn't like it, we can't help it. In fact we have had a number of confrontations with our clients over the years, and almost invariably we have continued to work together. They appreciate it after the smoke clears."

Ray Benson echoed some of what Maartman had to say in stressing that the company always strives to be "as expert as possible." Adds Benson, "The company is oriented towards encouraging people to grow within their own fields of interest." This fact has contributed, in Earle Klohn's mind, to one of the key factors in Klohn Leonoff's success—the low turnover within its staff. "Our people become a part of the company," stated Klohn, "not just a position or a title, but a part of the team."

In considering the specifics of his own career with Klohn Leonoff, Ray Benson had no doubts whatsoever: "I have chosen absolutely the right career for myself. I never have had a moment's thought that I am in the wrong career—ever. I just love civil engineering, I love consulting engineering. I am one of the blessed people, actually."

Asked to what he attributes his success, Benson had no difficulty in being quite precise:

"Well, of course, I think God-given talents obviously. You have to have those or you don't understand and appreciate the work that you do. Otherwise, though, it is a combination of several things. One is that I came from a poor and difficult background and that I was determined to succeed. Two, I had the opportunity to work in a discipline (soil and rock mechanics), at a time when [it] was developing very strongly in Canada, and there were opportunities for people who wanted to get involved. The third, is that I have had the chance to work with absolutely outstanding engineers, people like Peterson, Conlon, Klohn, and a whole bunch of other engineers. But also the top consultants: Peck, Deere, Cooke,[3] Libby, and Casagrande. (Of course [being of a later generation] I had no association with Terzaghi). But I have made numerous presentations to, or sat on boards with, everyone of these people. So that has got to rub off on you if you like your profession. To have rubbed shoulders and wrestled over problems with the top men, if that doesn't turn you on, nothing will."

Ian Morrison, wasting few words, had only this to say: "It has been a lot of hard work at times, but yes, it has been a fulfilling profession."

Leonoff summed up his feelings at somewhat greater length:

"Having taken a part in the great post-war development of British Columbia has been a source of gratification. The ultimate satisfaction is in seeing that this baby we created has grown into a credible middle-aged company, not only in British Columbia and the Prairies, where it is one of the leading engineering companies, but internationally as well.

"One regret arises when I see young engineers now going out on international projects, travelling around the world and experiencing other cultures. In my days of doing engineering, when I was sent on field assignments, they were only up in the bush at Puntzi Mountain or Kitimat or Pine Point. My administrative responsibilities in the company evolved at a stage where I missed that part of the practice. Earle Klohn, who stayed with engineering, started to get consulting assignments world-wide, so I feel that I missed out on that life experience.

"I'd like the people who now carry on the work for this company to know that it didn't just happen without planning. I think that the new engineer who comes into the company today and sees a fairly large organization, with all these departments in motion, perhaps doesn't realize the trials and tribulations that the founders went through in introducing high-quality civil engineering into British Columbia."

Klohn Leonoff Fortieth Anniversary open house, Richmond, B.C., September 25, 1991. Earle Klohn addresses the gathering.
Photo: Cyril Leonoff

The chairman of the Civil Engineering Department of a prominent American university has called engineering "The Anonymous Profession":

"When the bridges that engineers dream of finally do become realities, there are usually grand-opening celebrations packed with politicians, businessmen and civic boosters. They all smile for the news photographers, and they all claim credit for their part in the great undertaking. What they seldom do is acknowledge adequately the engineers who made the crucial technical, economic, aesthetic and other key decisions without which the bridge could not stand, look or function as a monument to human planning and design, which are so intertwined with the very fabric of civilization. Monumental works so overshadow their engineers that we tend not even to remember the engineers' names."[4]

The principals at Klohn Leonoff are well aware of this reality, and are, to varying degrees, disconcerted by it. According to Earle Klohn: "The engineering profession is the most misunderstood and the most under-appreciated of any profession in the world. People who criticize engineering don't understand or don't wish to understand that they wouldn't have a light bulb to read by or a pen to write with or a car to drive in or a road to go on or a bridge to go over or water to drink or sewers or almost anything else in the world. I don't know how they think these things come about."

Ian Morrison points out the additional fact that, of all the different types of engineers, the geotechnical engineer is perhaps the least recognized, inasmuch as his or her work is often hidden underground, or completely inconspicuous. This in sharp contrast to the grand buildings or vaulting bridges built by other engineers which remain for decades as visible structures that the public cannot help but view.

Certainly the social status of engineers in general (and often their remuneration) seems to be less than that of other professions—the surgeon, the barrister, or the architect with his monumental buildings. But then it is probably also true that it is not typically in the engineer's nature to seek publicity. Admits Morrison: "It doesn't bother me at all that my name isn't in the news. I am afraid that I am not much of a horn tooter." Bob Maartman has described his attitude this way: "Ian and Mark [Olsen] are guys who think the same way as I do. They don't give a damn what people think about them. They just enjoy the problems."

While the Canadian and provincial governments are quick to proclaim that the economic future of Canada lies in being at the leading edge of technology, they seem reluctant to provide the necessary support, institutions, and funding to achieve this objective. Too often the greatest recognition


Fortieth Anniversary – Charles and Peter Lighthall.
Photo: Cyril Leonoff

of the geotechnical engineer and geoscientist comes in times of disaster. The current scare relating to earthquakes on the Pacific Coast of North America, with the impetus to build "earthquake-proof" structures, is but one example.

Ray Benson, while admitting that he is on the inside looking out, has put the problem into a Canadian context:

"It is just so ingrained into Canadian engineers that they are unrecognized—part of the Canadian psyche, but more so in engineering. [The] diminution . . . of engineering as a truly national institution in building a country like Canada is very unfortunate. I don't fathom . . . how we ever allowed ourselves to get into such a position of, I don't say low esteem, but certainly not the esteem that the profession should be held in.

"We have our provincial organizations and ACEC [the Association of Consulting Engineers of Canada] and all the formulae for being a strong, identifiable, recognizable . . . body. But the approach engineers have is one against the other. . . . They seem to jump at opportunities to criticize and to sue one another. . . . It is probably one of the reasons that you see enrollment down at the universities.

"What is required in Canada [is] truly to change the whole way we look at ourselves and our profession. I am not optimistic that that will change quickly. . . . I don't have the time to work [on] committees that can have an impact. But we won't do it from here [Vancouver]. The heavy [impact] is down in the power centres, Toronto and Montreal and Ottawa."

Ernest Portfors, who has held the top office in the provincial Association of Professional Engineers (the profession's licensing body), has focused on the roots of the problem:

"The Consulting Engineers of British Columbia (CEBC) is really a trade organization, and their goal is to maximize exposure and work for consultants. Unfortunately, to my mind, they never have been very strong. I think the reason is that consultants tend to compete with each other so much that they are afraid to deal together in a group like CEBC."

"There is no question about it. Unfortunately, engineers don't get public recognition, because engineers aren't basically the sort of people [who] go out and beat their own drum. I think the only way [this] is going to change is if individuals in the profession are prepared to get into politics. Because the political level has to stand up for technology and engineers. We have [a few] engineers who are provincial and federal politicians. Some of them do a fairly good job and others are pretty mediocre. [But] you don't see as many engineers in politics as you do, for example, lawyers. I think by training, or perhaps it is by inclination, engineers have some difficulty with politics. My impression is that in order to succeed in [the political arena], you have to be prepared to tell the people what they want to hear, not what they should hear. We are trained to say things the way they are and to take our lumps."

Earth dams have been constructed by humankind since antiquity—the first extant records date back to about 4,000 B.C. Humankind has been concerned with stable foundations under dwelling places for an even longer time. Roman technology gave us the combination of natural elements which will coalesce into concrete, a material essentially unchanged today. In the twentieth century, new materials such as plastics, rubberized compounds, and metal alloys have greatly raised the sophistication of all engineering designs, geotechnical and otherwise. Regardless of these modern advancements, the men and women who work, and have worked, at Klohn Leonoff stand at the most recent end of a long line of men and women who have attempted to engineer the tactile world for the benefit of their fellow inhabitants.

Participation in the great post-war development of Canada, the betterment of life in Third World countries through KL's engineering works, and opportunities for world-wide travel and contact with other cultures, all these things have given Klohn Leonoff principals and staff a sense of inner satisfaction. Materially the company has also provided these individuals with a good, but not exorbitant lifestyle. With the success of these individuals has come the considerable success of the company. At the beginning of 1991, Klohn Leonoff Ltd. made the Arthur Andersen "Top 50" list as the 45th largest private company based in British Columbia, as profiled in *Business in Vancouver* magazine.[5] As well, KL ranked fifth largest of 105 member firms of the Consulting


Fortieth Anniversary – "Old-timers," from left: Lars Anderson, Peter Wiens, Bill Richards, Ian Morrison.
Photo: Cyril Leonoff

Engineers of British Columbia. However, by the end of the year, KL had moved up to second spot, ranking behind only H. A. Simons Ltd.[6]

The success which the company will enjoy in the years to come is of course almost impossible to predict. Consulting engineering will no doubt continue to be an aggressive, competitive business. In his 1991 year-end message to shareholders, Chairman Earle Klohn outlined some of the current trends in engineering, including in his message his own prognosis on the future of the company he now heads:

"It has become very apparent . . . that the globalization process which has had such a huge impact on the manufacturing and service industries is starting to be felt in the consulting engineering field. The net effect of globalization is to create large business units organized to operate in a very efficient manner, both internationally and domestically. Competition . . . is very fierce on all major projects. Most analysts predict that within the next few years only very large business units offering a wide range of products or services, or relatively small business units, offering very specialized products or services, will survive. Medium-sized firms will be unable to compete for the large projects and will be unable to survive on the small specialized projects. At its present size Klohn Leonoff would be considered to be a medium-sized consulting engineering firm.

"The obvious answers to survival in such an environment are diversification, joint ventures, and/or mergers. Klohn Leonoff has embarked on diversification in the areas of Community Services and Environmental Services. . . . Joint ventures have been actively pursued by Klohn Leonoff for several years. The most significant move in this direction was the formation of . . . Klohn-Crippen, a 50-50 joint venture with H. A. Simons, which merged the hydroelectric services of both companies. . . . Klohn Leonoff will continue to seek out joint venture partners for the pursuit of major projects. We will also consider setting up third company mergers, such as Klohn-Crippen, where such a move would enable us to successfully pursue work."[7]

Fortune magazine recently did a survey which concluded that most corporations do not continue beyond four decades of existence. Symptomatic of this trend, in recent times, the names of many of British Columbia's pioneering engineering and architectural firms have, sadly, disappeared, or the independence of such firms has been compromised by absorption as divisions of multidisciplinary, multinational companies. Happily, for four decades, Klohn Leonoff has succeeded in maintaining its identity and independence. Nevertheless, in the face of the global restructuring outlined by Earle Klohn in his 1991 address, the challenges currently encountered by a medium-sized engineering firm are very real and include navigating the ups and downs of volatile business cycles, raising equity capital, and developing skilled management. At the commencement of their fifth decade, Klohn Leonoff management and professional staff are carrying out an in-depth review of the company framework and engaging in thorough medium- to long-range strategic planning. Such an effort is designed to ensure that the company keeps its competitive edge, and that it is well positioned to maximize the opportunities that will arise in the changed business environment that will envelop the company as Klohn Leonoff moves towards the celebration of its golden anniversary.

Fortieth Aniversary - from left: Dorothy Ripley, Laura and Frank Pells.
Photo: Cyril Leonoff

EPILOGUE

In concluding his history of Klohn Leonoff, the author had wondered openly what the future might hold for the company. Modern modes of transportation and communication have made global economies a reality, with competition for major engineering assignments becoming increasingly international in scope. Consulting engineering companies are becoming ever larger and offering a far wider range of expertise and services. In addition, the manner in which engineering services are provided to clients is changing rapidly. Today many projects are marketed as complete packages at fixed prices. These packages often include engineering, procurement, construction, financing, and management requirements. To successfully pursue this work demands the bringing together of consortiums comprising several large companies, each having expertise in one or more of these areas. Entering the nineties, it was apparent that a medium-sized engineering company such as Klohn Leonoff would be hard-pressed to obtain a major role in this type of competition. The unanswered question was: "In future, how will Klohn Leonoff address this ever changing market place with its need for size and financial strength?" The answer to this question was not long in coming.

On July 3, 1993, Klohn Leonoff Ltd. officially merged with Klohn-Crippen Consultants Ltd. and the Crippen and Toronto divisions of H. A. Simons Ltd. to form a new company that will operate under the name of Klohn-Crippen[1]. The new company is managed by the former Klohn Leonoff management team and controlled by the former Klohn Leonoff shareholders. Earle Klohn is President and CEO[2].

The reasons for the merger, and the goals and objectives of the new Klohn-Crippen, were set out by Earle Klohn in the company's new brochure:

"Through the merger, our operating company, Klohn-Crippen Consultants Ltd., expands its range of multi-disciplinary services to encompass civil, energy, water resources, mining, geotechnical, transportation, industrial, process and environmental engineering and social development.

"Combining these well-known and long-established engineering firms enables us to more effectively meet the needs of all of our clients throughout Canada and internationally. It strengthens our consulting capacity and capabilities in all areas and, with over 300 employees in five offices in Vancouver, Richmond, Calgary, Toronto, and Sudbury, our ability to efficiently and effectively serve our many clients. Klohn-Crippen will also benefit from access to the resources of H. A. Simons Ltd., one of Canada's largest engineering consultants."

The merger has to date proceeded surprisingly smoothly, with the engineering and support staffs from all the companies involved coming together to form one large group of between 300 and 400 employees. Former competitors are now close allies, and all employees are reportedly striving avidly to make the new company a success. This would seem to bode well for the future of the new Klohn-Crippen. If the new corporation can in any way emulate the history of its parents, then future prospects for the new Klohn-Crippen should indeed be bright.

NOTES

Chapter One
SOIL MECHANICS: A NEW SCIENCE IS BORN AND COMES WEST

1. Charles Terzaghi, "Old Earth-Pressure Theories and New Test Results," *Engineering News-Record*, September 30, 1920, 632–37.

2. Dr. Karl von Terzaghi, Technische Hochschule, Vienna, "Closing Address of the President," *Proceedings of the International Conference on Soil Mechanics and Foundation Engineering*, June 22 to 26, 1936, vol. III (Cambridge, Mass.: Harvard Printing Office, December, 1964), 22–23.

3. President Karl Terzaghi, "Opening Session," *Proceedings of the Fourth International Conference on Soil Mechanics and Foundation Engineering*, August 12–24, 1957 (London: Butterworths Scientific Publications, 1958), vol. III, 55–58.

4. Prof. Çetin Soydemir, "Terzaghi's Period in Turkey (1916–1925)," *Terzaghi Memorial Lectures on Soil Mechanics and Foundation Engineering*, August 14–16, 1973 (Istanbul: Bogaziçi University, 1975), 212–29.

5. "Opening Session," 57.

6. Karl Terzaghi, "Past and Future of Applied Soil Mechanics," *Contributions to Soil Mechanics*, 1954–1962 (Boston Society of Civil Engineers, 1965), 404.

7. Karl Terzaghi, *Erdbaumechanik auf bodenphysikalischer Grundlage* (Leipzing und Wien: Franz Deuticke, 1925), reprinted 1976.

8. August 14, 1973, *Memorial Lectures*, II.

9. Obituary, by A. W. Skempton, *CGS News: Newsletter of the Canadian Geotechnical Society*, January 1982, 23, from *New Civil Engineering*, October 1, 1981.

10. Gordon McKay was a benefactor who funded science and technology graduate schools in Cambridge, Mass.

11. Prof. T. William Lambe, "Terzaghi and Soil Mechanics at M.I.T.," *Memorial Lectures*, 24–32.

12. Karl Terzaghi, *Theoretical Soil Mechanics* (London: Chapman and Hall, New York: Wiley, 1943).

13. Karl Terzaghi and Ralph B. Peck, *Soil Mechanics in Engineering Practice* (New York, London: Wiley, 1948).

14. Arthur Casagrande, "Karl Terzaghi 1883–1963," *Harvard Soil Mechanics Series*, no. 72, March 1964.

15. Karl Terzaghi, "Soil Mechanics in Action," *Civil Engineering*, New York: American Society of Civil Engineers, vol. 29, February 1959, 69–70.

16. V. D. Simons Inc., *Principles of Industrial Plant Engineering* (Chicago: Charles A. Lawes, 1931).

17. Charles Terzaghi, "Report Grays Harbor Pulp and Paper Mill" (Cambridge, Mass.: April 1929).

18. "Engineering Practice of V. D. Simons," *Industrial Plant Engineering*, 46.

19. Lawrence J. Burpee, *Sandford Fleming: Empire Builder* (London: Oxford, 1915); "Sir Sandford Fleming," *The MacMillan Dictionary of Canadian Biography*, 3d. ed. (Toronto: MacMillan, 1963), 236.

20. Robert F. Legget, "Intercolonial Bridge: A Monument to Fleming's Fine Judgement," *Canadian Consulting Engineer*, April 1972, 56–57; R. F. Legget and F. L. Peckover, "Foundation Performance of a 100-Year-Old Bridge," *Canadian Geotechnical Journal*, vol. 10, no. 3, August 1973, 504–519; Peckover and Legget, "Canadian Soil Penetration Tests of 1872," Ibid., 528–31.

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25. Robert Brewster Stanton, "The Great Land-Slides on the Canadian Pacific Railway in British Columbia," The Institution of Civil Engineers, London, December 14, 1897, 1–21.

26. N. A. Skermer, "R. B. Stanton and the Great Landslides of the 19th Century on the Thompson River: An Appreciation," *CGS News* March/April 1982, 13.

27. C. B. Crawford and J. G. Sutherland, "The Empress Hotel, Victoria, British Columbia, Sixty-Five Years of Foundation Settlements," *Canadian Geotechnical Journal*, vol. 8, no. 1, February 1971, 77–93.

28. Harold Morrison, son, interview by Jean E. Crozier, Canadian Geotechnical Society (CGS), Heritage Book Project, file no. 27, December 29, 1982, 1–10.

29. Ibid. I. F. Morrison died in 1958.

30. "Robert M. Hardy 1906–1985," CGS, *Geotechnical News*, December 1985, 11.

31. "Retiring U of A Dean Feels Committee System Frustrating," Edmonton *Journal*, July 12, 1971, 35.

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36. David Kirkbride, interview by J. E. Crozier, CGS, file no. 14, December 8, 1982.

37. Charles Ripley, interview by J. E. Crozier, CGS file no. 31, July 30, 1982, 22.

38. "Biography" prepared by R. Peterson, 1965; "Robert Peterson, 1918–1969", obituary by N. L. Iverson.

39. Hardy interview, July 2, 1981, 13.

40. Obituary, "Donald Wood Taylor," Institution of Civil Engineers, *Géotechnique*, vol. VI, 1956, 56.

41. Donald W. Taylor, *Fundamentals of Soil Mechanics* (New York: Wiley, London: Chapman & Hall, 1948).

42. Jacques Hurtubise, interview by J. E. Crozier, CGS, file no. 13, October 29, 1982, 4–6.

43. "Jacques E. Hurtubise, F.E.I.C. 1917–1967," *Geotechnical News*, December 1987, 23.

44. R. F. Legget, "Geology and Civil Engineering: Their Relationship with Reference to Canada," *Engineering Journal*, Montreal, October 1934, 431–42.

45. Robert F. Legget, *Geology and Engineering* (New York and London: McGraw-Hill, 1939).

46. Ibid., 538–83.

47. *Proceedings of the First International Conference on Soil Mechanics and Foundation Engineering*, June 22 to 26, 1936, 3 vols. (Cambridge: Harvard, 1936), reprinted December 1964. The western-Canadian delegates were Professors I. F. Morrison, University of Alberta and G. M. Williams, University of Saskatchewan; Ibid., vol. 3, "List of Participating and Absentee Members." Legget wrote an abstract on this conference, which was published in the *Engineering Journal*, August 1936.

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51. G. B. Williams, "Application of Soil Mechanics to the Design and Maintenance of Prairie Highways," Ibid., May 1945, 289–99.

52. Charles F. Ripley, "Canadian Geotechnical Engineering Forty Years Ago," *Geotechnical News*, December 1987, 30–32.

53. *Proceedings of 1947 Civilian Soil Mechanics Conference*, April 28–29, 1947, Ottawa, National Research Council of Canada, Associate Committee on Soil and Snow Mechanics, Technical Memorandum no. 9, August 1947.

54. William J. Eden, "Canadian Geotechnical Society," *Geotechnical News*, June 1985, 12–13.

55. Legget, "Memoir."

56. Lionel Peckover, interview by J. E. Crozier, CGS, file no. 29, October 29, 1982.

57. *Proceedings of the Sixth International Conference on Soil Mechanics and Foundation Engineering*, Montreal, September 8–15, 1965 (University of Toronto Press, vols. I, II, 1965, vol. III, 1966.)

58. *Proceedings of the Seventh Panamerican Conference on Soil Mechanics and Foundation Engineering*, Vancouver, June 19–24, 1983, vols. I to III, Canadian Geotechnical Society and National Research Council of Canada.

59. "Robert Legget: Man of So Many Parts," *Canadian Geographic*, February/March 1982, 32–37.

60. "Charles F. Ripley, 1987 CGS Legget Award Winner," *Geotechnical News*, December 1987, 16.

61. "Earle Klohn 1990 R. F. Legget Award Recipient," Ibid., December 1990, 6–7

Chapter Two

THE FOUNDERS

1. Interview, July 25, 1990.

2. AUDIOTAPE INTERVIEWS
by C. E. Leonoff
Quotations from these interviews appear throughout the text.

Arthur Alexander	Richmond	September 4, 1990
A. G. Lars Anderson	Richmond	November 1, 1990
Joanna M. Barnard	Richmond	September 6, 1990
Raymond P. Benson	Richmond	July 30, 1990
Donald M. Davison	Calgary	March 14, 1990
	Richmond	February 20, 21, 22, 1990
Kenneth R. Gillespie	Calgary	March 13, 1990
Thomas G. Harper	Richmond	August 29, 1991
Robert H. Hart	Richmond	August 29, 1990
Sandra G. Housken	Calgary	March 14, 1990
Earle J. Klohn	Vancouver	April 16, 17, 1990
Donna G. Le Clair	Richmond	August 5, 1992
Cyril E. Leonoff	Richmond	October 23, 1990
(by C. F. Ripley)	Victoria	October 30, 1990
Letta W. Lewis	Richmond	August 24, 1990
Peter C. Lighthall	Richmond	July 25, 1990
Robert C. Y. Lo	Richmond	November 14, 1990
C. H. "Bob" Maartman	Richmond	August 10, October 12, 1990
Harvey N. McLeod	Richmond	September 4, 1990
K. Ian Morrison	Richmond	June 5, August 20, 1990
John A. Odermatt	Calgary	March 14, 1990
Mark T. Olsen	Richmond	February 19, 1990
Myles L. Parsons	Richmond	August 8, 1990
Frank J. Pells	Richmond	June 30, 1992
Eric D. Pharey	Richmond	June 5, 1990
Ernest A. Portfors	Richmond	August 2, 24, 1990
Patricia L. Randall	Richmond	September 5, 1990
Richard J. Read	Nanaimo	October 18, 1990
William A. Richards	Colwood	October 30, 1990
Charles F. Ripley	Victoria	February 14, 16, 26, 1990
	Richmond	March 5, 7, 1990
Lloyd C. Rodway	Calgary	March 13, 1990
C. David Sellars	Richmond	August 22, 1990
Earl W. Speer	Richmond	July 11, 12, 1990
Mano L. Walia	Richmond	August 16, 1990
Bryan D. Watts	Richmond	October 17, 1990
Douglas J. Watts	Richmond	October 17, 1990
Peter Wiens	Richmond	November 6, 1990
Adrian Wightman	Richmond	August 22, 1990

3. Neil Hutcheon was a professor on the staff of the Mechanical Engineering Department and a special consultant to the PFRA on drilling equipment and instrumentation. Later he joined the NRC Division of Building Research and began investigations into various properties of insulation, chiefly heat and vapour flow in buildings. He eventually became assistant director of the division.

4. Casagrande, "Karl Terzaghi," 6. Terzaghi had previously married, and a daughter was born during the First World War, but he and his first wife separated in 1922.

5. The 1901 census gave the population of Winnipeg as 42,000. Nikolayev's population was 92,000.

6. "Outside in Space," *Time*, Canada ed., March 26, 1965, cover, 67–68B.

7. "Failure of Transcona Grain Elevator," *Engineering News*, vol. 70, 1913, 944–1107; Dimitri P. Krynine, *Soil Mechanics: Its Principles and Structural Applications* (New York and London: McGraw-Hill, 1941), 346–47.

8. *Proceedings of the Sixth Canadian Soil Mechanics Conference*, Winnipeg, December, 15–16, 1952, NRC Associate Committee, Technical Memorandum, no. 27, Ottawa, May 1953.

9. James Morton, *The Dusty Road from Perth* (Vancouver/Toronto: Douglas & McIntyre, 1981), 29–30 gives a description of this office.

10. "A. E. Paget," *Ripley and Associates: Consulting Engineers, 1953.*

Chapter Three

BRITISH COLUMBIA: FIRST CONTACTS

1. The company was Engineering Services Ltd. of Halifax.

2. C. F. Ripley, "Notes on Family History," May 19, 1966.

3. Paul Cook interview by J. E. Crozier and John Gadsby, Vancouver, CGS file no. 53, November 23, 1982, 1–4.

4. C. F. Ripley, "Notes on Soil Conditions and Related Engineering Problems in British Columbia," NRC Associate Committee, *Proceedings of the Seventh Canadian Soil Mechanics Conference*, Ottawa, December 10–11, 1953, Technical Memorandum no. 33, Ottawa, September 1954.

5. *Vancouver and New Westminster City Directory 1951* (B.C. Directories Limited), lists at 1156 West Pender Street: "Ripley & Associates (C. F. & H. A. Ripley), consulting engineers," 485; "Sherman, Norman C., president, N. C. Sherman, consulting engineers, importers & manufacturers' agents," 516.

6. David J. Mitchell, *W. A. C. Bennett and the Rise of British Columbia* (Vancouver/Toronto: Douglas & MacIntyre, 1983).

7. "From Prairie to Pacific: The Rich Land," *Time*, Canada ed., September 30, 1966, cover, 34–44.

8. "Great Land-Slides."

9. Karl Terzaghi, "Mechanism of Landslides," *Harvard Soil Mechanics Series*, no. 36, January 1951, reprinted from *Application of Geology to Engineering Practice*, Berkey vol. (New York: The Geological Society of America, 1950), 83–123.

10. "St. John Munroe," *Ripley and Associates: Consulting Engineers*, 1953.

11. J. W. Stewart, "Memorial to Victor Dolmage 1887–1980," Boulder, Colo., The Geological Society of America *Bulletin*, October 1981, 1–4.

12. V. Dolmage, "Chilko Lake and Vicinity British Columbia," Canada Department of Mines, Geological Survey, *Summary Report*, 1924, part A, 63A.

13. "Ripple Rock Man Dies," Vancouver *Sun*, June 9, 1980, A10.

14. Branch office of the International Engineering Company, which in turn was a subsidiary of the Morrison Knudsen Construction Company of San Francisco.

15. *Vancouver and New Westminster City Directory 1952* (B.C. Directories Limited), lists at 1605 West Fifth Avenue: "Ripley & Associates (C. F. and H. A. Ripley), consulting engineers," 471; "McMeans, Fred & Co., industrial heat and power," 807.

16. Bob Spence, interview by Ian Bruce, Vancouver, CGS, file no. 64, June 21, 1983, 12.

17. James Bryant Conant, American chemist and educator, in 1933 became president of Harvard University. In 1953 he was appointed U.S. high commissioner and ambassador to Germany.

18. Karl Terzaghi, Winchester, to F. A. Lazenby, Vancouver, April 21, 1962.

19. Charles Ripley, interview by J. E. Crozier, CGS file no. 31, November 18, 1982, 40.

20. The site was also remote—no rail or road connection between Vancouver and Garibaldi. Access was by steamship to the Pacific Great Eastern (PGE) railhead at Squamish or by water taxi from Horseshoe Bay, West Vancouver to Britannia, thence by bus to Squamish. On August 27, 1956, a "last spike" was driven at North Vancouver, made from copper mined at the Britannia mine, and the first train from Burrard Inlet to Prince George moved out. Bruce Ramsey, *PGE: Railway to the North* (Vancouver: Mitchell Press, 1962), 247–48. On Labour Day weekend Olsen travelled back from Garibaldi on the return trip of this train.

21. "The B.C. Electric Starts Work on the $25,000,000 Cheakamus Power Development," Vancouver *Province*, January 20, 1955, 12; "The Cheakamus Story," British Columbia Electric, *Buzzer*, January 20, 1956.

22. Karl Terzaghi, "Report on the Proposed Storage Dam South of Lower Stillwater Lake on the Cheakamus River, B.C.," Vancouver, B.C., April 12, 1954, *From Theory to Practice in Soil Mechanics: Selections from the Writings of Karl Terzaghi* (New York, London: Wiley, 1960), 394–408.

23. Casagrande, "Karl Terzaghi," 5–6.

24. Bridge River is a tributary 28 miles upstream from its confluence with the Fraser River at Lillooet.

25. Karl Terzaghi testimony, "Expert Report: Neglect Not Factor in Whatshan Wreck," Vancouver *Province*, December 2, 1953, 16.

26. Karl Terzaghi and Yves Lacroix, "Mission Dam: An Earth and Rockfill Dam on a Highly Compressible Foundation," *Harvard Soil Mechanics Series*, no. 73, reprinted from *Géotechnique* (London: The Institution of Civil Engineers), vol. 14, no. 1, March 1964, 13–50.

27. Ibid., 13.

28. A. Casagrande, Cambridge, to Ralph B. Peck, Urbana, October 25, 1963; R. F. Legget, "Karl Terzaghi 1883–1963," December 15, 1963, *Canadian Geotechnical Journal*, vol. 1, no. 2, March 1964, 122–24.

29. "Opening Session in Honour of Karl Terzaghi," *Proceedings of the Sixth International Conference on Soil Mechanics and Foundation Engineering*, vol. III (University of Toronto Press, 1966), 75–83; "Dam Renamed to Honor Dr. Karl Terzaghi," *Canadian Consulting Engineer*, November 1965, 21, Vancouver *Province*, September 1, 1965, 17.

30. C. F. Ripley, "Comments to Terzaghi Memorial Luncheon," Seventh Panamerican Conference on Soil Mechanics and Foundation Engineering, ISSMFE, Vancouver, B.C., June 21, 1982.

31. Earle J. Klohn, "Review of Company Development to Date," Minutes of Managers' Meeting, Harrison Hot Springs, March 20–22, 1972.

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2. McNeely DuBose, "The Alcan Nechako-Kemano-Kitimat Development: Introduction," *Engineering Journal*, November 1954, 1381–82.

3. E. T. Kenney was the B.C. Minister of Lands and Forests and MLA for the district at the time of the inception of the project in 1948, Kendrick 45–50.

4. Harry Jomini, "Alcan Development: The Kenney Dam," *Engineering Journal*, November 1954, 1386–97.

5. W. L. Pugh, "Alcan Development: The Kitimat Harbour," Ibid., 1450–59.

6. Ripley interview by J. E. Crozier, CGS file no. 31, November 18, 1982, 3.

7. Jean E. Crozier, "Robert Macdonald Hardy: Engineer, Educator, Innovator," March 1983, CGS file no. 45, typewritten.

8. General Engineering Department staff, "Alcan Development: Design and Construction of the Kitimat Smelter," *Engineering Journal*, November 1954, 1467–79.

9. R. M. Hardy and Charles F. Ripley, "Alcan Development: Foundation Investigation for the Kitimat Smelter," Ibid., 1460–66.

10. Elected in 1951, Charlotte Whitton became Canada's first woman mayor and served until 1964.

11. "Alcan Development: Foundation Investigation," 1465.

12. Howard White and Jim Spilsbury, "The Alcan Project," *The Accidental Airline: Spilsbury's QCA* [Queen Charlotte Airlines] (Madeira Park, B.C.: Harbour, 1988) 151–67.

13. *Accidental Airline*, 180–86.

14. The twin-engine Grumman Goose had safety features: it could fly on one engine and was amphibious—could land on a runway or on water.

15. *City Directory*, 1952, 471.

16. Charles F. Ripley for Ripley and Associates, Vancouver, to H. A. Ripley, Edmonton, November 26, 1951.

17. T. William Lambe, *Soil Testing for Engineers* (New York: Wiley, 1951).

18. "Foundations, Gardiner Pulp Mill," International Paper Company, KL Project Description Sheet no. 3016.

19. Earle J. Klohn, "Sensitive Paper Mill Structures Supported by Long Caissons Socketed in Bedrock," *Proceedings of the Fifth Annual Geology and Soils Engineering Symposium*, Pocattelo, Idaho, April 12–14, 1967, 107–140.

20. *Journal of Commerce*, Vancouver, February 26, 1966, 11.

21. Earle J. Klohn, "Foundation Settlement Problems: A Discussion of the Situation in British Columbia," *B.C. Professional Engineer*, August 1957, 16–22.

22. R. Peterson, Saskatoon, to C. E. Leonoff, Seattle, February 11, 1952.

23. Department of Agriculture, Regina, to Cyril E. Leonoff, Seattle, March 10, 1952.

24. Charles F. Ripley, Vancouver, to Cyril E. Leonoff, Seattle, February 13, 1952.

25. "Program of Refresher Course on Compaction of Soils," Ripley and Associates, Consulting Engineers, Vancouver, March 6, 1953.

26. "Smelter and Townsite Roads and Pavements, 1953–56," KL Project Description Sheet no. 5014.

27. *The WASHO Road Test, Part I: Design, Construction, and Testing Procedures*, Highway Research Board, Thirty-Second Annual Meeting, Washington, D.C., January 13–16, 1953, Special Report 18, Publication 310, 1954, 38–39.

28. "Northwest Highway System, Mile 1.3 to Mile 52.5, Base and Pavement Design," KL Project Description Sheet no. 5018.

29. Swan Wooster and Ripley, Klohn & Leonoff, "City of Vancouver Point Grey Foreshore and Scenic Drive Study," December 1967; George Peloquin, "2.6 Million View Drive Proposed: Scenic Point Grey Link Would Create Parkland," Vancouver, *Sun*, March 30, 1968, 29.

30. During the Korean War, in the investigation of a site for a proposed army supply depot, located near the head of Burrard Inlet at Coquitlam, B.C., Ripley and Associates had encountered soft marine clay at shallow depth underlying alluvial deposits. This deposition was of similar characteristic to that originally identified by Terzaghi in 1929 at Grays Harbor, Washington (Chapter 1) and was the first recorded instance of this treacherous foundation material in the British Columbia Lower Mainland. Ripley's report was initially received with disbelief by the Vancouver engineering design firm and the Department of National Defence. Nevertheless the site was eventually abandoned and the depot relocated elsewhere. (Ripley and Associates "Preliminary Report of Subsoil Investigation," Ordnance Depot, Coquitlam, B.C., file no. R-16, March 31, 1952; "Second Report," August 4, 1952).

31. Ripley and Associates, "Third Report of Subsoil Investigation," Fraser Mills Development, B.C., to H. A. Simons Ltd., file no. R-78, January 7, 1954, (Preliminary reports were submitted on December 10 and 31, 1953).

32. Karl Terzaghi, "Report Concerning Foundation of the Proposed Converting Plant of Pacific Mills Ltd., Fraser Mills site, Vancouver area, B.C.," May 12, 1954.

33. Ripley, Klohn & Leonoff were the first to apply the preload methodology to the thick sand, silt, and clay deposits of the Fraser River Delta. For a detailed description, see C. E. Leonoff and E. J. Klohn, "Preloading Foundation Treatment for Soft Soil Construction," *Public Works in Canada*, August 1961.

34. Crown Zellerbach Canada, *Richmond Division*, ca. 1956. Further extensions were later made to this plant; Bill Ryan, "Crown-Zellerbach $4,500,000 Paper Converting Plant Opens," Vancouver *Province*, September 25, 1956, 23.

35. "Crown Zellerbach Converting Plant," KL Project Description Sheet no. 3017.

36. C. E. Leonoff and C. F. Ripley, "Case History of a Preloaded Foundation," *Proceedings of the Fifteenth Canadian Soil Mechanics Conference*, Montreal, November 8–9, 1961, NRC Associate Committee, Technical Memorandum no. 73, June 1962, 186–215; *Engineering Digest*, March 1962; *Heavy Construction News*, December 1, 1961.

37. "Case History," 211–12.

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39. Earle J. Klohn, "Pile Heave and Redriving," American Society of Civil Engineers, *Transactions*, paper no. 3432, vol. 128, 1963, part I, 557–608. In 1968 Klohn would be honored as a fellow of this venerable society, founded in 1852.

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41. "A.S.M.E. Honors Howard A. Simons," *Simons Update*, July 1980, 3; "Obituary," *B.C. Professional Engineer*, July 1981, 26.

42. A. D. Purdon, "Greater Vancouver's Water Supply, *B.C. Professional Engineer*, June 1982, 7–11.

43. Berry was an internationally known professional engineer. He had been with the districts since 1926. See Theo V. Berry, "Disposal of Spent Water in the Greater Vancouver Area," *B.C. Professional Engineer*, November 1958, 15–21; Berry, "Water Pollution in Canada: Some Causes and Effects and the Urgent Need for Control," *Public Works in Canada*, April 1963, 29–30.

44. C. F. Ripley, "Damsites in British Columbia: A Challenge to the Engineer," *Proceedings of the Twelfth Canadian Soil Mechanics Conference*, Saskatoon, December 8–9, 1958, NRC Associate Committee, Ottawa, April 1959, 17–19. In this paper Ripley discusses the complexity of the unconsolidated sediments in the valleys of British Columbia and the inter-related role of the geologist and the engineer.

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47. "Two Local Engineers Win Gzowski Award," *Journal of Commerce*, June 13, 1964, 7; *B.C. Professional Engineer*, June 19, 1964, 60.

48. K. E. Patrick, "How Greater Vancouver is Winning its Fight Against Pollution," *Public Works in Canada*, April 1963, 31–36.

49. T. V. Berry, "History and Description of the Iona Sewage Treatment Plant and Appurtenant Works," Greater Vancouver Sewerage and Drainage District, *Programme: Opening Ceremony*, April 19, 1963; "Closing of City's Beaches Hastened Sewerage System," Vancouver *Sun*, April 19, 1963, 26.

50. "How Soft Soil and Water Problems Were Solved on Vancouver Iona Project," *Public Works in Canada*, June 1962; C. E. Leonoff, "Surcharge Fill Solves Iona Foundation Problems," *Daily Commercial News*, Roads and Utilities issue, Toronto, September 1962, 143–44; Charles F. Ripley, "Preloading Thick Compressible Subsoils," ASCE National Meeting on Structural Engineering, Portland, Oregon, April 8, 1970; Ripley, "Preloading Thick Compressible Subsoils: A Case History," 44th Canadian Geotechnical Conference, September 29–October 2, 1991, Calgary, Alberta, *Preprint Volume*, vol. 2, paper no. 94.

51. "Iona Sewage Plant Opens Friday" [April 19, 1963], Vancouver *Province*, April 17, 1963, 17; Norman Gotro, "Iona-Guardian of an Evergreen Playground," *Public Works in Canada*, April 1963, 35–51.

52. Cyril E. Leonoff, "Construction of Prince George's Earth Water-Storage Reservoir," *B.C. Professional Engineer*, September 1958, 11–17.

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8. "Tribute Paid to Pioneers," *Edson to Grande Prairie Trail* (DeBolt and District: Pioneer Museum Society, 1982), 260.

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10. Ibid., "Darwin School District No. 4639," 298–9.

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THE BUSINESS OF ENGINEERING

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5. H. A. Ripley, Edmonton, to C. F. Ripley, Vancouver, September 22, 1953.

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9. D. A. Ripley, H. A. Ripley and N. A. Lawrence, partnership of property located at 1930 West Broadway, Vancouver, B.C., "Statement of Equity of N. A. Lawrence as at June 30, 1957."

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12. Ripley and Associates Engineering Consultants Ltd., Memo, "Dividend Computations on Preferred Shares," E. J. Klohn and C. E. Leonoff, December 24, 1958.

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14. B. Sangster, Vancouver, to H. A. Ripley, Vancouver, September 3, 1958 and October 16, 1958.

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16. "Statement of Equity, as at June 30, 1957."

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41. Ripley, Klohn & Leonoff Ltd., "Financial Matters-Year Ended December 31, 1962"; C. F. Ripley to H. A. Ripley, E. J. Klohn, C. E. Leonoff, S. P. Dodd, December 31, 1962.

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66. "Soil Experts Meet Here," Vancouver *Sun*, September 22, 1966, 35.

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Chapter Seven

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3. *W. A. C. Bennett*, 286–90.

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15. Bill Fletcher, "Craigmont to Hit Production in '61: Early Construction Start on 4,000-Ton Copper Mill Seen," Vancouver *Sun*, October 12, 1960, 29.

16. Ripley and Associates Engineering Consultants Ltd., "First Report of Foundation Appraisal," Craigmont Plant, Merritt, B.C., file no. R-428, October 11, 1960; R & A, "Second Report of Foundation Investigation," November 28, 1960.

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Upstream construction is the oldest and cheapest method whereby the tailings are deposited in an upstream direction off a low starter dyke. The dam is thereby raised on top of previously deposited, unconsolidated, usually saturated tailings, limiting its height and safety.

Downstream construction is a relatively new method developed for constructing larger and safer tailings dams including resistance to earthquake forces. The dam is raised in a downstream direction, using cyclones to produce sand for the dam building. Placement, compaction, and drainage can thereby be controlled to whatever degree of competency is required.

Centreline construction is a variation of the downstream method whereby the dam crest is raised vertically rather than by adding material on the downstream side. In a centreline dam the crest is raised by cycloning sand alternately upstream and downstream. The major advantages are that the dam can be raised more quickly using a smaller volume of sandfill.

Earle J. Klohn, "Problems of Tailings Dam Construction," *Construction West*, December 25, 1972, 4A.

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Glossary

TECHNICAL TERMS

A

ablation till or moraine A layer or mound of unsorted material left behind by a retreating glacier and not preloaded by ice.

aggregate The mineral material, such as crushed stone, gravel, or sand, which forms a substantial portion of concrete, asphalt, or a road.

alluvial Soil sedimentation formed by the action of running water.

angle of repose The steepest angle to the horizontal that a granular soil assumes in its natural state.

aquifer A porous, water-bearing soil or rock formation that provides a groundwater reservoir.

artesian Groundwater under hydrostatic pressure that rises above an aquifer.

Atterberg (liquid and plastic) limits The consistency limits of a clay-water mixture passing from a liquid state through a plastic state and finally into a solid state as the water content is gradually reduced.

autogenous mill Wherein the aggregate is produced without any external aid.

B

baffle block Protrusion(s) built on a spillway to regulate or dampen the energy of the flow.

ballast Heavy material placed in a vessel or structure to provide draft or stability.

ball or rod mill A cylindrical mill using steel balls or rods to grind rock into fine sizes to facilitate separation of the minerals in a subsequent process.

batholith A large mass of igneous rock which has intruded into older formations.

batter pile A pile driven at an angle to the vertical in order to resist horizontal force.

bearing capacity (allowable) The load per unit of area that the ground can safely carry.

bell and spigot joint A pipe joint wherein the female end is flared to accept the cocked end.

bench mark A fixed point whose level is known and used as a datum for levelling.

Benkelman beam A field apparatus, designed by A. C. Benkelman of the U.S. Bureau of Public Roads, consisting of a lever arm placed between the dual rear tires of a loaded vehicle, and a dial gauge to measure the elastic deformation of a pavement under a moving load.

bent (dock) A rectangular two-dimensional frame built of driven piles and beams which is placed at right angles to the length of the dock it is supporting.

bentonite A soft plastic clay formed by chemical alteration of volcanic ash. Bentonite slurry is used as a lubricant in driving a pipe or pile, and to seal porous soil.

biota The flora and fauna of a region.

boreal (forest) Pertaining to Boreas, the god of the north wind, hence northern.

borrow material Material dug to provide fill elsewhere.

bosun chair Chair of a boatswain in charge of the rigging on a sailing vessel.

breakwater A wall or mound built out into a sea or lake and made of blocks or rubble aggregate to protect a harbour from the waves.

bulkhead A vertical wall to resist soil pressure or to close off water.

bulking of soil The increase in volume of excavated soil, such that the enlarged volume is greater than the volume of the excavation from which it came.

bund An earthen embankment built along a waterfront or to form a dam.

butt joint Structural members joined end to end and fastened by a splice plate or strap.

buttress (berm) A counterweight earth mound built alongside the toe of the dam to resist upward earth thrust or water pressure.

C

caisson A cylindrical or rectangular ring-wall for keeping water or soft ground from flowing into an excavation formed while digging a foundation.

cat (caterpillar) Trade name for a tractor-propelled bulldozer having a broad blade used to move and level earth.

chain (surveyor's) A land surveyor's measure to mark distance.

churn drill A drill which is advanced into the soil by means of a cutting chisel alternately raised or dropped by a cable.

civil engineering Originally a term applied to engineering for civil purposes rather than military. Today a professional discipline applied to a wide range of fields such as municipal works, structures, transport, harbours, waste disposal, water resources, dams, soils and foundations.

classification The arrangement of soils in accordance with their physical properties, such as grain-size distribution and plasticity.

clay A very fine-grained soil of colloidal size (finer than 0.002 millimetres). Clay exhibits plastic properties and has a consistency of soft, medium, or stiff within a range of water contents. When dry its strength is high, but when saturated clay becomes very soft and compressible.

clay (sensitive) When soft clay is kneaded or disturbed by construction equipment its structure is remoulded and it usually becomes even softer, in the extreme turning into a viscous liquid. Sensitivity is a measure of this remoulding.

cohesion A soil can be placed into one of two groups. Cohesionless soils such as gravel and sand have no attraction between individual particles, while clay and silt exhibit this property.

colloidal Particles in the range of 10^{-7} to 5×10^{-4} centimetres in diameter which, when dissolved in a liquid, remain suspended indefinitely.

colluvium A general term applied to loose and incoherent deposits usually collected at the foot of a slope or cliff and brought there by gravity.

cone (static or Dutch) penetration test The testing of soil by pressing a standard cone into the ground under a known load and measuring the penetration. In the Dutch cone an inner mandrel is driven separately from the outer casing, enabling the toe resistance to be measured separately from the skin friction of the casing. The cone may also be combined with a piezometer to measure the pore-water pressure in the soil.

consolidation The gradual reduction in volume of a soil mass in response to increased load, owing to the squeezing out of water from the pores.

consolidometer A laboratory apparatus for measuring stress-strain characteristics of clay soil by confining it in a metal ring and transmitting a vertical load through porous disks on the upper and lower faces of the specimen, thereby permitting water flow in and out. The deformation is measured by a dial gauge. The test is used to approximate the field settlement of a soil under loading.

core zone The central zone of a dam constructed of impervious materials such as clay or glacial till.

creep Slow permanent deformation (strain) of soil, rock, or concrete resulting from a small constant stress (such as gravity), usually imperceptible except to measurements of long duration.

creosote An oil distilled from coal tar, usually applied under pressure as a preservative for timber.

Cretaceous The system of rocks created in the final period of the Mesozoic era, covering the time span between 135 and 65 million years ago.

cut and fill The excavation of earth material from one place and its deposition as compacted fill in an adjacent place, such as in road-building or dam-building.

cut bench A long, narrow, relatively level terrace cut into a slope.

cyclone (hydrocyclone) A conically shaped vessel used to separate particles according to size and specific gravity. The soil-water mixture is introduced under pressure, imparting a swirling motion and vortex. Faster-settling particles (sand) move by centrifugal force to the wall of the cyclone and migrate to an apex opening, while the slower-settling fines move by a drag force to the axis and are discharged through an overflow.

D

dam A barrier placed across a watercourse to prevent the flow of water and cause its impoundment (reservoir). Dams are commonly constructed of concrete, rock, or earth.

dam (hydroelectric) A dam used to store water in order to generate hydroelectric power.

dam (tailings) A dam usually placed across a valley or depression for the purpose of permanently and safely storing mine waste.

dam (water supply) A dam placed across a river or stream to impound fresh water for use in a mill process or for domestic use.

dam or embankment (zoned earth) Constructed of an inner core of fine-grained soil to act as a water stop, and outer layers of sand, gravel, and rock (filter zones) to provide stability and protection against erosion and piping.

density (dry) The mass of solid particles per total volume of soil or rock.

dewater The removal of water from an excavation, or the reduction of water content in a soil, by use of pumps and/or well points.

diamond drill A rotary drill using diamond cutting bits to cut through hard rock.

dragline An excavating machine that works by pulling a scraper bucket hung at the end of a long crane. A skillful operator can throw the bucket and contained soil well beyond the end of the crane.

dragline double-casting Where the ground is extremely soft, two draglines working in tandem can move the soil a considerable distance from the rim of the excavation, such that the stability of the cut sides is maintained.

drill jumbo Used for heavy drilling work in rock tunnels. A movable frame and platform that usually travels on the tunnel track and incorporates several rock drills.

drumlin A glacial remnant consisting of a low, smoothly rounded and elongated hill resembling an inverted teaspoon, composed of or capped with glacial till.

dyke A mound of earth along a riverbank or reservoir to retain floodwater.

dynamic compaction A weight-dropping method extended over an area of ground to consolidate and strengthen coarse fill.

dynamic loading Loads that include impact and vibration, such as those created by machinery.

E

earth (see soil)

earthfill dam A dam built with a combination of clay, sand, gravel, and rock.

earth pressure The force exerted by a soil mass on a structure such as a retaining wall.

earthquake engineering The design and construction of buildings and structures to withstand the effects of an earthquake.

earthwork The digging or artificial raising of ground.

effective stress The pressure in a soil between the points of contact among the soil grains.

elastic property The resilience of a material that expands or contracts when pulled or pushed by known forces, but which regains its shape when these forces are released.

epicentre The point on the earth's surface directly above the focus of an earthquake.

extensometer An instrument for measuring the linear strain on a material associated with an increase in its length.

F

factor of safety A ratio of the stress at which failure is expected, divided by the design stress.

fan (geologic) An accumulation of debris brought down by a stream through a steep ravine to a plain below. The detrital material spreads out in the shape of a fan, forming a very low cone.

faulted (rock) A fracture along which there has been displacement of the two sides relative to one another.

field density test The weight per unit volume of a soil, a measure determined on a site.

filter zones (seepage) A combination of pervious layers designed and installed to provide drainage yet prevent the movement of soil particles via flowing water.

finite element One of the regular geometrical shapes into which a figure is subdivided for the purpose of numerical stress analysis.

flip bucket An upwardly curved section at the bottom of a spillway that flips the water beyond the toe of a dam in order to dissipate the energy of the water and prevent erosion.

floating (or raft) foundation A buoyant foundation built of reinforced concrete on river estuaries where the water table is high and no solid foundation is available, designed so that the total of its own weight and the load it carries is approximately equal to the weight of soil and water displaced.

folded (rock) A bend or undulation in the strata within a rock mass.

foundation The lower part of a structure that transmits the load to the soil or rock.

foundation dynamics The action of the foundation under the mechanics of forces produced by the motion of bodies.

Franki penetration unit The trade name for a device used to determine the penetration resistance of a soil. A hammer of specified weight and drop is employed, thereby producing penetration of a probe into the soil, and a measure is taken of the number of blows per unit of depth.

frequency response The vibratory response and displacement of a soil-foundation system due to dynamic loading produced by machinery, or the shaking produced by an earthquake.

frost heave The swelling of a soil owing to the expansion of water upon freezing which forces the soil particles apart and increases the void spaces. Silt is particularly susceptible to frost heave because its void sizes are ideal for the drawing of water through capillary action.

G

geodetic surveying Surveying of areas so large that the earth's curvature must be allowed for in the calculations.

geogrid A grid, made of synthetic fabric, placed in the ground to reinforce it. Geosynthetic fabrics usually formed from cellulose have come into widespread use in geotechnical engineering for reinforcement, erosion control, and as impermeable membranes for reservoir lining.

geohydrology A term used interchangeably with hydrogeology.

geology The branch of natural science devoted to the study of the planet earth, the composition and structure of the materials composing it, the processes at work in altering it, and the record of the animal and plant life forms that have inhabited it.

geology (engineering) The application of the science of geology to the practice of civil engineering.

geophysics The study of the earth by quantitative physical methods.

geoscience Earth science.

geotechnics The application of earth science and engineering principles to the solution of civil engineering problems pertaining to the earth's crust, embracing the fields of geology, soil and rock mechanics, geophysics, hydrology and hydrogeology.

glacial outwash Sand and gravel deposited by meltwater streams at the margin of an active glacier.

glacial till A mixture of unstratified clay, silt, sand, gravel, and boulders, ranging widely in size and shape, deposited by a glacier and usually preloaded by ice.

glacial till cap A layer of glacial till overlying other sediments. The underlying soils are usually very compact and dense owing to preloading by the glacial ice.

grade The continuous, natural and longitudinal profile of a stream channel or a ground surface.

grain size (test) The process of determining the grain size distribution of soil particles by means of sieve analysis or by a hydrometer in the case of colloidal soil.

granitic intrusion A granitic rock formation created by the crystallization of magma which has intruded into pre-existing rock.

gravel Rounded or semi-rounded natural particles of rock that range in size from 5 millimetres to 3 inches.

graving dock A drydock for holding a ship aloft in order to clean or repair its underside.

gravity dam A massive dam built of masonry, brick, or concrete which is prevented from collapsing by its weight alone.

groundwater Water within soil or rock and below the water table.

groundwater modelling A mathematical method of analyzing groundwater (flow, direction, quantity, and yield) based on such factors as size of the aquifer, permeability of the ground, and hydraulic gradient.

grout cut-off (or curtain) A slurry of fluid or semi-fluid cement, clay, or bentonite injected into the ground to form a watertight barrier and eliminate seepage under a dam or from a reservoir.

grouting A slurry of cement or other material injected into the ground for ground improvement and watertightness, or placed on the joints of rock, brickwork, or masonry in a tunnel to prevent seepage and rockfall.

H

headworks The structure at the head of a channel which diverts water into it.

highgrading Extraction of the minerals in an ore body which are of the highest economic value.

high-head (pressure or power tunnel) The fluid pressure of water produced by the height of that water above a given point.

hydraulic fill Dredged aggregate carried by water in pipelines or flumes and used to form an embankment.

hydraulic model A model built to scale, including measurements such as heads and flows, in order to interpret the workings of a full-scale structure.

hydraulics The study of the mechanics of water or other liquids in motion, and the application of such study to the engineering of rivers, water supply systems, hydroelectric generation, dam building, irrigation, and drainage.

hydrocarbons A class of chemical compounds containing only hydrogen and carbon.

hydroelectric The generation of electricity by the use of hydraulic power driving a turbine and electric generator.

hydrofracturing The fracturing of underground strata, caused by water under pressure.

hydrogeology The study of the hydrologic or flow characteristics of water which lies beneath the earth's surface.

hydrology The study of the occurrence, properties, circulation, and distribution of water on the surface of the land.

hydrometer analysis A method for determining the particle size of a fine-grained soil, particularly clay. A soil-water mix is placed in a tubular vessel where hydrometer readings measure the specific gravity of the particles over time, a function of the free-fall velocities of the soil particles, hence of their grain sizes.

I

ice lens An accumulation of ice in a frozen, fine-grained soil which occurs in lenticular-shaped layers parallel to the ground surface.

inclinometer An instrument placed in a cased vertical borehole to measure the location and rate of lateral earth movement and the angle of dip in dams, embankments, excavations, slopes, and landslides.

in situ A term applied to soil or rock occurring in the form in which it was naturally deposited.

in-situ densification Methods of densifying a soil in place and without the need for excavating and recompacting.

in-situ permeability test An in-place measurement of the capacity of the soil or rock to conduct water.

K

karstik A geologic occurrence whereby cavities are developed in limestone beds by dissolution of the rock in flowing water.

kraft paper A coarse, strong brown paper made from sulfate pulp and used for wrapping parcels or in the manufacture of paper boxes.

L

lacustrine Sediments deposited in the bottom of a lake, usually composed of fine-grained unconsolidated soils.

landslide A rapid downslope movement under gravity of a mass of residual soil or rock adjoining a natural or cut slope.

lagging Short lengths of timber, sheet steel, or concrete slabs placed behind main supports and used to secure the sides and roof of an excavation or tunnel.

level (surveyor's) An instrument consisting of a telescope and bubble tube which enables a surveyor to take level sightings over considerable distances.

lift drawing A detailed construction drawing for major concrete structures (dams and powerhouses) showing the details of embedded parts such as reinforcing, water stops, pipes, and galleries.

liquefaction The transformation of a soil from a solid state to a liquid state as the result of increased pore-water pressure and reduced shearing resistance, usually produced by a sudden shock or strain such as an earthquake.

M

mantle (soil) The uppermost soil level in the earth's crust, a layer which has been altered by weathering, organic growth, chemical, and water action and is therefore unsuitable for engineering construction. It is usually stripped from a building site prior to construction.

Marshall stability test A laboratory apparatus used to test the compressive strength of compacted asphalt pavement specimens.

mechanics (engineering) The application of the laws pertaining to the motion of solid bodies to those conditions met in engineering practice.

moraine (glacial) A mound or ridge of unstratified glacial drift, chiefly till, deposited by the direct action of glacial ice.

mudstone A blocky, fine-grained sedimentary rock in which the proportions of clay and silt are approximately equal.

muskeg A bog in wet, poorly drained boreal regions, often associated with permafrost.

N

neap tide A low tide which occurs in the second and fourth quarters of the moon.

nuclear densometer A nuclear device for measuring the *in-situ* density of soil.

O

optimum (density/water content) The water content at which a soil can be compacted to a maximum dry density by a given compactive effort.

O-ring A circular ring of rubber or other material used to prevent leakage in a pipe joint.

overburden (soil) The loose soil that overlies bedrock.

P

peat bog A naturally occurring, highly organic and unconsolidated deposit derived primarily from plant remains and lying in a water-saturated environment. Peat is so compressible that it is unsuitable for supporting foundations or earth embankments.

penetration test (dynamic) See Franki penetration unit.

penetration test (static) See cone penetration test.

penstock A pressure pipe, usually of steel, which supplies water to run a turbine.

permafrost Permanently frozen ground usually found in northern climates or under freezing plants.

permeability The capacity of a porous soil or rock to conduct a fluid.

permeability apparatus (permeameter) A laboratory apparatus for measuring the rate of flow of water through a soil or rock sample.

physiography A description of the physical nature of landforms.

pier (foundation) A wide column of concrete or masonry used to carry a heavy load such as a bridge.

piezometer A tube or standpipe for measuring the pressure head of water in a soil.

piezometer (electric cone) A battery-powered piezometer with submersible transducers, read-out displays, and recorders to provide accurate *in-situ* measurements of pore-water pressure and water-level data.

pile (end bearing) A pile that carries a load to a firm stratum beneath its tip.

pile (foundation) A relatively slender post of timber, steel, or reinforced concrete driven, jacked, or jetted into the ground, usually vertically, to carry the load of a structure.

pile formula (dynamic) An empirical formula in which the safe load on a pile is determined from the energy of the hammer-blow and the penetration of the pile for each blow.

pile (friction) A pile that carries a load chiefly by means of skin friction of the soil around its circumference.

pipe pile A pile composed of a circumferential steel pipe. The soil core is usually removed and replaced with concrete.

piping The progressive removal of soil particles by water percolating (resembling a boil) from a dam or cut slope and leading to the formation of channels, a process which may become disastrous to the stability of the dam or slope.

Pleistocene The last geologic epoch distinguished by glaciation.

plinth and parapet A low wall placed to protect the edge of a sudden drop and the projecting base of the wall.

pore-water pressure Pressure transmitted via the water filling the voids of a saturated soil. This pressure, when measured in the foundation of an earth dam, gives an indication of the degree of the consolidation process and the safe time rate for raising the dam.

porphyry copper A body of rock that contains disseminated chalcopyrite and other sulfide minerals.

portal (tunnel) The surface entrance to a tunnel. It may be faced with protective and/or decorative masonry or concrete.

post-tensioned concrete A method of prestressing concrete after it has been placed, used for bridges and heavy structures that are poured in place.

potline The line of pots in an aluminum smelter where the alumina ore is refined by electrolytical means.

power group The equipment where the wood waste is burned to generate steam power for a pulp mill. Chemical waste is also recovered from the mill process to generate thermal power.

powerhouse A structure in which the machinery to generate power is located.

precast concrete Concrete elements that are cast and matured in a factory before being set into place in a structure.

preload The loading of a site with earth or other materials in advance of construction to induce consolidation and settlement prior to building. The preload is said to be surcharged when its weight is greater than the building weight, in order to induce greater and faster settlement.

prestressed concrete The application of forces to concrete to deform it so that it will withstand its working load more effectively with less total deflection.

Proctor compaction test A standardized method of compacting soils in the laboratory which uses a tamper of specified weight and drop to compact a specimen retained inside a mould. The objective is to determine the optimum water content and density in a given soil, approximating that which can be achieved in the field by construction equipment.

proving ring A steel ring precisely turned, tempered, ground, and polished. When calibrated and used in conjunction with a dial gauge, its diametral deformation accurately measures the load applied to a specimen in small-scale laboratory testing.

pulping group The place in a pulp mill where the chemical processes are conducted. The wood chips are added to a chemical mixture, then cooked under pressure in a closed tank called a digester. The resulting pulp is then washed to remove the chemicals, screened, bleached, beaten, brushed, and rolled to form a flat, thin sheet.

R

radiocarbon dating A method of determining the age of a work by measuring the concentration of carbon-14 remaining in an organic material.

radionuclide A radioactive nuclide in which all atoms have the same atomic and mass number.

reagent An agent used to bring about a chemical reaction that will separate one substance from others.

rebar A steel reinforcing bar embedded in concrete to provide tensile strength.

reclaim (water, dam) The water from a milling process which is recovered from a reservoir behind a reclaim dam located downstream of the site. This water is then re-used in the mill.

refusal (pile) A pile that comes to a virtual stop when driven into the ground under repeated blows of a hammer.

retaining wall A wall built to hold back earth or other solid material.

Richter scale A logarithmic scale of earthquake magnitude devised in 1935 by seismologist C. F. Richter.

riprap A specially selected and graded quarried rock which is placed on the surface of an earth slope to prevent erosion by wave, current, or tidal action.

risk analysis A methodology for determining the probability of a sequence of events that could cause the failure of an engineering work.

rock (bedrock) A mass of natural solid mineral matter of different grains cemented together by a matrix. Bedrock is unbroken solid rock often overlaid by soil or rock fragments.

rockfill dam A dam whose main constituent is rock.

rock mechanics The science of the mechanical behaviour of rock and its application to engineering works such as mines, tunnels, and the stability of rock cuts and slopes.

rod (surveyor's) A staff of wood or light alloy, marked with easily read graduations, used in levelling or in stadia work for determining the distance of a visible point.

rod man The person on a survey party who transports and holds the rod in place on a point.

rubble-mound breakwater A mound composed of a mixture of dumped stones, some of which may weigh up to 10 tons, placed in a body of water at side slopes flat enough to prevent their movement by wave or ice action.

S

saddle dam A dam, auxiliary to the main dam, constructed to fill in a low point in the crest line of a reservoir.

sand A granular aggregate derived from rocks or minerals and composed mainly of quartz particles having a diameter in the range of 0.06 to 2 millimetres. The major engineering characteristics of sand are a good bearing value when confined, high permeability, and no cohesion when dry or saturated.

sand drain A vertical boring placed through a clay or silt soil of low permeability and filled with sand or gravel to enable the soil to drain more quickly. Its particular engineering use is to accelerate the consolidation in a loaded soil of low permeability.

sedimentary rock A layered rock, such as sandstone and siltstone, formed by the consolidation and cementation of sediments.

seismic stability The stability of a structure or earth mass under the action of an earthquake or earth vibration.

seepage The infiltration or percolation of water through rock or soil, and to or from a surface.

settlement Downward movement of a structure or ground as a result of the consolidation of the soil beneath it.

settlement (differential) The uneven settlement of different parts of a structure. Uniform settlement may not be harmful to a building whereas differential settlement among columns can result in structural damage.

shale A laminated, fine-grained rock formed by the compaction of clay, mud, or silt. Because of its tendency to split along bedding planes, clay shale may be a very treacherous material under heavy loads such as earth dams.

shear A deformation resulting from stresses that cause contiguous parts of a soil or rock material to slide relative to each other and in a direction parallel to their plane of contact.

shear strength A measure of a soil or rock material's internal resistance to shear stresses. Shear strength in a soil is a function of it's cohesion and friction.

shear test (direct) A laboratory method to measure the shear strength of a soil wherein the specimen is placed in a two-piece square box and the force required to pull the two halves apart is measured.

shear test (triaxial) A sophisticated laboratory test to measure the effective strength of a soil under natural conditions. The specimen is encased in a thin rubber membrane, a uniform pressure is applied around it using a fluid (or a vacuum for cohesionless soil), and an axial load is applied to induce failure.

sheepsfoot roller A soil-compacting roller consisting of a steel drum having steel bars welded radially to its surface, thereby simulating the kneading action of a sheep's foot.

sheeting and bracing Rough horizontal or vertical boards held against the sides of an excavation by struts and braces in order to temporarily keep out soil and water. Used for placing utility lines in a trench, or until a permanent wall can be built.

sheet pile cut-off A sheet pile wall driven into the ground under a structure, such as a dam, in order to prevent or reduce seepage.

sheet piling A series of flat piles, usually made of interlocking steel, driven side by side to retain earth and to prevent seepage into an excavation.

shoring A system of shores (posts, beams, or props) placed obliquely to steady or support an excavation or wall.

shotcrete A cement-sand mortar sprayed onto rock by a compressed-air ejector. Shotcrete forms a very dense, high-strength seal on the walls of rock cuts and tunnels.

sieve analysis Carried out in a series of pans whose bottoms contain meshes with a range of standard openings. The pans are placed in a shaker to determine the grain size distribution of gravel, sand, and silt soils.

silt A granular soil in the size range of 0.002 to 0.06 millimetres, making it finer than sand but coarser than clay.

slab and buttress A large but thin wall of reinforced concrete supported laterally by buttresses.

slope indicator Trade name for types of inclinometers manufactured by the Slope Indicator Company.

sludge Fine solids settled out from mine waste that may contain poisonous metals.

sluiceway An artificial channel for conducting a rapidly flowing stream of water.

slurry trench A trench excavated below a foundation or under a dam to an impervious layer, then filled with clay puddle or concrete to make a watertight barrier.

soil (earth) Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks.

soil mechanics The science that applies the laws and principles of mechanics and hydraulics to working with soil as an engineering material.

soldier pile A vertical pile to hold the outer face of sheeting against the earth.

sphagnum moss A soft moss found chiefly on the surface of peat bogs.

spigotting A method of deposition of the mine tailings through a pipeline. The heavier particles separate themselves in accordance with their size and specific gravity to form a beach, while the water and the finest particles return to the pond.

spillway An overflow channel over a dam.

spoil Overburden or other waste material removed in excavating, quarrying, dredging, or mining.

spread footing A footing that is widened or otherwise enlarged to lower the load per unit area on the soil and thereby reduce settlement.

spur line A secondary or branch railway line that connects with but is a subsidiary to the main line.

spur (rock) A ridge that projects sharply from the crest or side of a mountain.

stope An underground excavation formed by the extraction of ore.

strand line A former shore line elevated above the present sea or lake level.

stratigraphy The science of rock strata, concerned with the strata's geographic arrangement and chronological order.

stripping The clearing of a site of brushwood, topsoil, or other unsuitable material prior to building a structure. In mining, removal of overburden down to the ore body.

superelevation The construction of a foundation above its final design elevation to counteract future settlement.

super-plasticizing agent An admixture in concrete which allows a structural element to be stressed without cracking, fracturing, or appreciable volume change.

T

taconite A local term used in the Lake Superior region for the hard rock that encloses the Mesabi iron ore.

tailrace The channel by which water, after exiting from a turbine, is discharged into a river or lake.

talus Rock fragments, usually coarse and angular, lying at the base of a cliff or steep slope from which they originated.

tank farm A large flat area, usually surrounded by a dyke for fire and spillage protection, used for the placement of a number of storage tanks containing oil or other liquids or gases.

Tertiary (age) The first period of the Cenozoic era, which covered the time span between 65 million and 2 million years ago.

thaw bulb stability The stability of permafrost beneath a heated pipeline, which transfers heat to the soil in the form of bulb-shaped isotherms (lines of the same temperature.)

thaw settlement The settlement resulting from thawing of frozen ground and subsequent drainage of pore water.

thermal erosion The erosion of ice-rich permafrost soil by the combined thermal and mechanical action of moving water.

thermistor A gauge for measuring the temperature of soil.

tieback anchor An anchor embedded into solid rock or firm ground beyond the perimeter of an excavation, which by means of a tie rod holds back a retaining wall.

toe The lowest part of an earth fill or dam, located on the side of the dam away from the retained material.

torque The twisting force applied tangentially to a shaft.

training (estuary) Engineering works such as a retaining wall, dyke, groin, or levee designed to influence the flow, scouring, or silting capacity of a river.

transit (theodolite) A surveyor's telescopic instrument for the precise measuring of horizontal and vertical angles.

trestle A braced framework of timbers, piles, or steelwork used to carry a road, railroad, or pipeline over a deep depression.

triangulation The measurement of a large area of land by means of a network of triangles whose angles are accurately known.

tunnel A man-made underground passage, nearly horizontal, used for the transport of vehicles or liquids.

tunnel (diversion) A tunnel used temporarily to carry a river or stream past a dam site while construction is in progress.

tunnel (pressure) A tunnel in which the liquid carried therein is under pressure.

tunnel (power or transmission) A tunnel used for the transmission of a liquid, such as water, to run a turbine.

U

undisturbed sample A sample of cohesive soil taken from a bore hole or test pit which is so little disturbed from its original state that it can be used for laboratory measurements of consolidation and shear strength.

uplift pressure An upward force on a structure exerted by the earth under the pressure of water.

V

vane shear test A test to determine the *in-situ* shear strength of a soil. A four-bladed vane, attached to a vertical rod, is inserted into the soil at the bottom of a bore hole, then rotated at the top by a measured force until the soil shears.

vibro-flotation A method of *in-situ* densification of a loose soil deposit achieved by the insertion of a vibrating, poker-like probe. The probe is suspended from a crane, and water is pumped down the probe to form jets at its lower end.

vibro-replacement An improvement to the vibro-flotation process whereby graded stone aggregate is pumped through the probe holes to create stone columns.

void ration The ratio of the volume of voids to the volume of solids in a sample of soil or aggregate.

volumeter A field apparatus to calculate the density (weight per unit volume) of a soil. The volumeter consists of a water chamber and rubber balloon used to measure the volume of a hole from which the soil has been excavated and weighed.

vug (solution cavity) A small cavity in rock, usually limestone, which is caused by the dissolution of calcium carbonate.

W

wall friction The frictional resistance between a foundation wall or a pile and the surrounding soil.

wash bore A simple method of exploratory boring in soil deposits by which the hole is advanced and the soil removed by a chopping bit and a water jet.

water content The ratio of the mass of water contained in the pore spaces of a soil to the solid mass of its particles, expressed as a percentage.

water stop An impervious membrane embedded in concrete at critical points, such as joints, to stop the flow of water.

water table The boundary line between the lower zone of saturation of a soil or rock and the upper zone of aeration.

well point A perforated pipe, approximately 3 feet long and 1½inches in diameter, covered by a close-mesh screen to prevent the entry of fine soil particles. The well point is jetted into a water-bearing soil and connected at the top to a suction pump for the purpose of dewatering the soil.

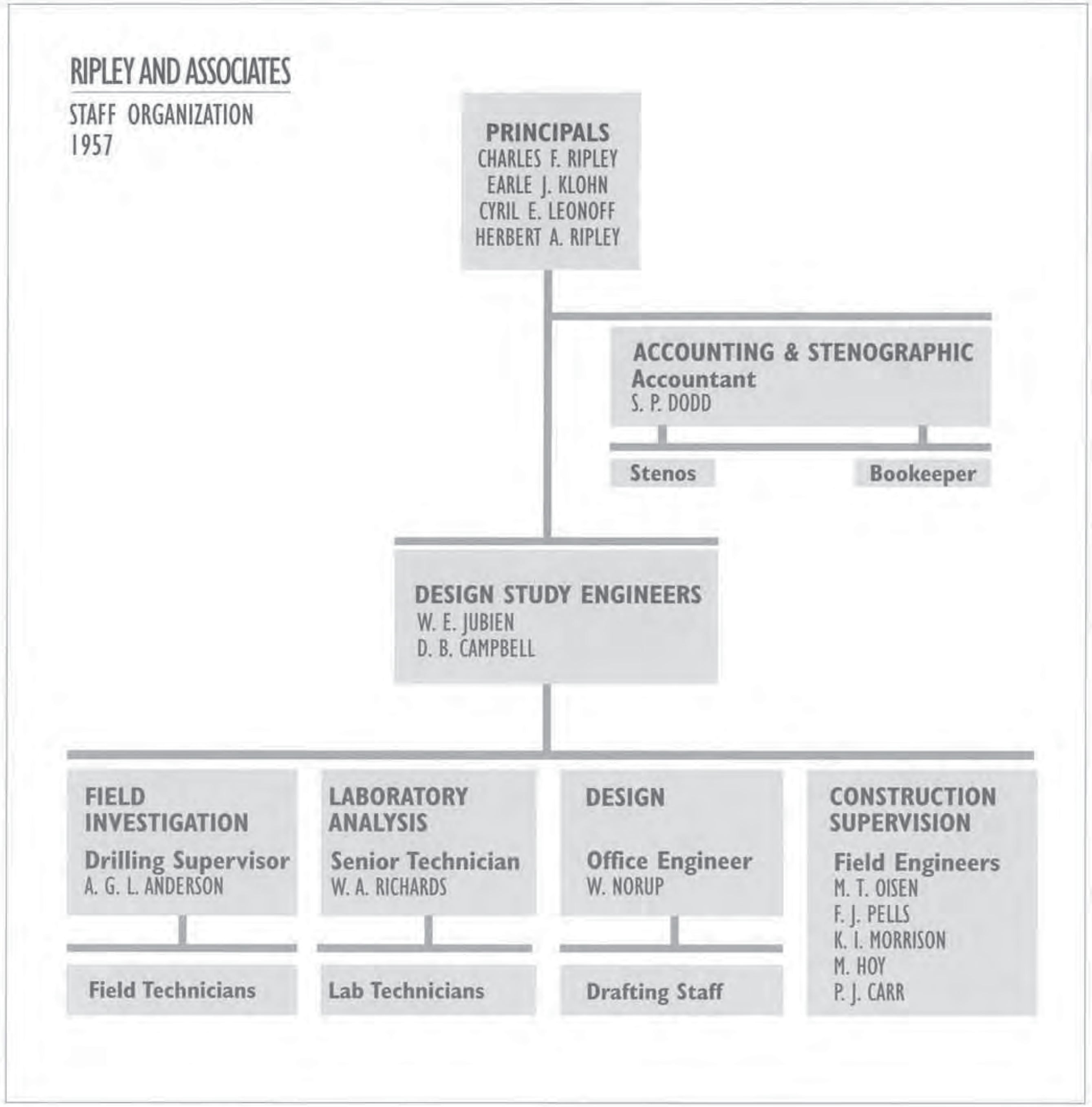
wick drain A drain made of a continuous fabric strip installed vertically into the ground by means of a crane-mounted telescopic lance. Similar in function to a sand drain, its purpose is to accelerate the consolidation of a loaded cohesive soil.

wobble-wheel roller A pneumatic-tired soil compactor having wheels suspended freely on springs, thereby allowing the wheels to follow the irregularities of the ground.

woodroom The place in a pulp mill where mechanical processes are conducted to debark, grind, and chip a log into small particles.

Appendix I

ORGANIZATION CHARTS



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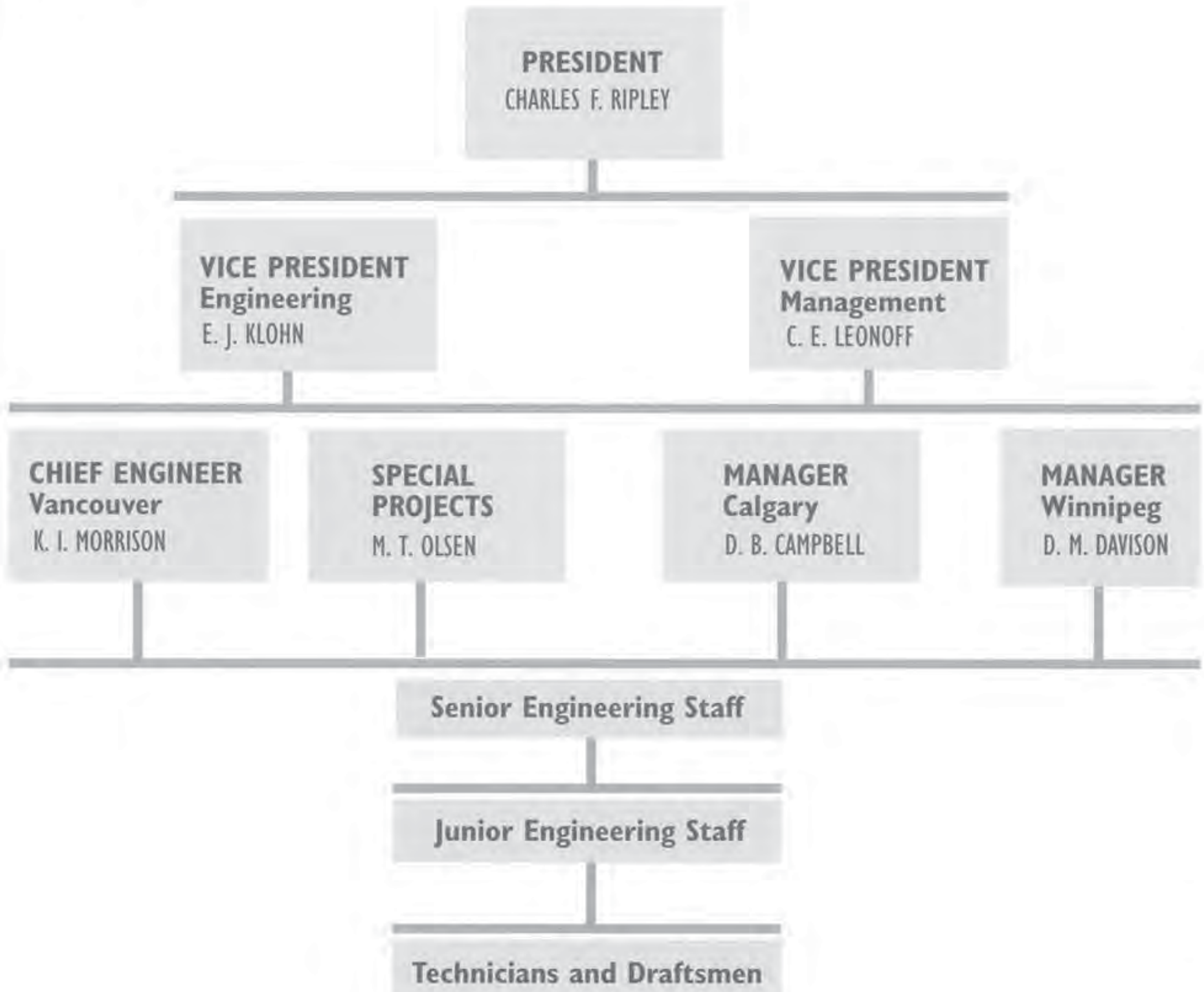

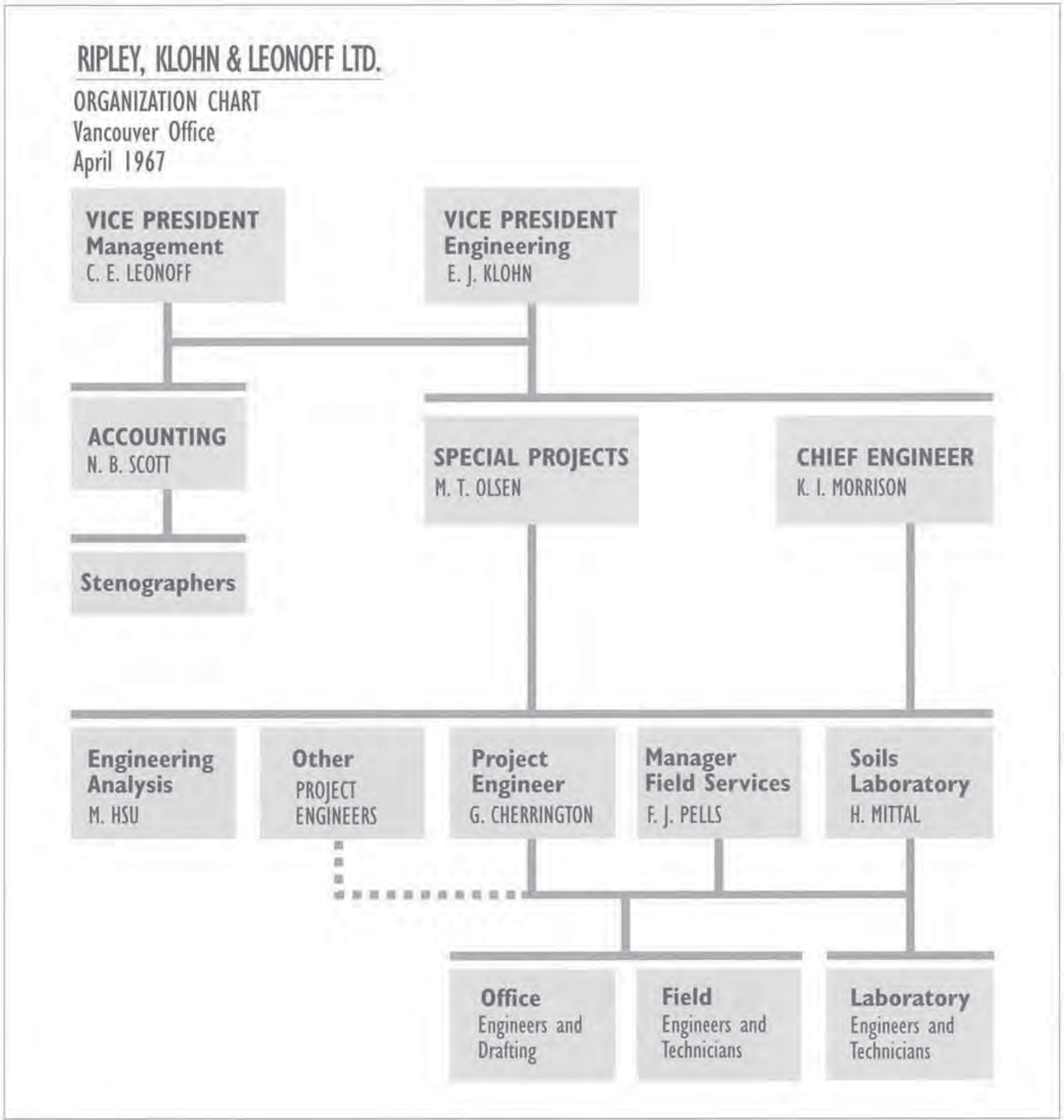
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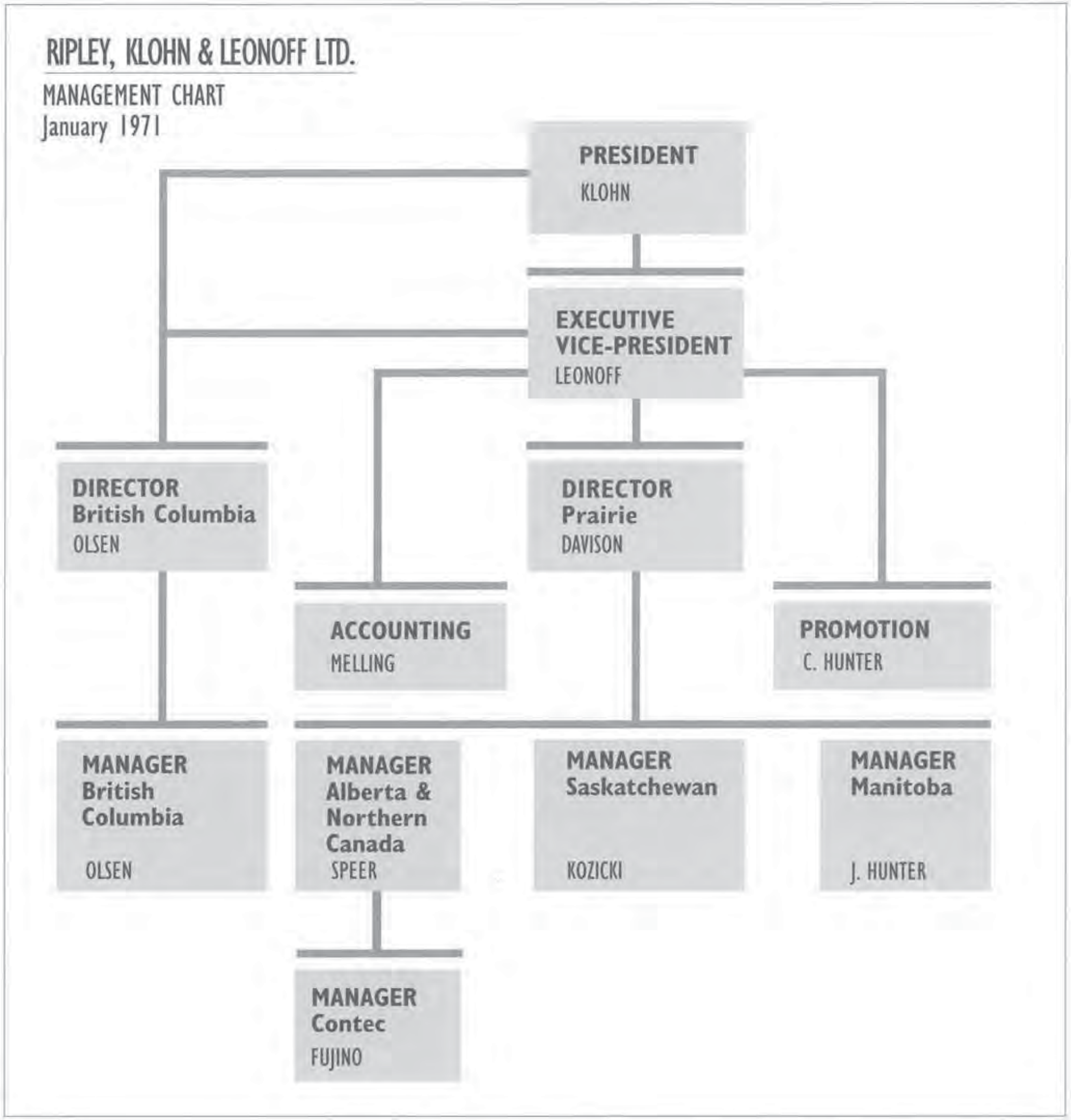
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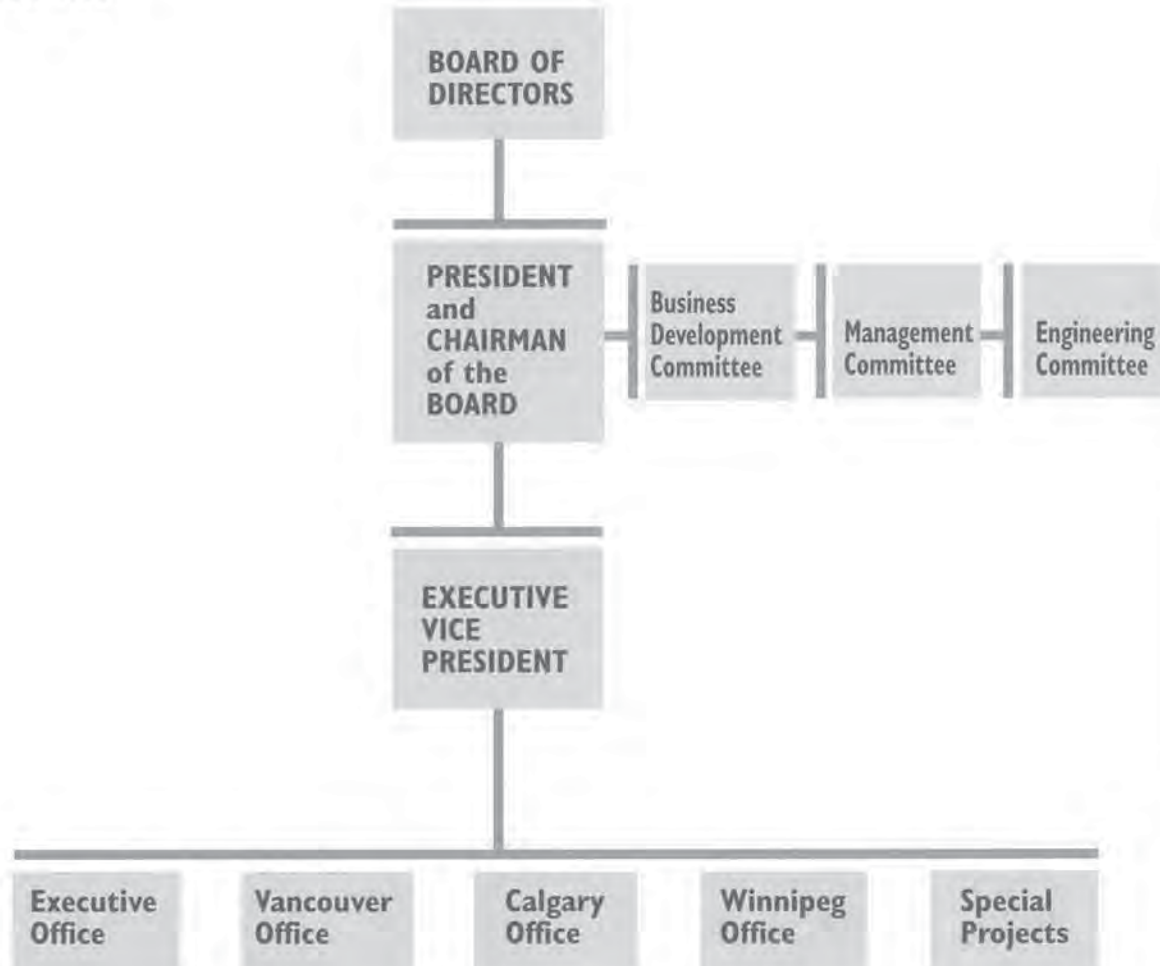

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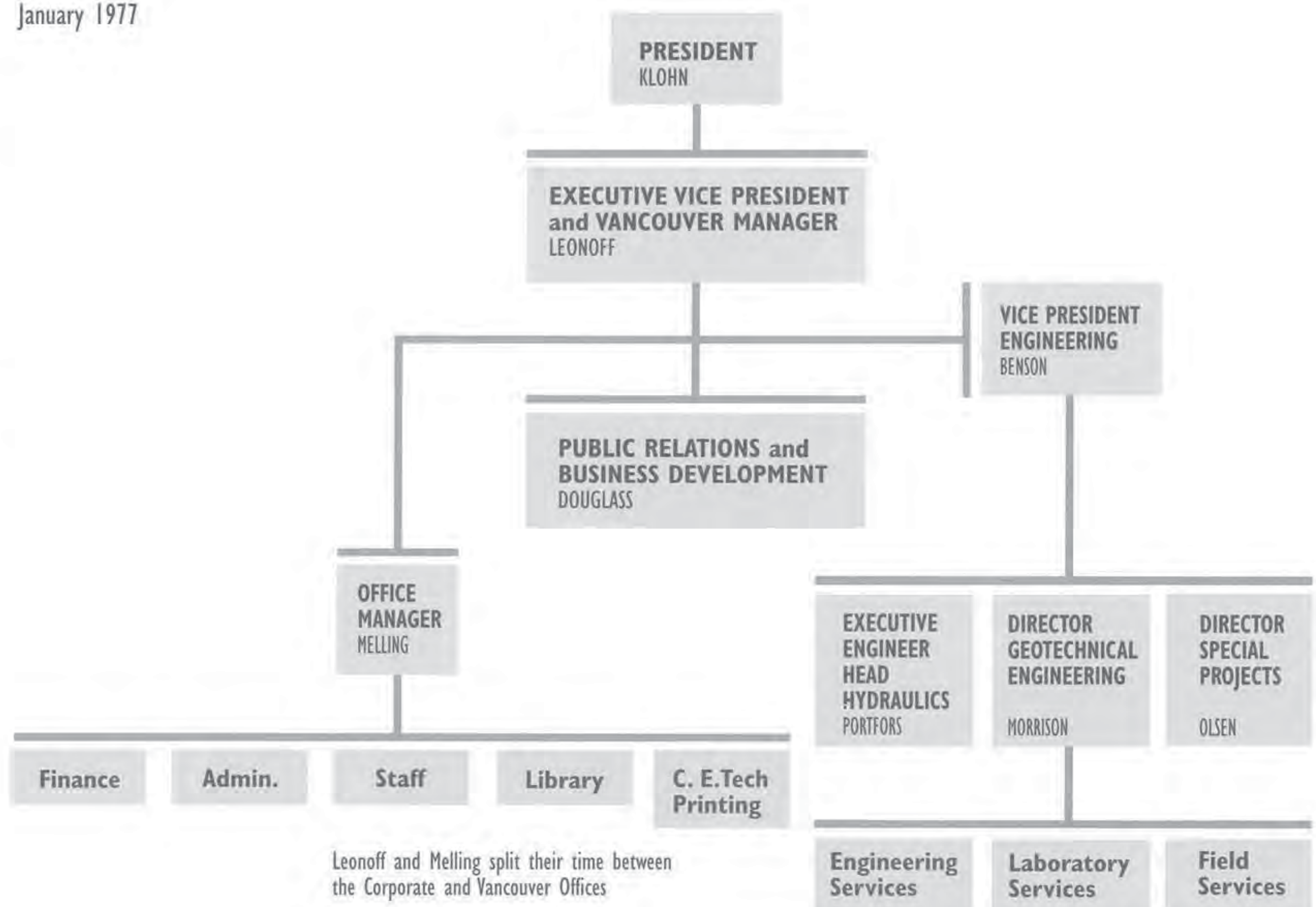

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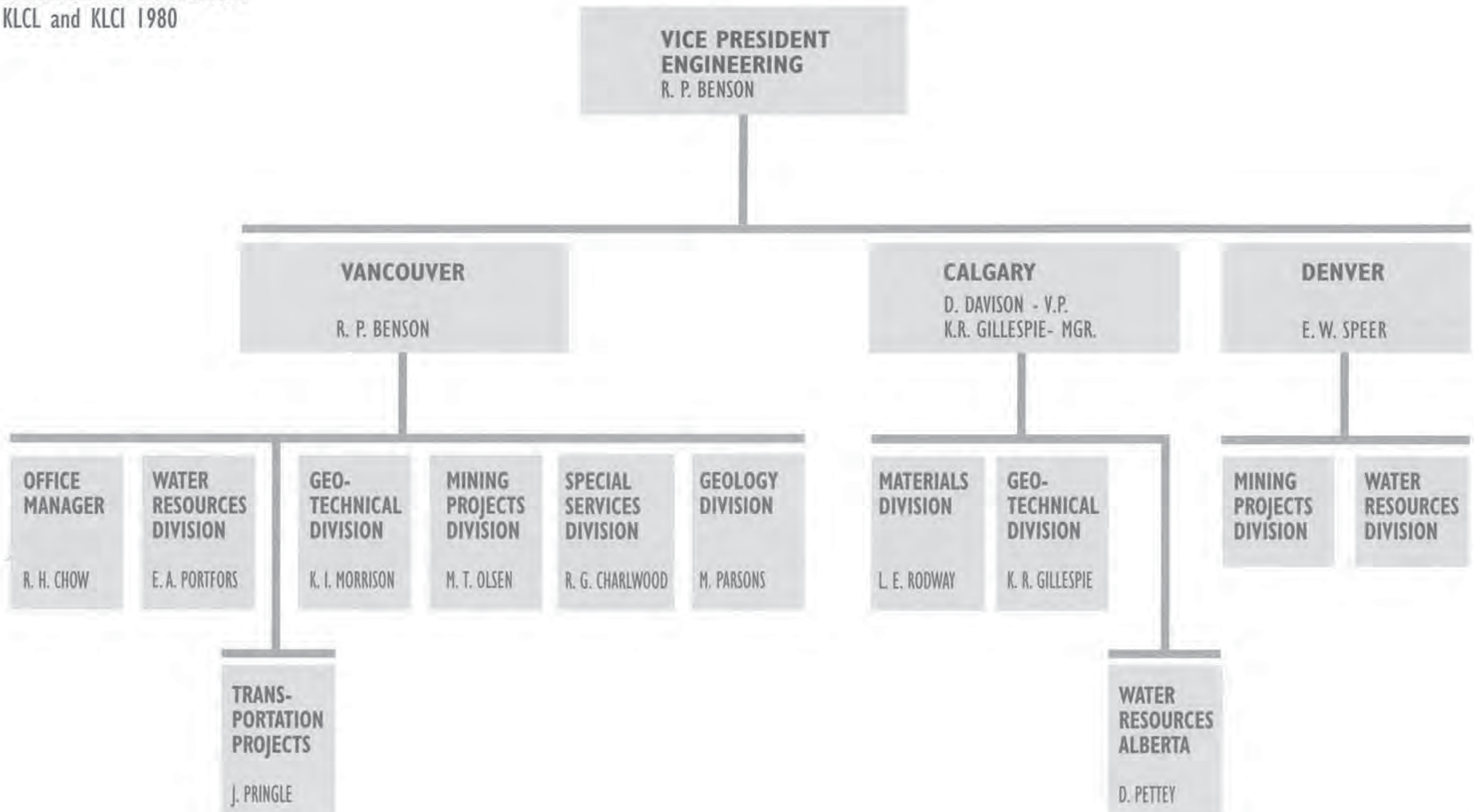

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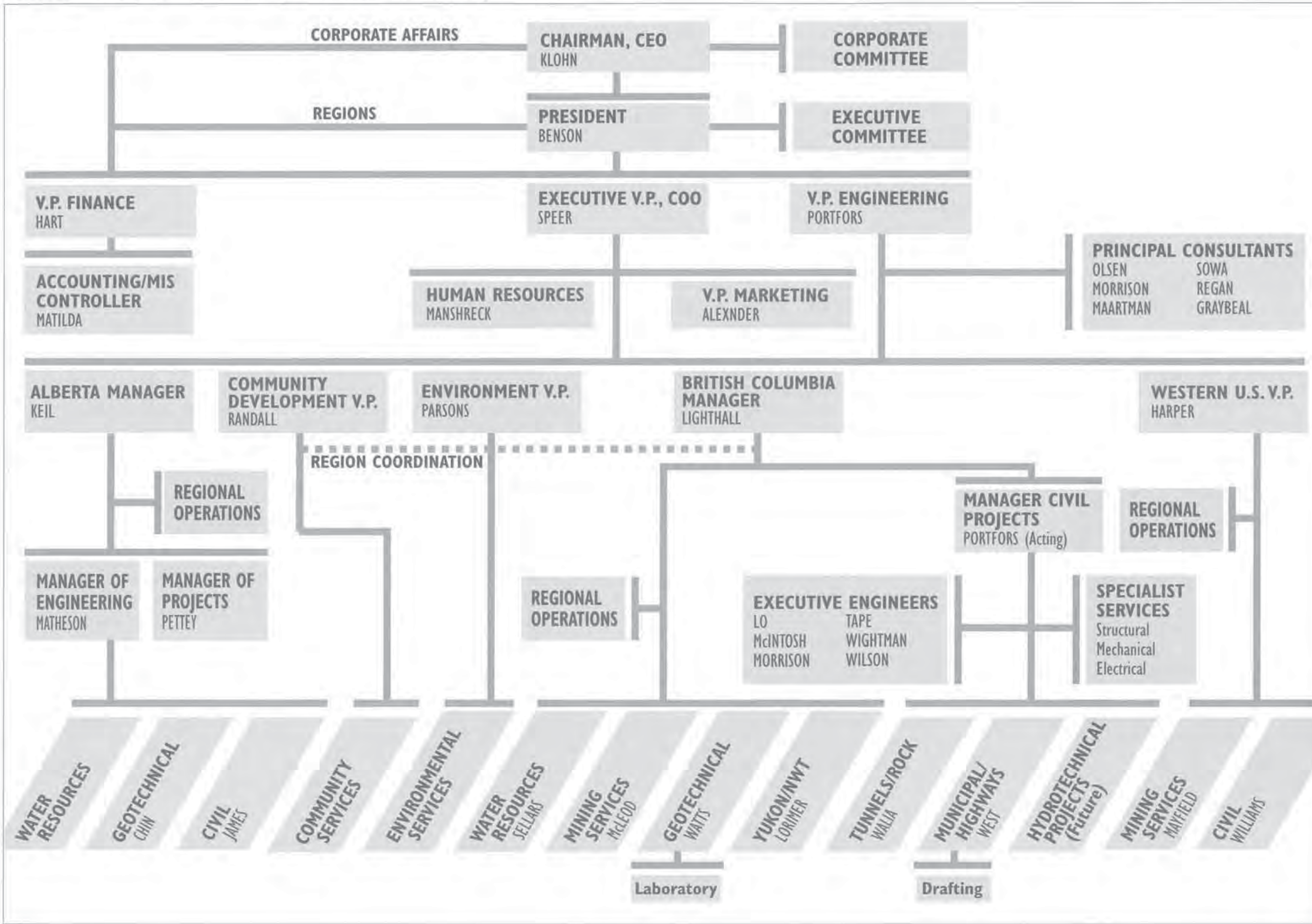

Appendix II

STAFF LISTS

Engineers and geologists of national and international repute who contributed significantly to the firm's capacity during the boom period (1977–81, Chapter 10) included: Edward I. Carey, a civil engineer trained at Nova Scotia Technical College, Halifax; Michael J. Davies, a civil engineer from England experienced in the design and construction of highways, structures, and municipal engineering projects; Dr. W. Scott Dunbar, a geophysicist and seismologist trained at UBC, Toronto, and Stanford who held an NRC Post Doctoral Fellowship to pursue basic research in rock mechanics; Edward A. Falloon, a civil engineering graduate of UBC with engineering work experience in Australia; David B. Gladwin, with a M.Sc. in mining engineering from Queen's University, Kingston; Ronald F. Grigg, a civil and computer systems engineer with a M.Eng. in dynamics of structures from the University of Western Ontario; W. Nicholas Hooper, a civil engineering graduate from the University of London with geotechnical and water resource experience in England, the Seychelles, and British Columbia; Brendan Killoran, a civil engineer trained at University College, Galaway, Ireland; Bernie C. Laws, an experienced materials and geotechnical engineer trained at the University of Saskatchewan; Peter S. McCreath, a brilliant scholar holding a B.Sc. in civil engineering from the University of Manitoba and a Ph.D. in civil engineering (hydraulics) from Imperial College of Science and Technology, London, in addition to receiving the University Gold Medal (1973), M.Sc. in water resources, University of Newcastle upon Tyne, England and a Diploma of Membership from the Imperial College (D.I.C.); Malcolm A. Macfadyen, an engineering geologist trained at the universities of Sheffield and Durham, England; Harvey N. McLeod, B.A.Sc. in engineering geology, UBC, who was sponsored by the company to take an M.Sc. in soil mechanics at the University of London and the D.I.C. Imperial College of Science and Technology; A. M. "Tony" Melone, a senior hydraulics engineer holding a M.Sc. in civil engineering from Colorado State University; N. A. Morrison, B.Sc. (Honours) and M.Sc. in soil mechanics and foundation engineering, University of Alberta; Jeffrey R. Pringle, a civil engineer from England, with a broad experience in highway, bridge, and tunnel engineering; Steve Rice, B.Sc. (Honours) in civil engineering, University of London; Philip E. Salt, holder of an M.E. (civil) from Auckland University, with a range of experience in earthquake engineering, structural dynamics, and soil-structure interaction; S. Byron Stewart, a civil and mining engineer from South Africa; and Brian I. Tollin, B.Sc. in civil engineering, University of Glasgow, Scotland, and M.Eng., University of Toronto, an experienced geotechnical engineer who became project engineer on the pile foundations and embankment construction for the Saskatchewan Wheat Pool elevator on Burrard Inlet.

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CYRIL E. LEONOFF is a professional engineer and historian who has written on both engineering and historical subjects. He was a principal of Klohn Leonoff Ltd. for thirty-three years. This is his third book.

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