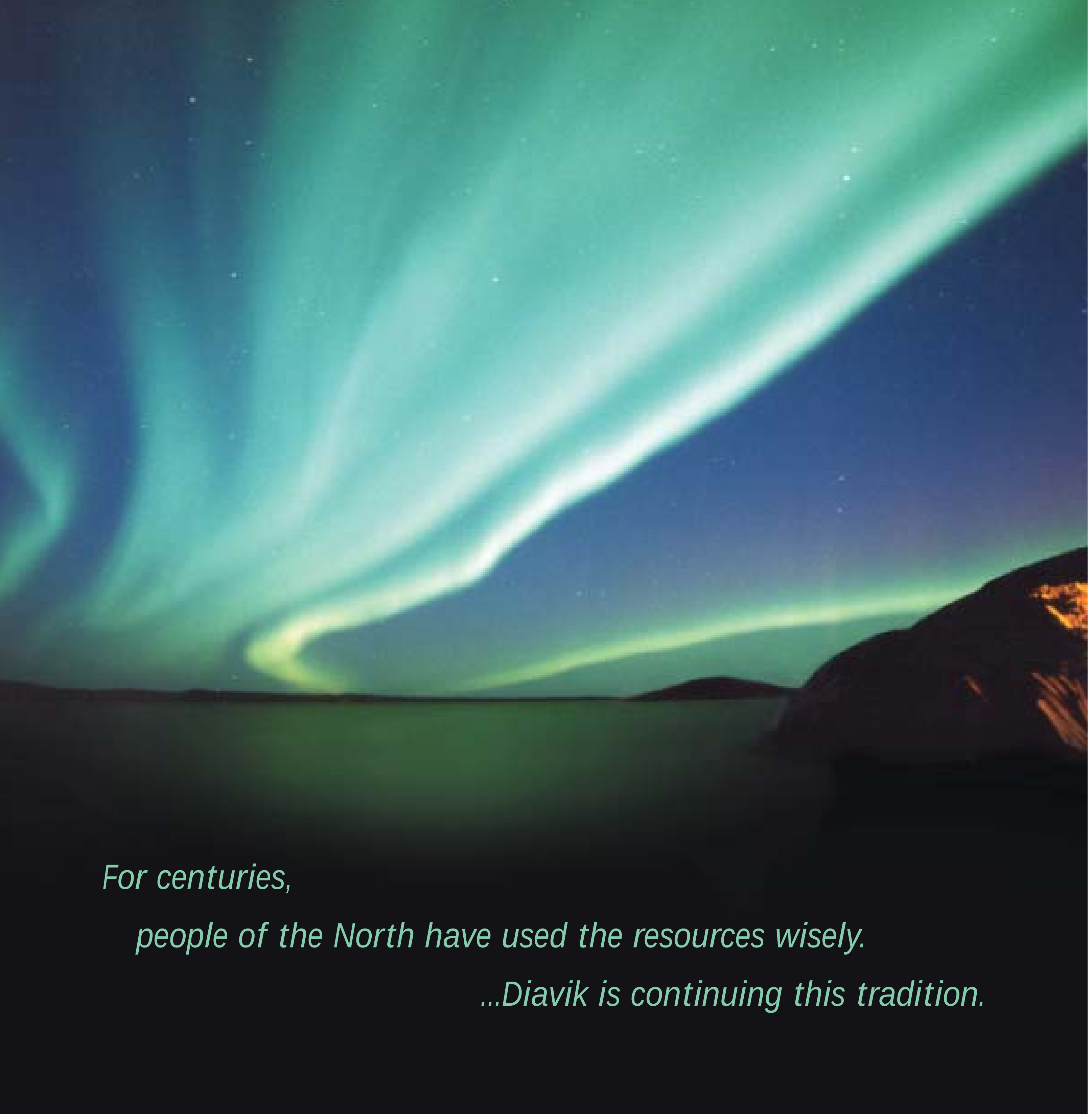
Diavik™

Constructing the Legacy

The Story of the Construction of the Diavik™ Diamond Mine



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Our Vision Statement

Diavik's vision is to be Canada's premier diamond producer, creating a legacy of responsible safety, environmental and employee development practice and enduring community benefits.

Our Values and Principles

We treat ourselves and all those with whom we meet and work with dignity, consideration and respect.

We are committed to active partnership with local communities, businesses, governments and non-governmental organizations.

We are dedicated to meeting the needs of our customers and to contributing long-term value to our investors and to the North.

We strive for excellence in all we do.

Gerard Laman photographing at 2 a.m. on a midsummer's day. Gerard indulged his love of photography while working as an NKSL project engineer.

Photographer Jiri Hermann, during one of several photo assignments at Diavik.

Diavik: Constructing the Legacy
The Story of the Construction of the Diavik Diamond Mine

Writer: Richard Olive
Design: Artisan Press Ltd.
Photography: Many project workers including Richard Dompierre, Arnold Enge, Doug Bryan, and Doug Ashbury provided photographs for this book and their contribution is acknowledged and appreciated.
Jiri Hermann and Gerard Laman provided major photographic contributions.
Cover photograph of rough diamond by Tim Atherton.
Tony Rattue and Dominique Lemelin, and Marcel Pineau and Abdellatif Dellah, photographs by Paul Labelle.
Don Holley photograph by Mark Anthony.

Cover: A gem quality 10.64 carat rough Diavik diamond with the Diavik Diamond Mine inset.
Page i: In November 2001, the A154 dike appeared to be complete but much work remained for the structure's central cut-off wall. Dewatering of the pool would have to await completion of this work during the following summer.

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Contents

With the A154 dike constructed and the water removed, the Lac de Gras lakebed's fine silt dries under the arctic sun. Workers' footprints, top, go where none have gone before.

Foreword

This book, entitled *Diavik: Constructing the Legacy*, deals with the engineering and construction phase of the Diavik Diamonds Project.

It is the story of how teamwork can deliver results which every contributor can be very proud.

I think of individuals, companies, consultants, communities, and the many other supporters, who have made this achievement a truly remarkable one. To every player on the team, a word of thanks and congratulations.

After three exciting years, pulling together in harmony, we have achieved a great result. This book is full of memories to be shared with our families and friends who have supported us.

"Footprints in the sands of time were not made by those who stood still."

Phil du Toit
President
Diavik Diamond Mines Inc.

Preface

The owners of the Diavik Diamonds Project are Diavik Diamond Mines Inc. (DDMI) and Aber Diamond Mines Ltd. (Aber). DDMI is a wholly owned subsidiary of Rio Tinto plc of London, UK and Aber is a wholly owned subsidiary of Aber Diamond Corporation of Toronto, Ontario. DDMI, located in Yellowknife, Northwest Territories, is manager of the project.

DDMI engaged Nishi-Khon/SNC-Lavalin (NKSL) to act as the engineer for project development. In this role, NKSL was responsible for the engineering design of most of the facilities, the procurement of the many required components, the letting of contracts for the construction work, and the management of the contractors on site. NKSL is a joint venture between Dogrib-owned Nishi-Khon of Yellowknife and SNC-Lavalin of Montreal, Quebec.

In the preliminary stages of dike conception, DDMI had some engineering work performed by Acres International Ltd. of Oakville, Ontario. Similarly, H.A. Simons, a Vancouver, British Columbia firm, provided management of the very early site construction work. The important contribution of these companies is recognized.

NKSL's work in engineering design, procurement, and contracts was carried out in Calgary, Alberta and then in Vancouver. Exceptions were the dike and water management system, engineered by specialist teams in Montreal, and the on-land dams designed by cold-region specialists in Toronto.

To design the mine's accommodation complex, DDMI engaged the Yellowknife firm Ferguson Simek Clark (FSC).

Various consultants on the project are listed in Appendix One. Many contractors and sub-contractors worked on the project. They are listed in Appendix Two. For ease of reading, parties are often referred to in the text by their commonly abbreviated names, rather than their full legal names. Literally hundreds of suppliers from across Canada and around the world provided products used in the project. It is not practical to list them all, but Appendix Three does enumerate the major suppliers of specialist equipment and material.

Chapter One

The Challenge

In mid-1994, the geologists of Aber Resources Ltd. discovered diamonds in kimberlite pipes penetrating the granite beneath the bed of Lac de Gras, in the remote, cold, forbidding interior of the vast Canadian tundra.

By late 1997, drilling and tunnelling proved the diamonds to be sufficient in number and quality to be well worth recovery. Indeed, here, hidden for millennia, lay one of the earth's treasure troves.

Aboriginal peoples had long hunted and fished the region during the short sunny summers, but had the good sense to retreat during the long harsh winters. Europeans came, and went also, if they did not perish during their visit. First came Samuel Hearne, during his epic walk from Hudson Bay and back. Struggling around the eastern shoreline of Lac de Gras in 1771, he was surely a doomed man if it had not been for his Aboriginal companions. His thoughts were of survival, not the possibility of diamonds beneath his feet.

Next, in 1821, came Captain John Franklin of the Royal Navy, and his not-so-merry men. Too proud to heed many an Aboriginal warning about the perils of the tundra, they trudged back past Lac de Gras to Great Slave Lake, after their reconnaissance mission to the north coast. Desperate for any morsel which nature might afford them, their numbers dwindled by the mile as the tundra claimed them. Never did they dream of the riches so close at hand.

As late as 1963, the prolific and acclaimed storyteller Farley Mowat, frustrated by his inability to locate a wolf's den on this northern tundra, lamented flippantly and unwittingly in *Never Cry Wolf*, that he had as much chance of finding a diamond mine in a country as open and vast as this.

But as sure as wolves were there, so too were diamonds, if only they could be discovered and recovered. But how to access the lakebed? How to keep the water sparkling? How to mine the kimberlite? How to recover the diamonds? How to safely store the waste? How to provide energy? How to attract, shelter, and feed a workforce? How to embrace the Aboriginal people of the area and share the opportunities created?

The design and construction of the Diavik mine is an epic saga of success on a grand scale in the most forbidding of places. The challenge attracted hardy and adventurous souls from every corner of Canada and the shores beyond. This book is a tribute to their work.

Situated above Canada's treeline and 220 kilometres below the Arctic Circle, Diavik's remote location created unique challenges.

Chapter Two

The Dike Conception

"The ore body had not long been discovered when Rio Tinto's Jon Gliddon interviewed me for the job. 'John,' he said, raising his index finger in the air, 'The most important thing for you is this – when you start pumping, the water level in the pool had better go down.'"

John Wonnacott, DDMI Deputy Project Manager

Satellite image of the Diavik site on East Island taken from 680 kilometres in space during summer 2001.

Given that the mine could only safely operate if the waters of Lac de Gras could be held at bay with certainty, DDMI realized very early just how vital the dike was to the success of the operation.

Every dam poses its own set of problems to the design engineer. At Diavik, however, there were problems which were unique and extreme, including:

- The dike would have to be built "in the wet" without the engineers ever having a chance to set eyes on the foundations.
- For eight months of the year, the lake would be frozen and the winter months would present construction workers with intense cold and extended darkness.
- The only construction material which nature provided at the site was granite, so that virtually all gravel and sand for construction of dams would require blasting and crushing.
- The dike foundation was permanently frozen (permafrost) under the abutments and the islands, but not frozen under the lake. The design would have to straddle both foundation types.

- DDMI's John Wonnacott surely spent more hours than anyone else explaining, persuading, and cajoling to bring the dike from concept to reality. For five years, day and night, the dike occupied his mind with never a detail escaping his attention or failing to arouse his concern. His work was crowned with the Canadian Council of Professional Engineers 2003 award which acclaimed the A154 dike as Canada's outstanding engineering achievement for the year 2002. The award is a tribute to the imagination, skill, courage, and perseverance of all the companies and their engineers who designed and constructed the dike.
- NKSL's Tony Rattue, left, and Dominique Lemelin discussing the A154 dike. Tony and Dominique carried the consultant's engineering of the dike through feasibility, design, and construction.

- Construction activities could not be allowed to contaminate the lake's pristine water.
- There was no permanent road within hundreds of kilometres of the site. All equipment, fuel, and materials not transported to the site on the winter ice road would have to be flown in.

Years of investigations preceded commitment to a design. Directed by John Wonnacott, activities included lakebed bathymetry, geological and geotechnical investigation of the foundation, desk and field studies of sediment movement, dike alignment studies, analysis of tentative cross-sections, and a search for the world's best technology for constructing impermeable barriers through soil and rockfill masses.

The geological work demonstrated that the crystalline bedrock beneath the lake was the granite and metamorphosed sedimentary rocks so typical of the Canadian Shield, covered by a blanket of glacial till, which in turn lay beneath a cover of loose sediments.

The till blanket, up to 15 metres thick, created challenges. It was strong enough to carry the weight of the dike but not sufficiently watertight to prevent seepage, so the impermeable cut-off wall would have to penetrate not only the rockfill mass of the dike, but continue right through the till down to bedrock. The till, however, proved to be very variable – generally a sandy silt, but containing gravel, cobbles, and boulders. In fact, towards the shorelines it tended to consist more of large boulders than anything else. As a result, any trenching equipment would have to be able to dig these boulders in its stride.

The sediment posed its own problems. John's team quickly came to the realization that the sediment, up to four metres thick, was just too weak to carry the dike and would have to be removed. Doing so threatened to stir up unacceptable turbidity in the lake. Not daunted by over a metre of ice on the surface, Wayne Gzowski of Yellowknife and his experienced crew from Arctic Divers plunged into the chilling depths to test and photograph just how mobile the sediment was. At the same time, Dr. Rick Thompson, oceanographer and mathematician at Tsunami Research International in British Columbia was breaking new ground in predicting the drift of plumes of suspended sediment in response to lake currents set up by the expected winds.

The typical cross section of the dike resulted from an evolutionary process in which John led the discussion with various consultants to decide what was necessary and what was possible. The process was driven by a search for greater economy without jeopardizing security. Finally, a section was chosen that cut 30 per cent from the original volume, but which was constructible, and most importantly,

- *Rocky tundra and the pristine waters of Lac de Gras.*
- *Schalk van Heerden, Denton Henkelman, and Ron Hampton, with DDMI, left to right, discuss project progress and cost.*
- *Prior to construction of the A154 dike, Diavik enlisted Wayne Gzowski and the underwater specialists of Arctic Divers of Yellowknife. Here, Wayne prepares to dive below the ice of Lac de Gras to film boulders that would be dropped through the water column to the lakebed. The exercise showed that construction of the dike's rock embankment – which would involve placing rock in the lake in a far gentler manner – would not generate silty water.*

satisfied all the safety requirements of the Canadian Dams Safety Association. A feature of the chosen cross-section was a thin central cut-off wall composed of plastic concrete, to be built within a fine crushed rock core contained by rockfill shoulders.

Plastic concrete is a variant of conventional concrete; it has a low cement content and it contains bentonite, a finely ground clay. The end result is a highly fluid concrete which can be successfully placed without compaction, and which is more deformable than regular concrete once it has set.

There was very little precedent for such a wall in Canada. It was essential that its integrity could be guaranteed and that nothing during its construction would blemish the lake. To this end, John Wonnacott, assisted by Tony Rattue, NKSL's chief dam design engineer, scoured the earth searching for the best technology and practice. In the small town of Schroebenhausen near Munich, Germany they discovered Bauer Spezialtiefbau GmbH, and in particular, Herr Stefan Schwank. This association was to last for the duration of the project. Bauer designed and fabricated equipment especially for the Lac de Gras conditions. It was eventually to become a fixture of the dike construction scene.

Meanwhile, the "fine crushed rock core" required some definition. How fine was fine enough? How fine was too fine? How would the granite of East Island break down in the jaws of the crusher? To answer these questions, Tony Rattue and his team members, Samir Asfour and Dominique Lemelin, studied the diverse requirements: it had to be capable of compaction, sufficiently impermeable to retain bentonite slurry, sufficiently permeable to pass water, and sufficiently well-graded to resist erosion by seepage water. A truckload of rock was hauled all the way from site to Milwaukee, Wisconsin for a trial crushing. Out of this process, Chuck Nyland of Kiewit (senior partner with Nuna Logistics, a majority Inuit-owned company, in the joint venture Lac de Gras Constructors, or LDG) developed the layout of the greatest temporary crushing facility to grace the new millennium in North America.

A problem still nagged. Exposures on land indicated that the granite surface was anything but smooth and regular. Instead, it was jagged, blocky, and criss-crossed by fractures. Although the panels of the cut-off wall could be confidently carried down through the dike and the till, it was asking too much to expect the equipment to eat through the massive hard granite. So the union of cut-off wall to the irregular bedrock surface would be achieved through a novel process called jet grouting. Once more, Bauer brought technology to the party, and so too did an Italian company, Pacchiosi, represented by their Canadian manager Yves St-Amour.

Construction would require immense quantities of cement, trucked in two tonne bags over the ice road. Most of the cement was destined for the A154 dike cut-off wall.

An LDG backhoe operator found digging ice and water a refreshing change from soil and rock. Prior to moving the dredge out over the dike footprint, workers smashed through the decaying ice in June 2001.

Wherever the dike abutted land, Arctic Engineering installed banks of thermosyphons – closed tubes containing liquid carbon dioxide. Thermosyphons, stretching from bedrock to chilling arctic winds, draw heat from the rock and maintain the integrity of the permafrost below.

While Tony Rattue's team was refining details of the cross section, site investigations continued apace during the short summer months and from the ice surface during winter. Dr. Brian Bornhold, sedimentologist with Coastal and Ocean Resources in British Colombia measured the bathymetry of the lakebed and the characteristics of the sediment, Mid-West Drilling probed the thickness of the sediment and the till, Randy McGilvray and Dr. Sam Proskin of EBA sampled and measured the soil properties while their colleague Kevin Jones at the company's Edmonton laboratory, experimented to find the best mix for the plastic concrete.

Much of this work was aimed at deciding just where the dike should be located. Obviously, it had to surround the proposed pit. However, that prompted the questions of just how wide the pit was going to be and what width margin should be left for safety beyond the pit rim. The simplistic view was that the shortest route would be best. It did not turn out that way. John Wonnacott tells the story: "In those days, I had the lake bathymetry pretty much memorized. It suddenly dawned on me that we could build a longer dike than apparently necessary, but one that required much less material because of its island-hopping nature. I thought of this one Friday evening, on my way home from work. When the idea came to me, I got off the C-train, reversed course, went back into the office, and plotted it out before the idea could be forgotten. We ended up saving construction time as well as direct costs. The effect on our project net present value calculations at the time was a gain of nearly C$100 million."

The conceptualization stage was a time of heady days. Studies on the project were progressing simultaneously at DDMI's office in Calgary and NKSL's office in Vancouver,

▾ *Sediment stirred up by Fraser River Pile and Dredge's dredge, left, and by the placement of quarried and crushed rock, lower right, is contained by the turbidity barrier. The barrier, a heavy yellow PVC sheet, was suspended from a floating cable and hung through the water to almost touch the lakebed.*

▸ *A barge in the Arctic is a rare sight to be sure. Flying the flags of Canada, the Northwest Territories, and Fraser River Pile and Dredge, FRPD's barge sets out to transfer the lakebed silt from the dike and pit footprint to the on-land storage ponds.*

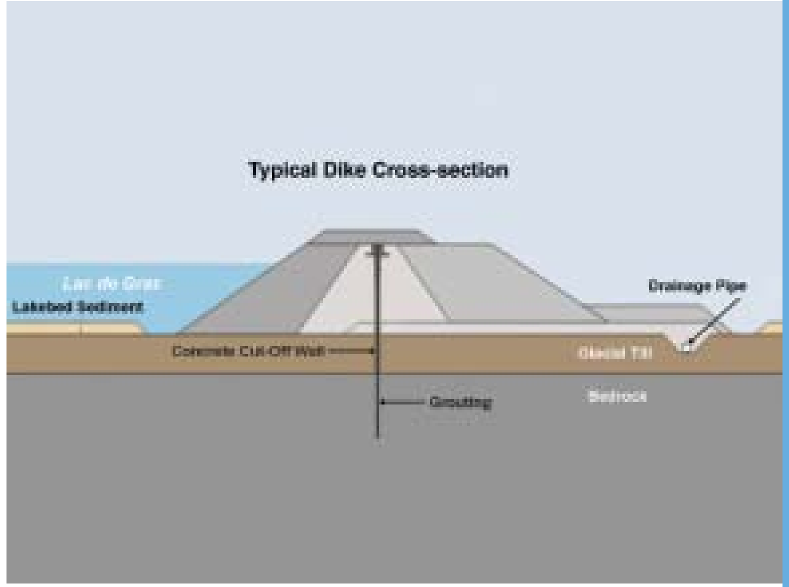
Toronto, and Montréal. Key players seemed in continuous motion between these centres and abroad, attending technical meetings, reviewing construction methods, and addressing the diverse needs of government, environmental, and Aboriginal groups.

Another example of John's creative thinking was the decision to incorporate thermosyphons into the dike alignment – literally bringing refrigerators to the tundra to extend the permafrost! The cut-off wall and the grouting beneath it would ensure that the alignment presented a continuously impermeable barrier right across the lake where the lakebed is unfrozen. Beneath the islands and the abutments, however, water-tightness is provided by the permafrost, that is, the frozen water that completely fills every crack and void in the ground. But what happens at the contacts? Could we be sure that we had continuity of contact between cut-off wall and permafrost?

John's solution was to construct the cut-off wall, then artificially extend the permafrost to envelope the end of the wall in ground that was previously unfrozen. The thermosyphons are the tools that did the trick.

During the early years of dike conception, it became apparent to DDMI that the dike was far from a run-of-the-mill dam. It contained many design features that made it unusual in Canada, indeed in the world. DDMI's parent company, Rio Tinto, needed assurance that the plans were viable. So too did investors and regulators. To this end, DDMI appointed a dike review board, consisting of five distinguished independent dams engineers: Doctors Bob Dodds, Fred Matich, Norbert Morgenstern, Andy Robertson, and Zip Zavodni.

The board was to meet quarterly over the next five years, critically reviewing the developing designs, the results of



The Montréal Meeting

By November 1999, many pieces of the dike jigsaw puzzle had been roughly shaped, but were just not quite fitting together. The beast was too bulky and hence too costly. John Wonnacott and Tony Rattue had seen all the individual elements work successfully, but a more compact package was needed to reduce the cross-section of the dike.

Bob Sinclair, then DDMI Project Manager, convened a meeting at SNC-Lavalin's Montréal office. John and Bob flew in from Calgary, Rio Tinto's Richard Olive from Melbourne, Bauer's Stefan Schwank from Munich, Kiewit's Chuck Nyland from San Diego, Fraser River's Ernie Zuccolin from Vancouver, all to join the locals – Tony's team, Kiewit's Val Ricci, and Pacchiosi's Yves St-Amour.

So much of the design depended on constructability – just what could be done, and done with confidence. For three days open debate raged from geotechnical theory to the practicalities of placing rock in arctic blizzards. At one stage, all were confounded by the competing claims of jet grouting proponents. In communal ignorance, an expert was needed! Expert consultant, Dr. Joe Kaushinger, was phoned at his home in Atlanta. Five hours later the colourful Joe, puffing and dishevelled, burst into the Montréal conference room to impart his wisdom.

The meeting was memorable for the range of skills and experience present, for the openness of the discussion, and for the attitude that every idea, no matter how seemingly crazy, would be listened to.

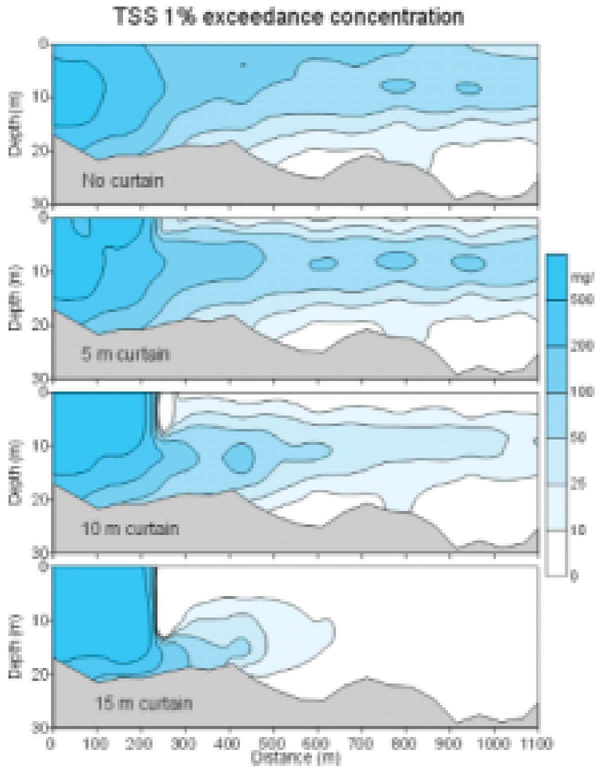
Out of the meeting came commitment from all parties to the cross-section which was eventually constructed. Remarkably, almost all those present stayed with the dike project through the years of design and construction to follow.

The dike review board comprised Doctors Andy Robertson, Zip Zavodni, Fred Matich, Norbert Morgenstern, and Bob Dodds, left to right.

analyses, the site investigations, the material test results, the proposed construction methods and schedules, the construction progress and quality, and finally, the behaviour of the finished dike as indicated by the embedded instrumentation.

In the view of DDMI Civil Engineering Manager Richard Olive, "The board gave comfort to the owners and the regulators, but just as importantly, it was a constant source of reassurance, of wisdom, of encouragement, and occasionally of cautionary advice to the engineering team. Their meetings also provided the very useful discipline of forcing us, in the midst of the chaos of activity, to stop, think, articulate, debate, and record our ideas so that we knew we were on solid ground."

To contain silty water, or total suspended solids (TSS) during dike construction, the area would be surrounded by a turbidity barrier, or silt curtain. To assess sediment movement, DDMI's consultant Dr. Rick Thomson enlisted Russia's most powerful computer. These plots show TSS predictions for four different possible silt curtain depths. The decision was taken to deploy the curtain to within one metre of the lakebed, which kept the TSS well within the regulatory limits. The predictions were very close to reality.



Overnight Express from Minsk

Predicting the drift of fine sediment in wind-generated currents is not an exercise that anyone in the street can turn a hand to. Indeed, it is among the most intractable of problems in engineering mathematics. But it was a problem that DDMI had to solve.

By chance, one of the world's champions at such puzzles was at our doorstep. Dr. Rick Thomson runs a small consultancy named International Tsunami Research from his home near Victoria, British Columbia. He quickly saw how to crack the puzzle, but what he needed was computing power, lots of it, more than Canada had to offer, more even than our southern neighbours could supply.

And Rick solved that puzzle too. By chance, at an international conference on the heady topic of computational mathematics, he had befriended some frustrated Russian counterparts. Dr. Alexander Rabinovich and Dr. Evgueni Kulikov had mathematical brains to match any on earth, and they had inherited from the former Soviet military machine its most powerful computer. Their frustration was a paucity of problems to really make it hum.

Suspended sediment drifting through Lac de Gras was just what the doctor ordered! And so Alexander and Evgueni started churning out analyses for DDMI. But every set of results raised another question.

"What would the results look like, Rick, if the wind was blowing from the east rather than the west?"

"Hey, good question. I'll give our Russian friends a call and get them to run it."

"But, Rick, it's midnight in Minsk!"

"No worries. Evgueni and the boys like nothing better than getting out of bed in the middle of the night to do a run. They love this stuff."

Sure enough, there on the fax machine in the Vancouver office, waiting to greet the engineers as they arrived would be the next set of beautifully graphed results, express from Minsk.

Chapter Three

The Dike Construction

"Our company, Kiewit, had built many dams, all across North America. Each had its own challenges, but the Diavik dike was special. When we were planning the job, the big issue that dominated our thinking was not so much the cold but the logistics. Constructing such a huge job with access for only 10 weeks each year via the ice road meant that our planning had to be good. No, better than good. It had to be perfect."

Val Ricci, LDG Project Sponsor

Midnight, early July 2002, and in the half-light of the sub-arctic summer night, the Bauer equipment works without pause to excavate the cut-off wall trench. The last remnants of ice upon Lac de Gras deny perfection in the reflection.

Two years, 2001 and 2002, were allocated to dike construction. However, the severity of the climate at year's beginning and end effectively chopped months off both years. At the front-end, in-lake work could not commence until the ice cover melted at the end of June 2001. At the back-end, dewatering of the pool had to start by mid-August 2002 to ensure that it was empty before freeze-up. So the nominal two years was an effective 14 months, and even that included one arctic winter.

Quarrying and Crushing

In anticipation of the thaw of 2001, LDG, the principal civil contractor on site, worked feverishly. They stripped the quarry and assembled the crusher. Together, the dike, the roads, the airport, the on-land dams, and all the various laydown areas, would require 8.4 million tonnes of quarried rock, two-thirds of which would need crushing. For the dike embankment alone the crusher would have to produce 1.2 million tonnes of quarry-run (Zone 3) rock, 1.4 million tonnes of 200 mm minus rock (Zone 2) and 1.1 million

▾ *Quarry workers Richard Marlow and Wayne Sigurdson of Yellowknife's NWT Rock Services got a blast out of their work every day! The pair wire detonators, which will set off the ammonium nitrate explosive in the quarry.*

▸ *Vancouver's Stanley Park has its nine o'clock cannon, but Lac de Gras' East Island had its six o'clock blast. Each evening at 6 p.m. precisely a shake of the island closely followed by a muffled boom announced the daily blast at the quarry. Drilling and blasting were executed by LDG's sub-contractor, NWT Rock Services.*

▸▸ *Feeding the crusher as much as 30,000 tonnes of rock per day required its fair share of loaders, dozers, and excavators.*

▸▸▸ *Cory Wearmouth, of Lac de Gras Constructors, wears dust protection at the crushing plant.*

tonnes of 50 mm minus stone (Zone I). Overall, the dike would require approximately six million tonnes of rock including nearly four million tonnes for the embankment and an additional two million tonnes for the downstream toe berm and the capping.

The crushing was on the critical path, meaning any schedule slippage would push back the project completion date. LDG utilized the largest crushing plant ever assembled in Canada to do the job. The plant crushed up to 33,000 tonnes of granite in a single day, but not without problems. The mineralogy of the granite led to the creation of more fine material than was required. For the workers this meant dust-choking clouds. LDG countered this by using special dry screening equipment designed for the purpose, or by spraying with water when the temperature was above zero. Nevertheless, dust levels always required use of facemasks.

The crusher workers coming off shift, with clothes and hair white with dust and the imprint of their masks upon their faces, commanded the awe of all.

Turbidity Barrier

Another preliminary task for LDG was preparation of the turbidity barrier. A yellow reinforced PVC sheet suspended from an anchored floating cable, the turbidity barrier was to curtail the spread of sediment-laden water by the lake currents. The sediments would be stirred up by the dredging and by rock placement, so it was imperative to have the kilometres of curtain ready for quick deployment just as soon as the ice disappeared. The barrier was to prove a very effective tool in ensuring that the suspended solids in the lake never exceeded the stringent limit of 10 parts per million, despite recurring maintenance challenges caused by storms.

Dredging

The other contractor anxious for the starting gun in June 2001 was Fraser River Pile and Dredge (FRPD). They had designed, fabricated, assembled, and tested their dredge at New Westminster, British Columbia, then dismantled and trucked all 75 loads to Yellowknife and on up the ice road. In the chilling weather of early spring they hacked through a metre and a half of ice along the lakeshore to create a pool in which they reassembled their "ship."

By late June the dredge was ready at its mooring. However, a kilometre of slowly decaying ice blocked the way to the starting point. Various ideas to break a path were tried but failed. On 1 July, in magnificent evening sunlight, FRPD's tug pushed an LDG barge, with backhoe aboard, into the ice. The hoe dug its way through the candled ice, but then discovered it was easier to smash its way through by

- As the crane places Zone 1 material for the filter blanket, a tug pushes in a continuing supply. Meanwhile, haul trucks and dozer extend the embankment out onto the completed blanket.

- Fraser River Pile and Dredge operator Gary Gill discovered that sound and feel, as opposed to underwater video images, were better methods to minimize the sediment plume.

- The Bauer fleet, resplendent in its shop paint, prepares to get dirty. The fleet, including a rock chisel, a trench cutter, and three grabs, ate through three kilometres of trench, averaging 15 metres deep, undeterred by rocks or permafrost.

- Bruce Tucker and Raymond Gill are among the LDG's crew carefully positioning pre-cast concrete guide walls exactly on alignment and precisely 80 centimetres apart. The guide walls fix the location and thickness of the cut-off wall. In the background, the vibrodensification probe compacts the core ahead of guide wall placement.

sweeping its bucket back and forth, sending the ice chips flying spectacularly as it went. Finally, the dredge, trailing its floating discharge line, was at the starting line.

The dredging was the first of 10 distinct operations, which had to occur sequentially to create the dike. A breakdown in any one would delay everything to follow, jeopardizing the dewatering date.

The dredge, expertly guided by the grand old men of the FRPD team, Mirek Hvezda and Bill Hamilton, exceeded all expectations. Far from delaying the activities following, it quickly pulled away from them and worked in comparative leisure. In fact, it even had sufficient time once it finished the dike footprint to clear the sediment from above the future mine as well.

Their success was due to immaculate planning for the job. Unlike FRPD's usual assignments of removing thick beds of sludge from rivers and harbours, they were challenged at Diavik with skimming the surface of the lakebed and creating minimal turbidity in the process. They designed a special cutter head for the purpose and even installed an underwater television camera to enable them to monitor their activities. In the end it was the operator's expertise and "feel" that made the difference. To check that their task was complete, the lakebed profile was measured by echo sounder before and after each set-up and Arctic Divers sampled the new lakebed. NKSL engineers, Samir Asfour, Cyril Turpin, and Dominique Lemelin evaluated results and gave their approval to move on once they were satisfied.

- Alvin Catholique of LDG hoses down Bauer trench cutter rollers. As the cutter wheels rotate, roller buttons grind through granite boulders. The cutting head descended vertically under its 45 tonne weight, with precise navigation data being fed to the operator.

- Full circle! After a determined rush to complete the embankment before the onset of freeze-up, LDG's night shift workers take pause at 3 a.m. 21 October 2001, to celebrate their achievement. They had carefully placed approximately four million tonnes of rock into open water over three and a half months.

- For Pacchiosi's jet grouters, life in "The Hilton" was hardly luxurious – dirty work in dim, misty conditions. With blizzards raging outside, however, the coziness provided by their crude shelter enabled jet grouting to proceed successfully in the coldest conditions ever attempted.

- With the rockfill embankment in place, the Bauer equipment commences installation of the cut-off wall from the south abutment. Here we see, from left to right, the cutter, a crane placing plastic concrete, a grab, and the chisel.

Filter Blanket Placement

Filter blanket placement followed. To guard against erosion of the till by any water which might seep under the cut-off wall, Tony Rattue had demonstrated that the till foundation uncovered by the dredge needed to be protected by a blanket of Zone 1 material, two metres thick. While the engineers insisted on a continuous blanket of the minimum thickness, LDG had a strong economic incentive not to make it excessively thick, as the material was expensive to produce and the crusher was busy enough without unnecessary extra work.

Val Ricci, Jean-François Poulin, and Gilles Beaudin masterminded an ingenious solution. The material would be placed by bucket, eight cubic metres at a time, by a crane sitting on a barge. Hence, one bucketful would provide two metres of cover over a two metre by two metre square of the foundation. But how was the crane driver to know precisely where he placed the previous bucket in the glassy surface of the lake? The answer lay in not observing the lake surface at all but rather concentrating on a computer screen in the cabin. The image showed the local dike foundation mapped out and superimposed with a two-by-two metre grid. High on the tip of the crane boom a global positioning system (GPS) unit continuously signalled the location of the hook and the bucket to the computer, showing up as a red cross. The operator's task then became one of moving the cross to the centre of a square. Upon tipping the filter material, the square was magically coloured to present a map of progress.

More echo sounding and diver inspection followed, and more assessment by the NKSL engineers, to ensure that the blanket was continuous, without holes.

The filter barge, like the dredge before it, gradually pulled away from the following players.

Utilizing instrumentation readings radioed automatically and continually to their office computer, Gaston Blanchette of NKSL, left, and Richard Olive of DDMI draw inferences about the behaviour of the dike.

Transferring water from inside the dike would require this dewatering pipeline. Here, Fernando Januario, left, with CRP, and Robert Schellenberger, with LDG, heat fuse a joint in the line.

Fill Placement

The next activity was the placement of fill – at last an activity with some visual impact. Three great challenges confronted LDG. As their Project Manager Don Delarosbil put it, "It was always going to be a huge challenge for us to get right around the 3.9 kilometres in a single summer season. But it was not simply a matter of loading, hauling, and dumping rock in any random fashion. We also had to make sure first that we got the various zones in the correct places – not too much and not too little of any – and as well we had to place it so that it did not segregate as it lowered through the water. Our entire team understood the rules of placement and followed them all the way. When, in the wee hours of 21 October 2001, the full circle was joined, their sense of achievement was unbounded."

What an achievement it was! In just four months nearly four million tonnes of material had been quarried, loaded, crushed, stockpiled, reloaded, hauled, and placed in a structure of complex geometry looping around a sub-arctic lake. Although at this stage the dike looked complete to the unknowing, the reality was that the challenges were just beginning. The embankment was in place, but it was still quite permeable. The challenge now was to make it watertight.

Vibrodensification

Before the cut-off wall could be placed through the core, the Zone 1 material had to be compacted. It had been placed loose and was sufficiently porous that there was serious risk that the trench through it would not retain bentonite slurry. The first of the Bauer machines, the vibrodensification unit, was put to work.

Suspended by a crane, the unit consisted of a 20 metre long, 0.4 metre diameter steel cylinder, weighing 12 tonnes. Capable of high frequency vibration, and of ejecting water or compressed air through its nozzle, the pointed cylinder descended under its own weight through apparently solid material. The ascent, however, performed in a succession of two metre lifts followed by one metre drops, saw the surrounding material cave in as compaction was achieved below. More material was progressively added to fill the void, so that by the time the vibrator exited the soil some 15 per cent extra Zone 1 material had been forced into what had apparently been solid.

Guide Wall Installation

Following the vibrodensification, one more step was required before construction of the cut-off wall could commence. This was to set L-shaped pre-cast concrete

Teamwork

Every day at 1:30 p.m., a small informal "brains trust" of contractor, consultant, and owner met. Either Don Delarosbil or Ray Riojas represented LDG, with Tony Rattue, Samir Asfour or Dominique Lemelin representing NKSL, and John Wonnacott or Richard Olive for DDMI. Here, in a spirit of friendship and cooperation, problems of the previous 24 hours and challenges of the next 24 hours were discussed and resolved. Accord in meetings, however, is worthless without cooperation in the field. In marked contrast to the calm work in the office, the crest of the dike throughout the summer of 2002 often displayed all the hurly-burly of Rue Ste-Catherine at rush hour. Haul trucks, backhoes, grabs, cutters, concrete trucks, cranes, jet grout rigs, curtain grout rigs, and endless pick-up trucks jostled for space. That calm prevailed at all was a tribute to both process and personality. Any awards for boundless goodwill in the midst of pressure and crisis must include LDG superintendents Vern Shaver, Peter Gillies, and Tom McHale, and especially Bauer's Peter Kliem.

guide walls to precisely delineate the sides of the trench into which the plastic concrete would be poured to create the impermeable wall. With the guide walls placed and backfilled, finally the trenching machines moved in to work.

Trench Excavation and Concreting

The Bauer grabs dug vertically downwards through the Zone 1 material of the dike core with ease. A messy operation, because work was always carried out through a pool of bentonite slurry, it nevertheless proceeded without incident until the glacial till was reached. The till presented a variety of problems. All too often boulders were encountered which entirely straddled the width of the trench. If the grabs failed to handle them, then the chisel, 12 tonnes of sharp-edged steel, was dropped to smash them, and failing this, the cutter would be sent down to simply grind them away. No obstacle could resist the relentless attack of the Bauer equipment.

Far from being simply the application of brute force, however, the exercise was equally the application of refined and precise technology. Accuracy of the trenching was essential to ensure that neighbouring panels would align into a continuous wall, creating an impermeable barrier. Accordingly, the cutter could actually be driven to a precise location by dexterous use of side thrusters. In-cab computer displays ensured that the operator always knew where the cutter head was in relation to where it was supposed to be.

Boulders were not the only problem with the till. Trenching work in weak glacial silt was a new experience for all parties, including the experts from Bauer. During the first summer season it was observed that the grab would often dig and dig without making downward progress. Evidently, fine till was flowing in from the sides of the trench. Overconsumption of plastic concrete confirmed this hypothesis. Many panels had of necessity stopped short of the bedrock. The deficit would have to be made good with an increased amount of jet grouting.

Jet Grouting

When the first summer season ended less than one quarter of the cut-off wall had been completed and the envisioned quantity of jet grouting had quadrupled, calling for changed plans and increased resources.

"When you consider the cut-off wall," explains Tony Rattue, "you can visualize a continuous concrete wall, about a metre thick, made up of tightly adjoining panels, all held securely within the core of the dike and the foundation. The continuity of the wall is assured because of the complete excavation of material from one end of the panel to the other prior to concreting, so it is difficult to imagine it leaking. Indeed we had examined samples of Bauer's walls in Berlin and Barcelona and they were effectively drip-tight. I had also gained experience of jet grout cut-off walls, made up of adjoining cylindrical columns, from the successful application in the cofferdam at Ste-Marguerite 3 Dam in Québec. I knew it could work, but the barrier would only seal if the columns made continuous contact with each other. The problem is that you are working blind, because they are buried deep in the dike's foundation and you never get to see them. My solution was to bolster my quality assurance team to make sure that every drilling and grouting record was minutely scrutinized."

It seemed at times that the jet grouting operation consumed more paper than cement. For every one of the 4,200 columns, Bauer and Pacchiosi produced four pages of complex, detailed quality control reportage, and every page was copied to four parties. The chief recipients were NKSL's quality assurance team of Alain Chagnon, Dominique Lemelin, and Yves Fugère. Like medieval monks labouring over manuscripts, they diligently checked off every last detail, generally in approval, but occasionally demonstrating that a column needed to be redone.

Curtain Grouting

While the jet grout columns constituted the waterproof barrier down to bedrock, the engineers required the barrier to extend right into the body of the rock itself – to block off every open crack or fissure in the granite, down for another 10 to 20 metres. This task, "curtain grouting", fell to LDG's subcontractor, ACT, who had assembled state-of-the-art equipment for the challenge. Their work, very ably directed by NKSL's François Virolle, proceeded quickly and without incident along the south side of the dike, where the granite proved to be very tight and impervious. On the north side, however, they encountered some excitement when a fissure, quickly dubbed "The Virolle Structure," drank up grout with an insatiable thirst. Eventually, with patience and persistence, gradually watching their dials and thickening their mix, François and the ACT team won the battle and declared the crevice sealed.

A Veritable Babel

Visitors to the site frequently remarked that although English was the official language of the project and was always heard at the south end of the island, on the north side around the dike, French was just as common. This was not surprising. LDG's earthworks crews and engineers were provided largely by Kiewit Québec. Likewise, NKSL's dike engineers all came from Montréal.

The dike linguistics became more mixed when Bauer moved in their crews from Germany and Pacchiosi's people arrived from Italy.

Summer of 2002 saw very hectic and congested activity on the crest of the dike with the various parties jostling for space.

By chance, NKSL's inspection team, Cyril Turpin, the two John Patey's, senior and junior, and Herb McLean, all called Newfoundland home. Their shared office naturally became "The Newfoundland Embassy."

In response to an expression of anxiety about whether there existed method in all the madness, Cyril calmly gave reassurance by imparting the wisdom of Newfoundland, "Don't worry. All is as it should be and work is proceeding exactly according to plan. A little chaos each day is no less than one would expect when you have Germans and Italians being coordinated by the French."

With the jet grouting complete, it was ACT's turn to install the grout curtain through a screen of inclined holes drilled deep into the granite bedrock.

LDG Project Manager Don Delarosbil, who set bold targets and led his 600-strong team to achieve them.

Prior to dewatering the pool, field crews from the environmental company Jacques Whitford, including Rae Band members Charlie Fish, Roger Drybones, Bobby Drybones, Johnny Weyallon, and Edward Quitte, left to right, spent the best months of 2002 catching and releasing 5,049 fish back to Lac de Gras.

Instrumentation

Now just one activity remained before dewatering. Like a cardiac patient awaiting testing, the dike had to be instrumented – piezometers to measure pressure, thermistors to measure temperature, and inclinometers to measure deformation. In all, at over 1,500 locations in the dike and its foundation, one parameter or another could be measured. Thus, a complete picture of its health could be had during its upcoming critical test of dewatering and on through its life.

Instrumentation is precise and delicate work. Installing, testing, and wiring fine electronic instruments in the presence of haul trucks, backhoes, and drills required experience and endless patience. The task fell to LDG's Pierre-André Garneau and Michel Riberdy and their subcontractor EBA, notably Randy McGilvray, Dr. Sam Proskin, and Clarence Choban.

While it is normal to expect a certain attrition rate with such instruments, it is a tribute to the work of these parties and the supplier, RST of Vancouver, that all the installations functioned flawlessly.

Fishing

It is not often that the noble pastime of fishing becomes an activity on an engineering planning schedule. Under the terms of DDMI's Fisheries Act authorization, however, the opportunity was taken to conduct some unusual scientific research – a census of the fish life in a defined area of a sub-arctic lake.

Through the idyllic days of July and August 2002, the lucky workers, members of the Rae Band of Dogrib people working with environmental company Jacques Whitford, set nets and cast lines into the waters of Lac de Gras trapped within the dike. Eventually they landed 5,049 fish, mainly small ciscoes but including some two kilogram lake trout.

The fish were handled strictly in accordance with a protocol designed and approved by the federal Department of Fisheries and Oceans. This included careful measurement of length and weight, revival in an oxygenation tank and release into Lac de Gras, outside the confines of the dike.

Dewatering

Don Delarosbil prides himself above all on being a contractor who delivers on schedule. "Pumps on day" of 15 August 2002 had always seemed a preposterous target back when work commenced in the lake in July 2001. But Don announced boldly, "It won't be mid-August. It will be late July." And in no uncertain terms he let his workforce know of his expectations. "LDG is committed to dewatering in July 2002," proclaimed the banner he had strung across the crib room.

In anticipation of the great day, Don had charged Claude Denault with designing and assembling the barges and pumps to do the job. To lower the 1.5 square kilometre pool by 400 millimetres per day required no less than eight 40 centimetre centrifugal pumps, divided between two barges, with each pump drawing 45,500 litres per minute. Claude's floating pumping stations came through a rigorous testing program magnificently, and just in time because finally the last panels were poured, and the last grout was jetted. All that remained was a few quiet days for it to set.

On 28 July 2002, with pride in his heart and a tear in his eye, Don Delarosbil ordered the pumps to start.

Initially the clean pool water was discharged directly to Lac de Gras. Later, as it became murkier, flow was diverted to the on-land clarification pond, which had been emptied in expectation.

Every day the instrumentation confirmed the load being picked up by the dike and indicated how effortlessly it was being carried. Every day the inspectors on foot and in helicopter failed to discern the least leakage.

For 60 days the pumps inexorably pulled down the pool, and finally it was over. Dry land inside, the crystal clear waters of Lac de Gras on the other and nary a leak in all the long 3.9 kilometres! The A154 dike was built and performing beautifully.

The baton now passed to the miners.

DDMI Construction Manager Richard Lock, in typical unruffled pose. Richard's relaxed demeanour often disguised his keen analytical ability and readiness to make tough decisions.

The Jet Grouting Crisis

The dike design always called for jet grouting to bridge the interface between the underside of the cut-off wall and the granite bedrock. Earlier studies had in fact considered more extensive use of jet grouting, even to it substituting entirely for the cut-off wall. But not many precedents existed and the process did not have the comfortable feel of the certainty of the panel wall. Moreover it was far more costly, as it consumed so much cement.

By the fall of 2001 repeated slumping of the till into the cut-off wall trench demanded a variation of the design. Where conditions required it, a solid "fence" of intersecting jet grout columns would replace the lower portion of the wall.

The change threw up a huge challenge, in the threat it presented to both the project budget and schedule. "To me the issue was really quite clear," DDMI Construction Manager Richard Lock said. "Up here, if you miss an ice road window, schedules can slip by whole years, not by days or weeks. I just had to keep the work going, and this meant immediate instigation of a cement airlift, as well as mobilization of more jet grouting rigs, mixing plants, and pumping stations."

Richard's decision was bold and confident. It immediately committed the project to another $20 million, but at the end of the day it was the decision that saw the project delivered ahead of schedule.

Impacts were immediate. Within days, a commercial Hercules freighter aircraft began landing thousands of tonnes of cement on site. In addition, jet-grouting contractor, Pacchiosi, was hired to complement Bauer, and was flying in rigs from across North America and crews from Italy. LDG was assembling heated shelters for work to proceed deep into the winter months, to an extent never before attempted.

So the jet grouting proceeded on two fronts, taking pause only in the very depth of winter. It was to remain the critical activity right through to the start of dewatering, but in the end, it allowed the pumps to be turned on ahead of schedule – a result made possible only by a bold decision at the right moment.

Chapter Four
The On-land Dams

"When I reviewed Xiaogang's work on the PKC dams – the stability analysis, the thermal analysis, the seepage analysis, and the deformation analysis – I could readily see that the glowing reports of his intellect had not been overstated. But somehow I worried how his gentle Chinese personality would stand up on site in the face of a tough North American contractor. What a surprise we were in for! The man's real strength lay in the field as much or more than in the office. The working partnership he forged with LDG's people sets a real benchmark in consultant-contractor relationships."

Richard Olive, DDMI Civil Engineering Manager

Building the Diavik Diamond Mine required the construction of 12 on-land dams including this sedimentation area which includes four dams.

Born in a remote corner of China, and deprived of schooling by the Cultural Revolution, Xiaogang Hu came to Canada to earn a doctorate in arctic engineering.

Doctors Abdellatif Dellah, left, and Marcel Pineau formulated Diavik's water management plan and devised the concepts for water treatment.

While the A154 dike always stole the limelight as the feature attraction of the project, another set of civil structures posed formidable engineering challenges to both design and construct. Collectively, these were known as the on-land dams.

There were no less than 12 dams needed, falling into three distinct groups: first there were the two processed kimberlite containment (PKC) dams, then the four sediment facility dams, and finally, the six collection pond dams.

Although no individual dam is especially large (the highest is 18 metres), taken together they represent a very significant block of work, requiring some 1.5 million cubic metres of rockfill and 200,000 square metres of plastic sheet liner. More than statistics, what makes the dams notable is how they have used their permafrost setting to advantage. They capitalize on frozen ground, according to

Dr. Igor Holubec, NKSL's arctic engineering specialist in Toronto. "Working with what nature offered makes these dams particularly elegant," he said.

The PKC will store in perpetuity all the ore that passes through the process plant once the diamonds have been recovered. In essence, this is simply crushed kimberlite. It will have gone through no chemical processes, only the physical ones of crushing and screening. Nevertheless, given its quantity, it would represent a threat to the clarity of the lake if not contained. So the need existed to construct an on-land containment area in the vicinity of the process plant.

A nearby valley was a natural choice; with dams at either end, a storage basin could readily be created. The only difficulty was that the basin was too small for the known quantity of kimberlite, some 33 million cubic metres. Of this amount, 60 per cent, all finer than one millimetre, would be delivered as a liquid slurry, while the other 40 per cent, a gravel ranging from one to six millimetres in size, would be delivered as a solid by truck.

Igor Holubec and his team member, Dr. Xiaogang Hu, wrestled with the geometry problem. They showed that they could build up the natural terrain along the sides of the valley with the coarse solid fraction, gradually increasing the volume of the basin so that it could comfortably contain the continuing stream of the fine material in the slurry. There was no need to build the two dams plugging the ends of the valley to their complete height in the first instance; it would be sufficient to take them to just one quarter of their ultimate height to see the operation through its initial years. Meanwhile, in Montréal, their NKSL colleague, Dr. Marcel Pineau and his team of

Keeping the dam cut-off trenches clear was quite a challenge as they were often filled with snow.

In what could be likened to dressmaking on a macro scale, with shadows long even at noon and the thermometer below -30ºC, the A&A team clean and fuse plastic sheets.

Marc Laliberté, Marie-Andrée Morin, and Dr. Abdellatif (Abe) Dellah were grappling with a different but related problem. Evidently, the project would produce quantities of turbid water during construction which would have to be clarified before it reached the lake. The questions were: How much dirty water? From what sources? In what months would it be produced? How much rainfall? How much snowmelt? How could we clarify it? And at what rate? And, last but not least, where could it be stored in the meantime and how much storage would be needed? Not one of these questions was simple to answer, but together they constituted the figurative "ball of wax."

Marcel Pineau's water balance analysis assessed not only all the best estimates, but also all the "what ifs?" What if we had the 100-year snowfall? What if we could only discharge 25 per cent of the A154 pool to the lake? And so on.

Out of it all came the conclusion that what Diavik needed was a plant which could treat 30,000 cubic metres of water per day, sufficient for a city of 100,000 people. In addition, seven million cubic metres of temporary storage were needed. While Marcel Pineau and Abe Dellah got to work designing the plant, Igor Holubec and Xiaogang Hu concentrated on the storage problem.

When the last Ice Age entombed North America, the great ice sheet scoured East Island from southeast to northwest. In the process it carved out a series of roughly parallel valleys and bays. The PKC would occupy one such valley. Its neighbour became the sediment storage facility.

Like the PKC, the valley for the sediment facility was to be closed off by dams at its east and west ends. Here though, one of the valley walls had virtually been eaten away by the ice sheet so that a third dam, the north dam, was required to complete the enclosure. Finally, the impoundment was divided into two cells by an intermediate filter dam which had the function of retaining the coarse sediment particles in one cell while allowing the turbid water carrying the residual ultra-fine particles into the second holding cell before being pumped to the water treatment plant for clarification.

Dam engineers must always confront the twin questions of how to prevent leakage through the dam, and how to prevent it through the foundation. The answers for any one of these on-land dams would be good for all of them, with the result that they all have quite similar cross-sections.

Making the dams themselves impervious was a comparatively easy issue. There was no clay present on the island, so a synthetic material would have to be brought in. The lightest and most economical to do the job was a stiff plastic

What is so special about -40º?

At Lac de Gras during January and February the temperature quite often drops below -40º. So what is so special about -40º? Nothing really, except that any young physics student will reply, "It's the one and only temperature at which Centigrade and Fahrenheit are identical."

But ask Nelson Gauthier of LDG about -40º. "I don't care if you call it C or F, I'll tell you one thing about it, it's seriously cold. Our crews, cleaning up the trenches by hand, and A&A's men, down on their hands and knees joining HDPE sheets, all deserve medals for bravery. No dam construction anywhere, at any time, was done in weather colder than this."

It's 19 January 2002 and with the temperature plunging to -40ºC, an excellent day to work on the processed kimberlite containment dam foundations!

- The geotechnical engineer must always adapt his design to the soil conditions encountered. In places at the Diavik site, much of the "soil" is massive ground ice, several meters thick. Samir Asfour and Igor Holubec, both of NKSL, discuss the problem.
- Once summer arrived, the on-land dams grew from their foundations. The high density polyethylene liner was placed, welded, and covered with a protective layer of sand as well as layers of progressively larger rock. Each layer was immaculately trimmed for constant thickness. The reverse sequence of layers lies beneath the liner avoiding possible rock punctures.
- Blowing snow off completed high density polyethylene liner.
- In mid-winter's few hours of daylight, workers remove frozen lumps from the sand prior to burying high density polyethylene liner.

sheet made of high density polyethylene (HDPE) 1.5 millimetres thick. Not that it was without its problems. The sheets would have to be carefully laid upon, and buried by, layers of sand to prevent puncturing. They would have to be joined, one to the other, by heat welding to form a continuous barrier. And the bottom edge would have to be carefully joined to the foundation to prevent leakage below.

The saga of successfully joining the sheets together and to the foundation is an epic worthy of Scott of the Antarctic, but first let us consider how to make the foundation impermeable.

The valley floors were filled with frozen glacial till – silt, sand, gravel, and boulders through which water had infiltrated and frozen year upon year, so that now the "soil" was as much ice as soil. In fact, in places it was ice, great thick wedges of blue-white ice up to four metres thick.

Igor Holubec and Xiaogang Hu reasoned that the ground was already saturated and frozen – 100 per cent solid – and so by definition it must be impermeable. Why not, to the extent possible, leave it untouched? The key was to make the marriage with the HDPE sheet without thawing the ground ice, and to ensure that evermore it would remain frozen. All that was required was to cut a trench along the length of the dam in the depth of winter, smooth out the bottom, start off the rolls of sheet in the trench, then backfill it with compacted till, so that the bottom edge of the sheet would be frozen rigidly, continuously, and permanently into the ground, well below the thawing effect of global warming. Easy to say, difficult to do. The work would have to be done through the depth of winter, with temperatures in the minus 30's, even minus 40's.

Water under pressure is the most persistent and thorough inspector. If the least hole exists, the water will find it. The huge challenge in the construction of the on-land dams was to maintain quality of work in conditions unfit for man or beast. It required thoroughness, patience, understanding, and no small sense of humour. Xiaogang Hu led the engineer's team, ably supported by Lee Langlois, Oskar Sanio, and Claude Leycuras. Their counterparts with LDG were Nelson Gauthier and Yvon Corneau.

The work exceeded all expectations, and often inspired awe in visitors. Observing Dale Webster's skill with the backhoe in shaping the bottom of the cut-off trench up the steep abutment of the west PKC dam, DDMI's Laurie Hilkewich commented, "It's a work of art, sculpture at its finest. It's a tragedy we have to bury it." Al Harmon's A&A team, all

A small portion of the 350,000-strong Bathurst caribou herd migrates through the Lac de Gras region in spring and fall. Here, caribou move alongside a Diavik sedimentation pond dam.

local Aboriginal men well acquainted with cold, meticulously heat welded thousands of metres of seam and pressure tested every last metre to prove the quality of their work. Ted Mikkonen, dozer operator extraordinaire, spread the layers of sand, transition, and rock as tidily as at any dam on earth.

At the end of the day, what was the result of their work? A common assertion among dam engineers is that there is no dam that does not leak. It may well be that the PKC and the sediment facility dams at Diavik are just the exception to that rule. No drop has been detected escaping them. Their foundations are frozen solid and the embedded thermistors are saying that they are just getting colder.

The sedimentation pond is part of Diavik's comprehensive water management system protecting the waters of Lac de Gras.

A Brisk Dip in Lac de Gras

While all the on-land dams exist to ensure that no pollutants will ever enter Lac de Gras, DDMI's environmental team under Erik Madsen has embarked upon an Aquatic Effects Monitoring program to verify the dams' performance.

As part of the program, lake water is sampled and analysed at regular intervals and at set locations, over the complete range of depths, both at times of thick ice cover and during open water. The lake constitutes the headwaters of the Coppermine River which enters the Arctic Ocean at Kugluktuk. Consequently, one of the monitoring stations is located near the outflow at the western end of the lake.

In the warm balmy August sun, a run by jet boat down some 40 kilometres of glassy lake to take the samples is a delight indeed. So delightful in fact, that the intrepid scientific team of Mike Baker, April Desjarlais, and Tim Evans believed it warranted a celebratory swim at the destination – just a quick dip, of course, because this water was recently blue ice.

The gods of the tundra do not take kindly to mere humans swimming where they were never intended. No sooner had the trio dragged themselves, wet and bedraggled, back into the boat than the sky blackened and the wind began howling from the east. What had been a one hour skim going out became a three hour buffeting in icy spray through metre high waves on the way home.

Fortunately, Mike, April, and Tim were equipped with radio, warm clothing, safety vests and survival kits, as required of all travellers off the site. The episode illustrated, however, the vagaries of the northern weather and the puniness of man upon the Barren Lands.

Chapter Five

The Process Plant

"The year 2002 in the process plant was always going to be critical for us, as construction managers. We knew that concrete workers, steel workers, mechanical erectors, electricians, pipe workers, bricklayers, and painters would all be battling for access. Nick Mills, our Construction Manager, coordinated these activities. His unerring judgment of where to place the priorities saw the process plant not only completed but also precommissioned months ahead of schedule."

Joseph Shirley, NKSL Project Director

The process plant, centre, with the maintenance complex, accommodation complex, temporary south construction camp, power plant, sewage treatment plant, and boiler plant, clockwise from left. Ore is delivered to the run-of-mine building by haul truck up the ramp in the foreground.

Actually, focus on the process plant goes back to well before 2002. DDMI Ore Processing Plant Manager Harry Ryans had collaborated with NKSL's John Robertson and Mark Stephenson to design a compact and straightforward plant that took full advantage of the site topography to move material through it. The concept was simple: build an insulated shell in the summer of 2001 so that all the mechanical and electrical work could proceed through the following winter and the remainder of 2002.

The shell was to be a monumental building 152 metres long, 40 metres wide, and 35 metres high. The massive steel frame would carry 50 tonne and 25 tonne overhead traveling cranes, and would be clad with thick insulated "sandwich" panels. Clearly the steel and the cladding would have to be transported on the ice road of January through March 200l.

Ken Lee and his structural design team, in Nishi-Khon/SNC-Lavalin's Vancouver office, prepared the hundreds of steelwork drawings required for tender, and bids were called in mid-2000. At this time, protracted delays in the granting of the project's water license threatened the project schedule. In these circumstances, DDMI was unwilling to make the contractual commitment to the large steel order, but had already decided that Supreme Steel of Edmonton was its preferred contractor.

Finally, in November all regulatory hurtles were cleared. The challenge was put to Supreme's John Leder: Could he fabricate at least 60 per cent of the 5,000 tonnes of steel, and all of the 80,000 square metres of cladding by the end of March, to get it on the ice road and then fly in the remaining steel required? Not one to shrink from a challenge, John guaranteed 85 per cent as a minimum. Activity in all five Supreme plants went into overdrive.

He worked intently with the design engineers at a range of initiatives to hasten production. Steel sections were changed to those available; galvanizing was substituted for painting. Thankfully, the ice road lasted until the first week of April, just long enough to allow passage of 100 per cent of the Supreme order!

When the massive steel elements arrived – each prefabricated as much as possible to minimize on-site work – the foundations were not yet ready to receive them. While Lac de Gras Constructors' rock teams had been able to advance the excavation in the cold, concreting of foundations had to remain until at least the half-warmth of spring. Through April and May, the process plant resembled nothing more than an army bivouac with rows of tents covering the myriad footings, hot air being forced into each to thaw the rock and allow the concrete to set.

Playing With Building Blocks …Precisely

In any structure, a moment of truth arrives when the structural steel columns are fitted over the anchor bolts protruding from the concrete foundations. This was particularly the case at the process plant, where the bolts were so stout and inflexible, the columns so massive and unyielding. There was just no way the schedule could accommodate any rework. What was fabricated in Edmonton simply had to fit onto what was cast on East Island.

NKSL's Greg Miazga, Reid Crowther's John Tymstra, and LDG's Gord Baglier mulled over this problem. Error was simply not acceptable. They took pains to have precisely built templates constructed, with double the normal thickness of plywood and holes that would barely fit the anchor bolts. John Tymstra surveyed and rechecked the templates with great precision. Gord's men set the bolts and poured the concrete.

As footings became available, rows of soldier-like columns appeared, then mighty roof trusses, followed by lattices of bracing, girts and purlins, and finally cladding over the whole. The shell finally stood completed and enclosed in November 2001, just before the deep chill, and not quite a year since the award of the structural steel contract.

NKSL's design engineers had wisely decided to make the shell quite independent of the contents. Not only did this separate the erection activities, it also ensured that no vibrations from the oscillating and rotating equipment would be transferred to the structure. But some components were simply too large to be placed in the building once complete. These included the permanent cranes, the slurry tanks and, in particular, the massive ore bins. Components weighing up to 65 tonnes were fabricated by Supreme in Edmonton, transported up the ice road, placed in their ultimate position, and had the building erected around them.

By the quirks of contract packaging and sub-contracting, the site saw the strange situation of two competitors simultaneously erecting steel which had been fabricated by the other. Supreme undertook to erect the recovery building steel, which had been fabricated by their Edmonton competitor, Scott Steel, while Scott was erecting arctic corridors fabricated by Supreme. Scott was also busy with the run-of-mine building. Hence at either end of the process plant through the dark, bitterly cold days of the winter of 2001 into 2002, the iron workers of Supreme and Scott braved not only the customary dizzying heights of their occupation, but also bone-numbing cold. Many who observed these men at work would no doubt nominate them as their heroes of the project.

When Peter Leder's Supreme workers came to place the columns, every column fitted like fingers fitting into a glove – despite there being 24 stiff unwiggling steel fingers. The result was a fine testament to the expertise and collaboration of four separate parties.

LDG's concrete team produced a consistently excellent finished product in structures all over the island, but nowhere was their expertise better displayed than at the west end of the process plant, where it abuts a high vertical rock face. With precision drilling and surgical blasting, the rock was sculpted to the desired set of steps and benches. However, nature was not about to cooperate. Steeply dipping fractures in the rock could potentially see massive blocks of granite slip into the excavation and endanger workers. LDG's crews expertly secured the blocks with cable bolts and encased the face with concrete, which was eventually to support the scrubbers, the end wall, and the entire run-of-mine building.

Whereas others can point with pride to the monuments they have created, all too often the concreter's best work is buried out of sight. Thus it is with LDG. Out of sight, maybe, but not unrecognized.

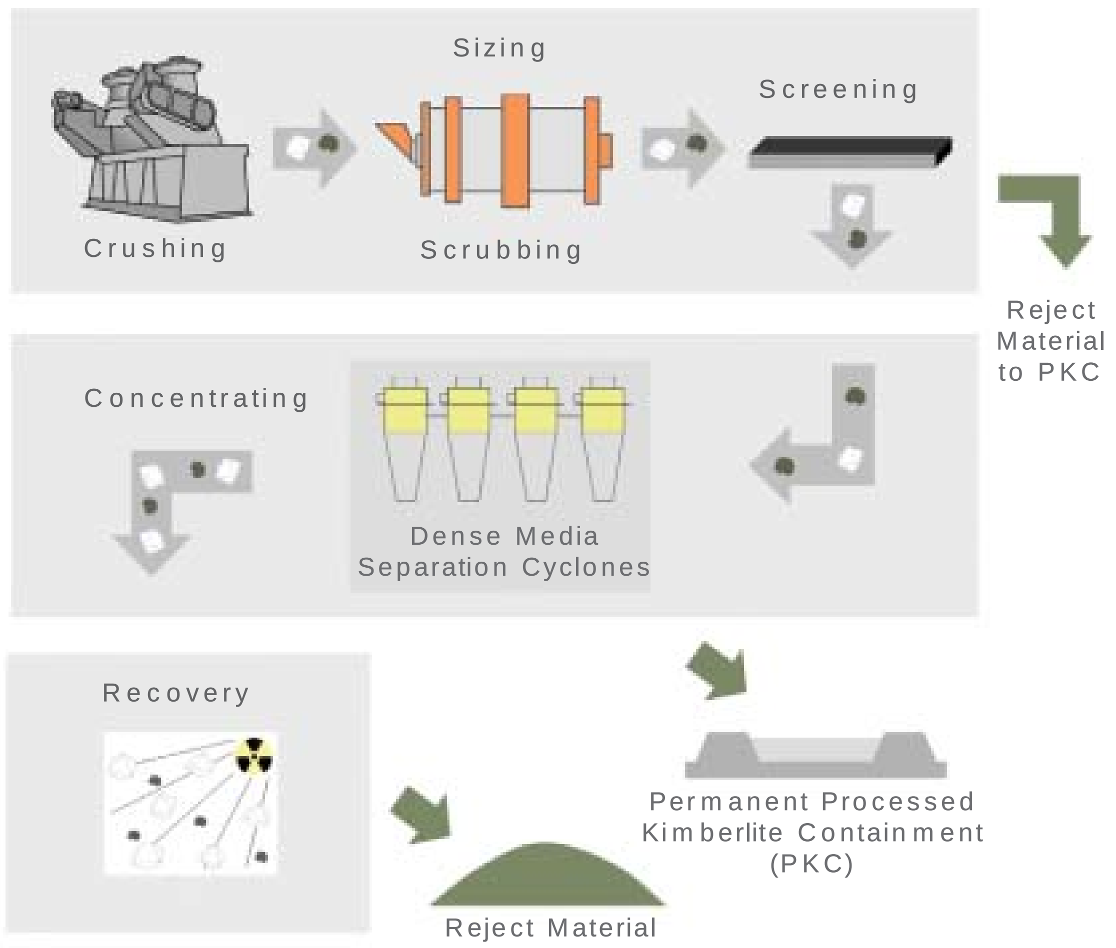
The Supreme Steel crew prefabricated steel into the largest possible assemblies on the ground, to speed erection and to minimize work at height.

LDG's concrete workers pour a floor in the process plant.

Diavik will process 1.5 million tonnes of ore annually, or approximately 4,100 tonnes per day. Diamond ore processing does not require chemicals to separate and recover the diamonds from the kimberlite host rock. Rather, processing uses gravity-based methods, which rely on the diamonds' higher density to separate them from much of the waste kimberlite. In the recovery building, the diamonds are separated from the waste heavy minerals using X-rays under which only the diamonds glow. The diamonds are then shipped to the production splitting facility in Yellowknife. Waste minerals are directed to the PKC.

Back in NKSL's Vancouver office, Procurement Manager Jim Miller, was nearing the completion of two years work arranging the supply from all corners of the earth of all those pieces of the mosaic which were needed to make up the most modern of diamond processing facilities. There were vibrating screens from South Africa, crushers and scrubbers from the United States, pumps from Brazil, a high-pressure rolls crusher from Germany, and X-ray sorters from Australia, all part of 225 separate equipment supply packages for the project. Jim Miller's team had called for and evaluated tenders, recommended the preferred supplier, placed the order, inspected progress of manufacture, and shepherded every last component through Yellowknife and into the hands of his colleague, Mike Shamro, for dispatch up the ice road before Mother Nature's inexorable deadline of the thaw.

Ore Processing at the Diavik Diamond Mine



▼ *With never more than his well-worn tweed jacket to protect him from arctic winds, NKSL Construction Manager Nick Mills maintained uncanny awareness of progress of hundreds of diverse activities.*

▶ *Rob Strohmann, who managed Adam Clark's workforce of 250 electricians, welders, and mechanical fitters, points out details to Richard Masse, Larry Laferriere, and Carl Baron.*

▶▶ *Supreme Steel's Stan Victor directs the lowering of the massive scrubber support beam.*

▶▶▶ *Structures within structures! Heavy ore bins stand within the process plant shell, as Supreme Steel workers fix wall girts in preparation for external cladding.*

Once on site, the myriads of crates and containers became the concern of John Salter and Rob Strohmann of the Adam Clark Company. In Rob Strohmann's words, "Our first great challenge was to make sure we brought in sufficient tools, equipment, and material on the 2002 ice road. Then it was a job simply to unload it and know what was where – 2,500 loads, 24 hours per day, in driving snow and darkness. Next, there was the continual battle for space with other contractors in the plant. We built up to 248 people by mid-summer – welders, pipe fitters, mechanical fitters, electricians, and instrumentation specialists. Of course they were all a long way from home, and lonely, but when Nick Mills put the pressure on to bring the job in early, they responded and did just that. But what is really amazing, thanks to their personal commitment and the constant and persistent efforts by our Safety Officer, Danny Brushett, we had only one lost time incident during our work on the entire project, after expending over 500,000 work-hours. That's an extraordinary performance."

As the Adam Clark team assembled and tested all the equipment, their work was watched keenly by the owners and engineers. DDMI Senior Mechanical Engineer Dale Tweed and his NKSL counterpart Glen Peace saw that the installation of every mechanical component complied with the very best of world practice, while their electrical counterparts, Darren Barlow and Murray Aason did likewise. The purpose of the close scrutiny was not to catch the contractor out, but to be assured that when the time came to start up there would be no glitches requiring disassembly and reassembly. In Dale Tweed's words, "Adam Clark's tradespeople were first class individuals who

Rotary scrubbers, degrit cyclones, high angle conveyors, and overhead cranes all surrounded by endless yellow handrails. The complexity of the work of the Adam Clark crews - all dedicated to constructing a process plant that will find the one stone in a million - is apparent.

Mark Stephenson, left, clarifies details of his process design to NKSL's Project Director Joseph Shirley. Mark, from the UK, and Joseph, from South Africa, were among many who brought international expertise and experience to the project. Foreground, is one of the cyclones used to separate diamonds from waste kimberlite.

consistently demonstrated the desire, and ability, to perform a quality installation while meeting an extremely aggressive schedule."

The smooth commissioning had also received help from another quarter. BHP Billiton's Ekati Mine, just across the northern shoreline of Lac de Gras, demonstrated the great northern tradition of neighbour helping neighbour by providing 12,000 tonnes of barren kimberlite from their Misery pit to enable Diavik's pre-commissioning tests to be carried out before its own ore was exposed. The ore was trucked across the frozen lake in March 2002, and run through the process plant as a trial run in October 2002.

Rough gem quality Diavik diamonds with the largest stone, lower left, weighing eight carats.

The Unheard Clink

The afternoon of 25 November 2002 was typically cold, miserable and overcast. Sometime shortly after lunch, an almost inaudible "clink" of a minute stone dropping into a stainless steel can went unheard. Against the cacophony of construction noises it was a mere tinkle, but it heralded the start of the new era at Diavik. The first diamond had been delivered.

Like finding needles in haystacks, sorting diamonds from kimberlite is no easy matter. At Diavik, the ore carries about four carats per tonne. Given that a carat is just 0.2 gram, that is less than one gram per tonne, or about one part in a million. So all the plant and all the conveyors connecting them are dedicated to sorting the one valued part from the 999,999 parts of waste.

The process is entirely physical, with every piece of equipment devoted to one or other of the activities of crushing, sizing, or separating. The properties of diamond that enable it to be separated are firstly its density (significantly greater than much of the kimberlite) and secondly its fluorescence under x-rays.

The ore, which may well include chunks up to a metre in diameter when delivered, will be broken down in the first stage so that no particle is greater than 25 millimetres in diameter. So this is the largest diamond that can be produced. At the other end of the size range, anything less than one millimetre will be rejected, so all diamonds captured will be larger than this. Before being rejected, larger ore fragments will be recrushed in stages to liberate entrapped diamonds. No reject material will be larger than six millimetres in diameter.

So how many diamonds will be produced? At peak period, over 16,000 carats per day, which will almost fill a one-litre container. While that may not seem much from the more than 5,000 tonnes of rock that have been mined, hauled, crushed, and processed per day, the beauty of the Diavik deposits is the very fine gem quality of most of the stones, and the high price they will command.

Under the joint venture agreement with Aber, each partner retains the right to receive and market its share of all diamonds produced. DDMI's 60 per cent share of diamonds are marketed by its sister company Rio Tinto Diamonds in Antwerp, Belgium. Aber will supply a portion of its 40 per cent share of Diavik diamonds to Tiffany & Co. of New York.

Elevated arctic corridors connect all buildings enabling people and services to circulate, protected from the elements.

Chapter Six

The Ancillary Facilities

"When I first arrived on the Diavik site in January 2000, I realized that this project was not the typical green field project. Diavik was more like a white field project! We were starting from scratch with only a small camp located within a freezer. Everything was ice or snow. With every facility, from the airport, to the power plant, to the sewage treatment plant, to the fuel storage, as well as the process plant and the dike, winter was an inevitable consideration. The diversity and complexity of the facilities created a mountain of engineering work in our Vancouver office – 7,500 drawings, 300 purchase orders, 70 contracts. Don Holley oversaw it all for me. He had all the drawings approved in time, all the orders placed in time, all the contracts let in time. It was quite an accomplishment."

Ted Bassett, NKSL Project Manager 2000-2001

▼ *The North Inlet water treatment plant is capable of clarifying 30,000 cubic metres per day to drinking water standards. That is enough for a city of 100,000 people. Erik Madsen, DDMI's Environmental Manager, studies the purified product.*

▶ *Adam Clark workers couple the halves of an exhaust stack at the power plant.*

▶▶ *Like a mediaeval monk marching from darkness to light, a Scott Steel ironworker approaches his creation. Scott's crews erected the truck shop steel work through the depths of winter, classing themselves amongst the hardiest of the hardy.*

▶▶▶ *Newfoundlander Don Holley managed NKSL's engineering and procurement from the Vancouver office. Here, he reviews a satellite image of East Island. His team of engineers and draftspeople produced over 7,000 drawings in 18 months.*

The Diavik maintenance complex is really misnamed. Complex it is, but maintenance is just part of it. The building, as large as a football field, in fact houses three distinct functions – the truck maintenance shop, the warehouse, and the administration offices, all huddled together for warmth.

The complex, which is the work of LDG (concrete), Scott (steel), Adam Clark (mechanical and electrical), Adco North (heating, lighting, and cranes), and Ninety North (finishing), presents the operators with world-class facilities. The maintenance facilities include nine truck bays, all with heated floors and automated lubricant supply, as well as a wash bay and welding, mechanical, and electrical shops.

The Diavik project, and in particular the maintenance complex, represented a huge challenge for Scott Steel. Experienced on a variety of industrial projects, the 5,000 tonnes of steel they had to fabricate and erect quadrupled their previous largest order. The Diavik project was constructed during a period of significant labour shortages resulting from the very high levels of construction activity in Alberta. This was to seriously challenge Scott, but they succeeded in pulling together a hardy, effective crew under the wiry and hairy Garth Woynarowich. His broad smile, through a face of wild frost-encrusted whiskers, reminded all who passed by that with the right attitude there could even be fun sitting on high exposed beams in the minus thirties.

The power plant was also a joint creation of LDG, Scott, Adam Clark, Adco North, and Ninety North. Housing five Caterpillar diesel generators producing 4.4 MW each, the most significant feature of the power plant is its extraordinary efficiency. Whereas internal combustion engines might typically extract about 35 per cent of the

Terry Watling of NKSL reviews the results of the water treatment operation executed by Degremont's Josée Bourdon.

The Diavik power plant houses five Caterpillar diesel generators. Heat recovery doubles the plant's energy efficiency.

energy of the fuel, the Caterpillar units purchased for the project deliver 40 per cent as electrical energy, and another 40 per cent is extracted as heat by cooling both the generators and the exhaust gases. The heat is transported by circulating glycol to warm the interiors of the process plant, the maintenance complex, the accommodation complex, sewage plant, boiler plant, and the arctic corridors.

On the odd occasions when the power plant is not operating, or when extra heat is required, the boiler plant will be called into action, by a Delta V digital control system, which is fully integrated to those of the power plant and all the other facilities. The plant contains three 700 horsepower boilers.

Two water treatment plants have been constructed. For drinking water on site, water is drawn from the lake at a purity that already exceeds that delivered in most Canadian cities. The treatment plant is simply an insurance to protect the health of employees from any unexpected upsets in water intake quality.

Whereas this potable water plant is small, processing just 280 cubic metres per day, the North Inlet plant, which clarifies and filters industrial water returning to the lake, can process up to 30,000 cubic metres per day. It transforms murky, sediment-laden water to a sparkling product for which many Canadian communities would thirst. The plant, supplied and initially operated by Degrémont of Montréal, was installed by Adam Clark.

Another artificial stream to enter the lake is the effluent of the sewage treatment plant. While not sounding particularly inviting, this stream in fact almost meets drinking water standards. The tertiary treatment plant, the first of it's kind in the Northwest Territories, employs a biological process, which initially proved difficult to stabilize, in part, because of the severe fluctuations in population during construction. Thanks to the heroic efforts of Tli Cho operators, Keith Eckland and Darryl Matchett, the plant was brought into stable operation. The treated effluent surpasses all relevant national and international standards. As the plant was designed to cater to the south camp construction population of 800 people, the future, with less than half that number of workers, will be comparatively light work.

Apart from the major facilities which attract most attention, the Diavik site could not operate without a host of lesser facilities, all the work of Adco North, who laboured continuously for the entire duration of the project. Their workforce, mainly mechanics and electricians, peaked at 100. Adco North's creations, too numerous to

The Far-Flung Suburb of Vancouver

Many a DDMI business contact puzzled over the telephone area code of 604. "So, you are in Vancouver?" they would enquire. Given that the 604 area code has been restricted to the lower mainland of British Columbia for some years past, it came as a surprise that the area had an outpost in a remote corner of the Northwest Territories, fully 1,800 kilometres from Burrard Inlet.

The explanation lay in the fact that the telecommunications contract was awarded to Vancouver Teleport (VT), who connected East Island to their land station in Langley, British Columbia by satellite link. "What you have, in effect," explained VT's Rich Aitzemueller, "is the world's longest cordless telephone."

Not only was the connection long, but it was also state-of-the-art. This was the first remote site on the planet to be equipped with VOIP – Voice Over Internet Protocol – which allows computers, telephones, and faxes all to operate on a common infrastructure.

For VT's Ian Knight, Dave Lovrit, and Mike Deboon, installation was an ongoing nightmare, as demand for service and the geographic spread of it quickly expanded. Eventually they succeeded, leaving the DDMI staff with solid telecommunications, for both business and personal use.

▾ *Jaymes Dircks, NKSL's piping supervisor anxiously observes the boilers on the first day that they heat glycol.*

▸ *Storage for a full year's supply of bulk ammonium nitrate has been constructed in a remote part of East Island, in full compliance with all safety and environmental regulations.*

▸▸ *Throughout the construction period, Aboriginal elders showed a keen interest in developments. Here, Cheryl Wray explains the process plant to Jonas Lafferty, Harry Apples, and Edward Camille. Her colleague, Noel Doctor looks on.*

▸▸▸ *Rick Sheck's Norpo team from Yellowknife brought power to every corner of the island.*

completely enumerate, included the boiler house, the sewage treatment plant, the emergency vehicle building, and the site services building.

All the various buildings in the south end of the island are linked by arctic corridors, or heated elevated passageways, which carry not only pedestrian traffic but also electrical and communications cables plus clusters of pipes carrying drinking water, fire water, sewage, and a water/glycol mix for heating. Supreme manufactured the arctic corridors in modules measuring 20 metres long by four metres wide by three metres high in Edmonton, complete with all pipe work, cable trays, and cladding, and forwarded them to the site for Scott to erect. The arctic corridors enable the operating staff to move from the warmth of their bedrooms to the majority of the workplaces without ever having to experience the arctic chill.

Because the ice road is available only eight to ten weeks each year, Diavik must haul and store on site a year's supply of diesel fuel for the trucks, the power plant, and the boiler plant. This requires no less than 54 million litres of storage, the equivalent of 27 Olympic swimming pools. Gem Steel, colourfully captained by Brad Gemmer, provided the storage in three welded steel tanks, each 41 metres in diameter and 15 metres in height, which dominate the south end horizon.

Another commodity with a similar storage challenge is the ammonium nitrate that is needed to manufacture explosives on site. Western Denesoline Explosives Ltd., a joint venture between Calgary's Western Explosives and the Denesoline Corporation, owned by the Lutsel K'e Dene Band of the Northwest Territories, will supply the explosive and handle both the storage and the mixing. They designed the entire storage and mixing facilities and had them constructed by Clark Builders. The storage building must be the most remote of all buildings to ensure safe clearance distance. It will store in bulk up to 12,000 tonnes of the white granular fertilizer. The long vaulted profile of the building mimics the shape of the stockpile it will contain.

The emulsion plant contains offices, a maintenance shop, and the mixing facilities for the explosive emulsion created by mixing water, diesel fuel, and a few patented additives, with the ammonium nitrate.

Amongst the hardiest teams on East Island these last two years were the "reticulators" – those deliverers of both electricity and water.

Norpo, popularly referred to as "Rick and the Cowboys" as though they were a rock group, erected 466 poles and 24 kilometres of 13.8 kV power line around the island. In fact,

Sun dogs, formed when the sun's rays are refracted from ice crystals in still air, appear behind Diavik's three 18 million litre fuel storage tanks. The occasional appearance of these "triple suns" mystified curious workers from the south.

Metcon workers installed a labyrinth of pipes around East Island. Here, Jack O'Leary arc welds the fire water system under the watchful eye of Ken Basille. The heavy polyurethane insulation required to prevent freezing of the line is apparent. As further protection, electric heating cables are carried on the steel pipe immediately beneath the insulation.

placing power poles in a pure granite terrain, and stringing them in blinding blizzards needs stouter hearts than the average rock star possesses, but Rick Sheck and his Yellowknifers were as tough as nails and up to the job.

Metcon Construction, a northern Aboriginal joint venture, likewise braved the elements to place the many strands of black pipeline that snaked their way along every road, across every ridge, through every valley of the island. As much or more than any contractor, Metcon took up the challenge to provide opportunity to northern and Aboriginal workers. As their manager, Daryl Salanski, points out with pride, "Although not originally planned, we had to fuse and join high density polyethylene pipe in temperatures we had never worked in before. The crew needed continual encouragement, but they did it, and what's more, did it without a single lost time incident. A credit to them all."

Raptors in the Rafters

Construction planners try to think of all possible contingencies in their quest to have the perfect schedule. But during the rush to complete the maintenance complex, work was brought to a halt by the most unpredictable of causes. A peregrine falcon, a raptor officially listed among Canada's birds as "of special concern," decided that Scott Steel's roof rafters in the truck shop were just the place for a nest. Albert Bourque, of the Northwest Territories' Department of Resources, Wildlife and Economic Development (RWED), was successful in enticing the bird of prey out of the building to find more natural settings.

The maintenance complex enclosed and complete, provides sufficient room for Diavik's fleet of operations equipment.

There were many contacts with wildlife, which proved to be harmless to all parties. One morning Richard Lock was greeted by a wolf, quietly sitting at the camp door. Greg Miazga and Richard Olive, chatting in the most unnatural setting of the process plant foundations, were surprised to be joined by an Arctic hare who, like a pet cat, squatted at their feet. Dale Tweed was joined in a walk near the fuel tank farm by a fox which gave his trouser leg friendly nips to signal his presence. More worrisome, barren-ground grizzly bears occasionally wandered about, seemingly indifferent to the chaos of construction. In fact, during the spring of 2001, one grizzly took such a liking to East Island that he seemed about to call it home.

Uncomfortable with the notion of such a predator cohabiting with 1,100 humans, RWED's Raymond Bourget, working with DDMI's Cheryl Wray, tranquillized the bear, slung it under a helicopter, and relocated it on the tundra 40 kilometres to the south. Wolverines, too, were infrequent but intimidating visitors. The workforce however, meticulously heeded the warnings not to feed the animals, so visits from scavengers were rare.

Surely the most delightful of the wildlife was the litter of fox kits, not far from the crusher, which entertained the workers at sunrise with their playful wrestling and chasing, under watchful parental eyes, over the soft hills of "pixie dust," as the fine sand was known.

Most importantly hundreds of caribou wandered through, totally unhurried as though they knew that they had the right of way, which they did. They browsed and foraged contentedly within a stone's throw of trucks and shovels. If they were the least bit concerned they disguised the fact very well. It was almost as if they were oblivious to human presence. A couple of caribou died of natural causes on the island, but it was a matter of pride to the project that no instance is known of wildlife being killed, harassed, or injured by construction activity. Wildlife management formed part of the responsibility of DDMI's Environment Department. Their work started with the orientation briefing, which every new site employee received. The workers learned and heeded the message that the wildlife was to be respected.

Chapter Seven

The Mobile Equipment

"When you are choosing trucks that will cost over three million dollars each, you just have to get it right. There is no second bite at the cherry, no question of a trade-in next year for the new model."

Brian Saul, DDMI Senior Manager, Development

A mine at last! New Diavik mining equipment gets dirty as it starts to strip away the till covering precious ore.

As today's open pit mines go, the Diavik operation is not a major earthmover. Imposing as it might sound, the 20 million odd tonnes of ore and waste rock which must be moved each year, represent a comparatively modest task to the modern miner. Nevertheless, the DDMI mining team of Brian Saul, Dave Passfield, and Calvin Yip faced knotty problems in mid-2000. The project feasibility study had proposed two hydraulic shovels at 25 cubic metres and 16 cubic metres respectively, loading a fleet of fourteen 177 tonne haul trucks. Somehow the mix did not seem correct, so the trio sat with a blank piece of paper to rethink the problem.

Dave Passfield explains the context. "We were very conscious of the site's isolation on the tundra and the lack of supporting resources that would be at our disposal. This placed a premium on the reliability of our mining capacity. So whatever we chose for equipment would have to be of proven reliability and very easy to maintain with a minimum of operations and maintenance people. Also, we placed a premium on standardization, because we wanted to reduce our spares inventory and limit the range of equipment for which new maintenance crews would have to be trained. Finally, we were intent on selecting suppliers backed by local agents to ensure availability of spare parts and in-depth technical support."

Destined for Diavik, a Komatsu 830E haul truck's rock box dwarfs its transporter on the ice road.

Jack Roper of Mullen Trucking looks on as a haul truck rock box arrives over the 2002 ice road.

Two halves of a truck come together.

DDMI's Dave Passfield inspects one of Diavik's two Driltech D75EX blasthole drills.

The excavator sizing studies showed that the mix of a larger and smaller machine, while providing sufficient capacity on average, just did not manage the task when either broke down. After considering and rejecting combinations of two 25 cubic metre machines, then two at 16, the team finally compromised on two 20 cubic metre diesel powered hydraulic excavators. The Hitachi EX3600 model was selected because of its proven track record and the support of local agent, Wajax. As a backup to the shovels a LeTourneau L1400 front-end loader, of matching 20 cubic metre capacity, was also sourced through Wajax.

The mining team then turned their attention to the trucks. They reasoned that the larger the truck capacity, the fewer required and hence the fewer operators and maintainers. Going too large, however, would require wider roads and larger maintenance shops. Eventually, all things considered, the economic choice was a fleet of ten 218 tonne trucks, with electrical drive systems, of which seven were to be purchased and built before project start-up. The trucks chosen were the Komatsu 830E model supplied by Transwest Mining Systems. The Komatsu 830E, with 2,500 horsepower, is capable of hauling 147 cubic metres of material weighing 218 tonnes.

And so the selection procedure continued: Driltech drills from Transwest; Komatsu dozers, graders, loaders, and backhoes from Coneco; 100 tonne Komatsu trucks for haulage of water and processed kimberlite from Transwest.

Having received their orders by July 2001, all suppliers fabricated frantically to achieve delivery over the 2002 ice road. Massive components coming ashore were gazed upon in awe by the site population, habituated to mere 100 tonne trucks.

She may well be the tallest woman on site but Tanya Sever barely reaches halfway up the wheels of the LeTourneau loader.

Trying to play the part of his biblical namesake, Steve Sampson of NKSL attempts to push start the 20 cubic metre Hitachi excavator.

No component attracted more interest than the boxes of the 218 tonne haul trucks, because of their size certainly, but more particularly because of their thick rubber trays. The frames had been made in Chile and the mats in Australia, where the Argyle diamond mine had been using them for more than 10 years. The mats soften the loading for the operator and will outlast a conventional standard steel tray.

Nothing missed the ice road. As the first signs of spring appeared Dave Passfield put aside his analytical hat to don the hardhat of the construction site. With DDMI colleagues John de Boer and Terry Notter, and the teams from Wajax, Transwest, and Coneco, the hands-on work of assembly got under way.

By September 2002, when the dike was completed and dewatering of the pool was well advanced, the operators were trained, the equipment was assembled and Dave Passfield proudly led his army into the battlefield to start the big dig.

Diane Rever operates one of Diavik's fleet of Komatsu 830E haul trucks.

Marius Willard, aboard the Hitachi excavator, loads the truck operated by his wife Diane Rever

A Team of Two

The animated chatter and shrill laughter of petite Diane Rever, from the Eastern Townships of Québec, sound in stark contrast to the gruff male voices of her five habitual breakfast companions. But don't be fooled by appearances. Despite the levity, Diane carries a heavy burden on her back each day – 218 tonnes of it!

After spending much of the project driving a 100 tonne 777 for Lac de Gras Constructors, Diane decided to upgrade – to driving a 218 tonne Komatsu haul truck for DDMI. Moving with her is her husband, Marius Willard. And what does Marius do? Why, he operates the Hitachi 3600 excavator, which fills Diane's Komatsu 830E haul truck.

For Diane, standing just 1.6 metres tall and not even reaching to the hub of her 3.6 metre diameter wheels, the day starts with a long climb up 16 steps to her cabin.

Once there, she has the luxury of soothing classical music from the CD player or radio as she sits in air-conditioned comfort.

What? Air conditioning in the Arctic? Well to be truthful, it has more to do with keeping the bugs out in summer, than lowering the temperature.

It is safe to predict that Diane and her fellow drivers will become much more familiar with the heater controls.

Chefs Ed Swanky and Irena Strbac offer roast hip of bison.

Chapter Eight

The Services

"A construction project is like a machine. It will only work effectively if it is well serviced. We wanted the project to benefit from first-rate services, and we also saw this as an opportunity for northern and Aboriginal enterprises. We found the companies, and to their credit, they did not let us down."

Ron Hampton, DDMI Senior Manager, Project Controls

For more than two years, through summer sun and winter blizzard, as many as 1,100 workers went busily about their appointed rounds – from breakfast in the morning, to checking e-mails, to collecting newly arrived people and materials, hammering, welding, driving, drilling, and finally, thankfully, a hot meal and a warm bed. How much was taken for granted about all the services which simply, magically, just happened! But, of course, the services did not "just happen," they resulted from dedication, effort, and commitment every bit as vital to the success of the project as the standing of steel or the compacting of concrete.

For many workers, the very first time they stepped from the world outside into the world of Diavik was at the check-in counter of G&G at the Yellowknife airport. The two G's are Nova Scotians Greg Works and Glenn MacCara. If any party embodied the pioneering entrepreneurial spirit of the North it was G&G: two buddies, starting out in business together, no employees, few resources, simply the will to work, the heart to help, and the confidence that their best efforts would bring prosperity. From the very early days of

The two G's — Greg Works, left, and Glenn MacCara. G&G's ties to Diavik date back to early exploration days.

The two construction camps, with 1,150 beds between them, provided a cozy haven from winter blizzards.

The happy smiles of the Ek'ati Services staff, like Lisa Enzoe sustained many a lonely soul far from home.

At the south camp commissary, Vanessa Dow of Ek'ati Services offers news from home.

exploration Greg Works and Glenn MacCara aligned themselves with the fortunes of Diavik. Now with a staff of 12 and a warehouse and offices, the pair, both cherished members of the Diavik family, wonder how it happened. "Thinking back to that cold December morning in 1994, when Greg and I were first dropped on the Diavik site with nothing but a plane load of timber, it seems unbelievable looking at what is has developed into today," reflects Glenn MacCara.

Day after day, G&G processed people and materials through the airport and onto every conceivable flying machine they could muster. No fuss, no argument, no bother, just delivery with a smile! "No worries, buddy." That is the credo of G&G.

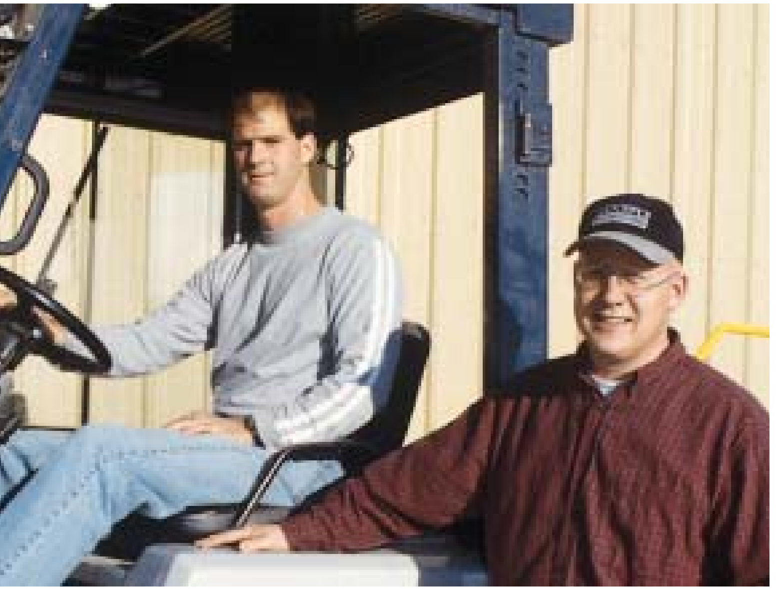
Once on site, workers were ferried to one of the "homes away from home," the north and south construction camps. Built from prefabricated modules, the camps accommodated 1,150 people – 450 in the north and 700 in the south. North camp was the work of Ek'ati Services, a joint venture of the Yellowknives Dene and Edmonton's Travco. ATCO supplied the south camp.

While "nothing fancy" would be a fair description of the camps, they did provide clean individual rooms, shelter, warmth, and privacy. More importantly, workers met smiling faces from the happy housekeepers who cheerfully made the beds each day and changed the linens each week. Employed by Yellowknives Dene joint venture company Ek'ati Services, the housekeepers were recruited from communities all across the North and kept the camps as sparkling as any city hotel.

Ek'ati Services was also responsible for the catering. Napoleon famously stated that an army marches on its stomach. Small wonder, then, that the Diavik workforce marched so well. Rare as it is to achieve unanimity of opinion among 4,000 people, all who have passed through the Diavik camp agree that the meals have been extraordinary. For quantity, certainly! But more particularly, for the quality, the variety, the preparation, and the imagination.

Saturday night, "theme night," was always a treat, as camp residents enjoyed ethnic surprises, such as Italian, Mexican, Greek, Chinese, French, or the very popular Aboriginal night when treats included caribou, muskox, dried meat, bannock, whitefish, and Arctic char.

Two other services gave comfort in the home away from home – the security and the medical services. Although the employees of SecureCheck and Medic North ranged right across the site, it was primarily in the camps that they practised and were seen.



Valerie McDermott and Emily Harris tag team in the laundry.

So hungry was a wolverine, and so attractive were the aromas coming from the kitchen, that he decided to eat his way through the floorboards. Not a bad plan until he chewed his way through the insulation surrounding live electrical wires. The wolverine scurried off across the tundra and the Emergency Response Team moved in to extinguish a small fire caused by the temporary visitor.

Guy Gouin of Medic North hunts for foreign matter in the eye of Dave Legros of SecureCheck.

Never abrasive, never oppressive, but always quietly present and friendly, the security officers of SecureCheck insured that all enjoyed peace, quiet, and tranquility, with none of the unruliness and brawling which some might expect in a camp on the rugged frontier.

Equally as unobtrusive, but even more comforting were the physician assistants and emergency medical technicians provided by Medic North. High quality medical and dental care was available 24 hours a day, including advanced cardiac life support, advanced trauma life support, and emergency response by ambulance. The medics were kept busy. Bob Whyte experienced a hectic week in February 2002 when in a span of seven days he treated five patients with cardiac problems. Despite all the safety awareness initiatives on site, Bob also had to suture five patients within a 10-day period, while Rick Lillico had to care for a very hypothermic patient who had been driving a Caterpillar tractor when it cracked through the ice and sank. The team also had to care for no less than 10 appendicitis patients while delivering them to surgery in Yellowknife.

While G&G marshalled all the airfreight through Yellowknife, by far the bulk of the tonnage arrived during those frigid weeks of January, February, and March when the 350 kilometres of ice road allowed goods to be trucked in.

Constructed each year by Nuna Logistics, under the masterful eye of John Zigarlick, for the joint use of the Lupin, Ekati, and Diavik mines, the road is briefly one of Canada's major highways. Featuring dual carriageways as broad and as imposing as the Trans-Canada Highway, the great ice road chills the imagination with its eerie blue ice, as much as 1.5 metres thick, but crazed with cracks.

Keeping The Green Mile Sparkling

The bedroom wings of the south camp protruded either side of a long, long passage with green flooring tiles covering all 248 metres of it. Little wonder it soon became known as "The Green Mile."

Keeping this passage sparkling was no mean task given the incessant traffic of the heavy work boots of 700 residents. Maybe it was that the colour reminded him of home in far off Marches Point, Newfoundland, but chirpy Clifton Jesso, weather-beaten well beyond his years and crippled with arthritis, dedicated himself to the endless task. Many a tramper was heard to guiltily apologize to Cliff, for leaving a footmark on his glistening floor, only to receive a hearty, "Oh, it's fine, it's fine. It'll keep me in work tomorrow, now won't it?"

Just as durable was the diminutive Emily Harris, probably the only great-grandparent on site, who endeared herself to the entire south camp population. From Aklavik in the Mackenzie Delta, Emily had been housekeeping on the site since the exploration days, and was not about to give it up anytime soon. Asked her ambition, Emily replied: "To get a job down at the new accommodation complex. The rooms are so beautiful, and, you know, some of those boys will still need me to keep their rooms tidy."

Tli Cho crews became proficient baggage handlers, as well as unloading heavy freight from the frequent aircraft arrivals. Canadian North operated three Boeing 737 flights per week direct from Edmonton, carrying workers on their turn-arounds. Daily flights operated from Yellowknife. First Air, Buffalo Airways, Air Tindi, Arctic Sunwest, Northwestern Air Lease, Summit Air, and Great Slave Helicopters also serviced the site. Every week the community charters collected workers from remote communities all across the North.

Nancy Zoe of Tli Cho, under the tutelage of veteran radio man and forecaster, Neil McDonald, handled up to 18 aircraft movements per day.

Reid Crowther Surveyor Rob Strand takes a long shot.

Nevertheless, the 650 dauntless drivers of RTL and Mullin Trucking ferried endless loads – cement, explosive, steel, generators, massive tanks – to the very heart of the tundra.

In fact, some of the tanks were so large that they could not be accommodated by the regular road network, and had to start their cross-ice journey at their point of manufacture in Hay River and cross the frozen Great Slave Lake.

Overall, mishaps were few, but when they occurred RTL had the readiness and in-house capacity to respond. As Donnie Robinson states, “It is the drivers, the mechanics, and the direct supervisors who keep track of the entire operation. They are the heart of RTL. These people gave 110 per cent. Our accomplishments are theirs.”

“What does Tli Cho do on site?” a newcomer asked. After some hesitation, the answer came, “Oh, they do everything. Everything, that is, that nobody else does.” Officially, Tli Cho had the “site services” contract, of which the most tangible elements were road and airstrip maintenance, snow clearing, and handling of aircraft on the ground. When you consider that the scope extends from air traffic control to the burning of garbage, that “everything” reply has some truth to it.

Their workforce of up to 75, composed mainly of Dogrib people, had to learn quickly to be flexible to respond to the needs of the day. While handling the baggage for all incoming and outgoing passengers was predictable, helping pilot and co-pilot from a crashed and burning DC4, as George Koyina, Charlie Ekendia, and Fred Migwi did, was not. To Tli Cho’s team, it was all in a day’s work.

At a time in history when most feel challenged to even try to chase the latest in technology, let alone catch up or get ahead, pity the poor surveyor. Probably no profession has had its tools of the trade so thoroughly reinvented. Reid Crowther, as they are known to all on site, despite having been recently re-christened as EarthTech, did not offload their old theodolites to remote Lac de Gras; they brought with them the best that the technological revolution had to offer. For instance, they surveyed the lakebed, before and after filter blanket placement, by combining echo sounding and global positioning systems (GPS), taking 10 survey shots per second with an accuracy of two to three centimetres. They processed and mapped results with the very latest of database and mapping software, calling upon any of the two million surveyed points they had accumulated. The biggest challenge of their contract, said Ty Deans, was managing the sheer volume of information. “And, oh yes,” he adds, almost as an afterthought, “It is tough taking readings at -40ºC.”

Nuna Logistics' Bill Hampel builds up the ice thickness during December and January to increase the carrying capacity of the ice road.

The warmest job on site! To avoid attracting animals, all food scraps and combustible materials are burned. Here, Tli Cho's William Michel operates one of the site incinerators.

Ty Deans and his colleague, John Tymstra, captained the team of up to 18 persons. "Early in the project we had trouble finding staff. We needed to train people but the workload was so constant that it was tough to get ahead. But gradually we did. For example, both John Bonnetrouge and Robert Strand began in early 2000 as survey assistants. But they have now progressed to being instrument technicians and are pursuing further training. Likewise Deanna Desarmeau arrived with little experience but over the course of the project developed into a premier computer technician. During the dewatering, her aptitude with the water balance model and pool mapping was invaluable to us, to NKSL engineers, and to the contractors."

Where to Start? The Great Tank Convoy

A common question for a non-technical visitor to a major construction project is, "Where do you start a project like this?" At Diavik, the first really significant construction challenge was to establish sufficient fuel storage to last the 12 months from one ice road to the next. Without fuel, no dozer can push, no loader can lift, no truck can haul.

The first year's operations, would consume no less than nine million litres of fuel, requiring 19 mighty tanks, each nine metres wide by 10 metres high. The tanks were fabricated by Northern Transportation Company Ltd. (NTCL) in Hay River on the south shore of Great Slave Lake in late 1999 for haulage up the 2000 ice road.

Temporary fuel tanks trucked to site by RTL. These were among the first loads to be transported up the ice road to Diavik. For construction, Diavik would safely transport over 8,000 loads of fuel, construction, and other materials up the ice road.

For NTCL's John Marshall, the greatest challenge was hydrotesting the tanks for leaks. "It was the middle of winter, with outside temperatures about -35ºC. To test, we used a low pressure, high volume, 20 centimetre cargo pump to pump 4,500 litres a minute of cold water into the tank from the Hay River. We covered each tank with a big military parachute, used four diesel heaters to send heat up the parachute to keep the tank water from freezing, then let it sit for 24 hours."

For DDMI's John Wonnacott, however, the problems were just beginning. Permitting delays stalled project go-ahead. February passed, and March slipped by, day by day. April Fools' Day generally signals the end of the ice road, because the portages of compacted snow between lakes start to thaw at the southern end of the road.

With the tanks ready to roll and the road's life a mere week or two, John took two initiatives.

First, he had an ice road built right across 220 kilometres of Great Slave Lake. This shortened the highway route by 200 kilometres and avoided the need to dismantle and reerect numerous power line crossings.

Second, he persuaded John Zigarlick of Nuna Logistics, the ice road manager, to carefully tend the dying ice road north of Yellowknife, by restricting traffic on the portages to nighttime. This avoided the mushing of soft snow in the springtime sun. So it was that John Wonnacott and John Zigarlick eked out the life of the road until 9 April 2000, the latest closure on record.

To Doug Ashbury and Doug Morrison, snowshoeing along the shores of Yellowknife Bay, it was a surreal sight on that April Sunday afternoon to see black dots upon the horizon of the lake materialize into a procession of monumental tanks, outrageously overhanging their transport trucks. They rumbled to the end of Yellowknife Bay and pushed on the final 400 kilometres to Lac de Gras.

The project had indeed started.

Chapter Nine

The Accommodation Complex

"It's one thing to equip the mine with the best of technology, but at the end of the day it's our people who will determine our success. And at the end of their day, what they need is a hearty meal and a warm bed."

Richard Lock, DDMI Construction Manager

The Diavik accommodation complex with its four wings and central core.

The permanent accommodation complex is unlike any other facility on East Island. It benefits from the input of architects. The difference shows!

DDMI commissioned the Yellowknife architectural and engineering firm of Ferguson Simek Clark (FSC) to design a facility which would provide a superior living and working environment for staff – one that respected both the workforce and the site. They were challenged with designing the best accommodation of any mine in Canada.

Mine accommodation has conventionally been regarded as "camp," a temporary place to sleep while away from home. In contrast, the accommodation at Diavik will be the basis of a community – a place where people will live, work, and interact for a significant percentage of their lives.

Numerous features were included to differentiate the Diavik living experience from that at other mines.

NWT Rock Services workers drill steel piles deep into bedrock to support the accommodation complex.

With a bedroom and bathroom at either end and a section of passageway through the middle, residential modules, fabricated in Edmonton, complete with furniture, are lifted in place by crane.

The need for social interaction is catered to by provisions that allow large groups to gather – at meal times, or watching theatre style television, or playing pool in the recreation area. At the same time, some people prefer to be in smaller groups or alone, but not locked away in their room, so a variety of quiet spaces has been provided, such as smaller eating areas, lounges at the end of each floor in each bedroom wing, a library, and quiet rooms, which may be used for religious purposes. The accommodation complex is also home to the Diavik Learning Resource Centre.

To encourage and facilitate community functions, the complex provides meeting rooms for special interest groups. Many of the workers, especially Aboriginal workers, are also painters, artists, and crafts persons. A workshop has been provided for them. The building encourages a healthy lifestyle, through the provision of athletic and fitness facilities that are visually open, providing life to the building and encouraging all to participate.

The complex takes advantage of the views of Lac de Gras. Like a resort, as many of the rooms as possible have lake views, and the dining room too is located to maximize the view of the lake. The complex is located as far as possible from the mining and production activities, without compromising the length of walk to work. Direct connection is made via arctic corridors to avoid the need to step outside during the winter blizzards.

FSC's team of 35 was headed by architect, Stephen Cumming. He designed the building core using wood frame technology and typical NWT construction techniques to enhance the contracting opportunities for local contractors. He chose the construction materials and methods to maximize performance of the building for the life of the mine, within acceptable cost.

Sub-consultant, Stu Bellingham of Calgary, advised on the kitchen and food preparation and handling areas. As Stephen Cumming comments, "No matter how good the food is in a cafeteria, sooner or later the colour of the trays or something else will start to bother you. In the food services at Diavik, we have tried to provide as much choice and freedom to the residents as possible. Instead of food being doled out from a cafeteria line, the food services are arranged around a series of self-serve stations, where residents can take the food they want in the quantity they want. Not only does this make the folks feel more in charge of their lives, but it encourages healthy lifestyles and discourages the waste of food."

Building on Permafrost

One of the best pieces of advice for anyone planning to dig foundations into permafrost is, "Think again, find some rock, and place your building there."

The problem is that opening up the excavation exposes the frozen sides to warm summer air, causing them to thaw, collapse, and flow.

The accommodation complex was sited on a picturesque meadow carpeted with the delightful micro-flowers of the tundra. Little hint did this benign blanket give of the civil engineering trap it covered.

The excavation quickly exposed ground ice, metres thick, extending across the entire site of the complex. As luck would have it, spring days rapidly gave way to the warmth, even the heat, of the summer sun. The excavation grew outwards by the day, flows of quasi-liquid silt invading the site.

The solution lay in blanketing the floor and the slopes of the excavation with a layer of rockfill to insulate the ground from the warm air. Hundreds of steel piles drilled deep into bedrock provided an array of stilts upon which the entire accommodation complex now sits.

The moral: Leave what is frozen well alone.

Bill Fitzmaurice and Lewis Ferguson of Ek'ati/Travco level the flooring joists for a bedroom wing.

Ek'ati/Travco's Aimé Beaudoin stands proudly before the prefabricated dormitory modules and prepares to hand over the assembled complex to Supreme for cladding.

Ninety North's Jack Omilgoetok, left, and Ellis McDonald, apply the blowtorch to a moisture barrier on the accommodation complex core.

Ryfan's Shaun Roblin wires up the bedroom wings from the crawl space. All bedrooms are to motel standard with satellite television and Internet connection.

The layout of the complex sees four wings radiating out from the central core, which houses all the communal facilities. For engineers long habituated to the bland box-like rectilinear functionalism of all the industrial facilities on site, entering the core of the accommodation complex presents something of a surprise. "Hey! It's full of odd angles, little corners and funny shaped rooms!" exclaimed orthogonally minded mechanical engineer, Dale Tweed of DDMI. The building was designed with oblique views between areas so that staff could see others coming and going. For example, while pondering whether to devour coconut cream pie for desert you can witness your workmates working out in the gym.

The challenge of constructing the core was taken up by Ninety North of Yellowknife, who was also busy with work in the power plant, the process plant, the recovery building, and the maintenance complex, quite apart from the sorting facility in Yellowknife. The company had never previously worked on a mining project and it was a huge step for them. Site Manager Jim Fraser directed a workforce of 160 of his own people and no less than 10 specialist sub-contractors. "The scale of the project presented many firsts for Ninety North. Initially, our greatest challenge was probably the difficulty in finding sufficient skilled workers, and to utilize as much of our resident northern workforce as possible. But it's amazing how they grew on the job, given the chance. We had a couple of younger fellows who started out on the project with little or no experience. These two men, Joe Pander and Jack Omilgoetok, both ended up running crews confidently and capably," Jim said.

The bedroom wings were the creation of Ek'ati/Travco. Each of the four wings comprises three levels, each containing 22 bedrooms, a communal lounge, and a laundry. Hence,

▾ *Lisette Brulé, an electrician with Argo installing process control for sump pumps.*

▸ *The Diavik accomodation complex core includes a variety of facilities including the dining area.*

▸▸ *Joshua Atkinson with Cando Insulation, a subcontractor of Hay River Mechanical, insulating the heating system at the accommodation complex.*

▸▸▸ *Ek'ati Services First Cook Tom Brosseau prepares for the next meal at Diavik.*

the complex contains 264 single bedrooms in total. As every worker will have an "opposite number" on rotation off site, occupancy of the rooms will alternate between two "tenants." Conscious of this use pattern, FSC designed duplicate lockable drawers, cupboards, and wardrobes to ensure parity, security, and privacy to each occupant.

Ek'ati/Travco modularized the wings into 156 separate boxes, most containing two bedrooms, complete with ensuite bathroom, plus a portion of the central passageway. Vertical duct spaces were provided for passage of utilities. Rob Stocki supervised fabrication in Edmonton, while Bill Fitzmaurice put the pieces together on site. A special part of Ek'ati/Travco's commitment to the project was to participate in the planning and execution of DDMI's apprenticeship training program. Northern apprentices in carpentry, plumbing, and electrical work relocated to Edmonton to work in Ek'ati/Travco's manufacturing facility on the modules, and then followed the modules to site to work on installation. The result was a win for all parties.

For Rob Stocki the big challenges were ones of coordination and planning, as much as the physical work. "Coordinating design development with the architect, engineer, and owner, during the early stages of the project required much effort. Installation schedule changes then presented a challenge. We were requested to accelerate our module erection and delay commissioning to accommodate other work on site. It is always difficult to maintain efficient installation operations during winter and a varying schedule just makes the problems worse. Largely thanks to Bill Fitzmaurice's great facility for forming and maintaining excellent personal relationships, all our work was delivered efficiently and on time."

With several hundred hungry workers due for lunch, Kitty Lessard, sandwich maker extraordinaire with Ek'ati Services, makes ready the midday meal.

Off shift, workers take advantage of the permanent accommodation complex's recreational facilities. Spectators look on from the suspended jogging track.

Rob might also have mentioned the quality of the work delivered. Diavik workers will have the pleasure of living in rooms constructed and equipped to the standards of top hotels.

When asked to nominate the heroes for his company, on this project, FSC's Stephen Cumming commented, "Design of buildings is a team sport, and without the dedication of the entire FSC team, the accommodation complex would not have been successful. I could include NKSL's entire team in that, especially Don Holley, Dick Towson, and Gerard Laman, as well as all the contractors and sub-contractors. Good buildings do not happen in isolation. They require good clients. Richard Lock and John Wonnacott demonstrated a consistent commitment to quality, right from the initial design brief."

The Diavik Learning Resource Centre was created to offer workers training and skills development opportunities beyond Diavik's conventional site-based training program. Marion Storm, left, with DDMI Administrative Assistant Mariah Maring, is the centre's coordinator.

The Learning Resource Centre

While at the site, Diavik workers have the opportunity to advance their training through the Diavik Learning Resource Centre.

"We design an education plan specific for each learner," according to Marion Storm, Learning Resource Centre Coordinator. Through the centre, located at south camp during construction and now in the permanent accommodation complex, workers can upgrade math, science, and computer skills. They can also write Grade Equivalency Diploma (GED), trade apprenticeship, college and university exams on site. The centre also assists with workplace literacy and provides access to on-line courses through several computer workstations.

"We work in partnership with Aurora College and southern trades colleges to deliver pre-trades education and trades apprenticeship courses," Marion added.

"We also work with the college's community adult educators to enhance learning for a seamless portable education."

The Diavik Learning Resource Centre also offers an arts and culture program to promote cultural and community awareness, as well as literacy, through the making of art. People can work individually or in groups to learn and create traditional and/or contemporary art. As well, there is a literacy component revolving around art vocabulary to enhance reading and writing skills in a meaningful way.

Incorporated into the centre's approach to learning is ongoing contact with workers' communities. "With workers on a two week in / two week out rotation, this will help ensure that learning can continue on site or while the employee is at home in his or her community," said Marion. "We can supply any individual with a range of state-of-the-art technology and resources so they can reach their dream."

Safety and Emergencies

Chapter Ten

"At Rio Tinto we do not accept that injuries are inevitable. Our goal is to create a work environment in which all employees, whether an underground miner or an executive, have the same expectation of going home each night uninjured."

Rio Tinto 2001 Social and Environment Report

Highly trained volunteers on the Emergency Response Team, included, Alexandra Karpoff, Marcy Todd, Brad Rodgers, Darryl Armstrong, and Rocco Meraglia, front row, and Bobby Zoe, Clell Crook, Gary Tkachuk, and Gary Drybones, back row.

Through the years of construction, the site greeted innumerable experienced contractors and contract workers, from across Canada and around the world. If there was any one common reaction to the site they found themselves upon, it was the insistence, the obsession some would say, on safe working practices.

DDMI Safety Manager Mike Cooper was unflappable in the face of charges of obsession. To Mike it was the safety of the employees that counted. "My statistics were my barometer," he said. "In 2000, we had an LTIFR of 1.29. Not bad, but we pushed hard for the big year of 2001, and it fell to 0.94. And harder again for our next big year of 2002 and down it came, all the way to 0.38."

For those uninitiated into the arcane mysteries of industrial safety statistics, the LTIFR is the Lost Time Injury Frequency Rate or the number of lost time injuries per 200,000 person hours. Mike Cooper's pride in his figures is understandable when you realize that the construction industry has a history of workers injured on the job, with LTIFR's typically

A grader clearing snow from the ice road accidentally ventured onto thin ice.

Emergency Response Team members, Crystal Talbot and Rocco Meraglia, prepare for training.

Mike Cooper, DDMI's Health and Safety Manager, brought to Diavik his experience and relentlessly drove improved safety performance.

Bill Kramer, NKSL's Safety Manager, smiles contentedly at the safety record achieved.

up over 5.0. In effect, it means that workers on the Diavik Diamonds project stood less than 10 per cent the chance of being injured as construction workers generally.

The Diavik team can also take pride in achieving a safety milestone rare to the construction industry– 1 million safe hours. The 1 million mark was reached 13 November 2002 after 116 consecutive days without an LTI. Diavik's workerswould continue to add to the milestone during the months to come.

Mike Cooper is the first to acknowledge that credit for the performance should be shared. "Bill Kramer and Dave Merrill and the NKSL staff stood right behind me, and some of the contractors' safety performance and leadership was extraordinary. It's tough to single out individuals but I just have to mention Brian Chaput of LDG and T.R. Pouitt of Tli Cho as safety managers who influenced excellent safety results."

Beyond the safety systems and leadership, Mike saves his greatest praise for all those individual contractor employees who worked in some of the most difficult conditions imaginable. They faced temperatures and wind chills that would freeze skin in seconds. Often, workdays had only a couple of hours of daylight. In winter, tasks were performed with the encumbrance of bulky clothing. In summer, workers were subject to persistent attacks of hordes of buzzing insects. Through it all they never lost focus on safe work practices.

While vigilance to proper equipment, clothing, and procedures can bring down accident frequency, fast response to emergencies plays an equally vital role.

The Emergency Response Team, staffed by enthusiastic, generous, fit young men and women who volunteered from across all the parties on site, drilled frequently under the astute leadership of Daryl Armstrong of Tli Cho and Bill Kramer of NKSL. There is little doubt that their rapid response saved lives at the diverse emergencies they were called to attend: an operator trapped in a dozer that broke through the ice, two truck rollovers, two aircraft crashes, two fires in the camps.

◂ *The memorial. Two missing bolts from the joint below the plaque symbolize the lost team members.*

▾ *Co-workers of Gregory Wheeler and Gerhard Bender share the burden of their memorial.*

A Tragedy

Sadly, there was one emergency where no assistance, no matter how rapid, could have helped. On the evening of 17 July 2001, Gregory Wheeler of Newfoundland and Gerhard Bender of Alberta, were fixing sheets of insulated cladding high upon the south wall of the process plant. Without warning, the manlift which was carrying them toppled and brought the two young men crashing to their death. It was the one black day in the project, and was followed by weeks of sombre reflection by fellow workers across the site.

The sense of family runs strongly at Supreme Steel, where owner John Leder and his brother Peter, who managed their site operations, have built a tight-knit team of loyal ironworkers. Devastated by the loss of their friends, the team vowed that they would not be forgotten.

Using their craft skills they worked upon spare steel beams from the process plant to fashion a memorial cross, which together they shouldered to a remote, beautiful knoll high on East Island.

There it will stand, throughout the years of operation and through the centuries, even millennia, to follow, in silent memory of the two project workers who did not live to see their work come to fruition, Gregory Wheeler and Gerhard Bender.

Chapter Eleven

Building a Sustainable Business

"Before construction started, we set very high standards with regard to environmental protection, social well-being, and economic sustainability. These standards where echoed and reinforced by the communities. During construction, the Diavik team dedicated itself to meeting these standards, and the results speak volumes about everyone's commitment. As we move into operations we remain committed to implementing plans and programs aimed at continuing to achieve these objectives."

Murray Swyripa, DDMI Vice President
Health, Safety, Environment & Human Resources

Doug Laverdiere, left, and Robert Lafferty, of Gem Steel, constructing one of Diavik's fuel tanks. Robert was among over 200 northerners to complete a DDMI and partners community-based training course. He would go on to a welding apprenticeship.

In creating the Diavik Diamond Mine, DDMI and its many teams not only constructed a world class diamond mine, they also laid the foundation for building the business as a Canadian one – one that will see Canada in short order becoming a major world player in the diamonds industry. But also a Northern business – one with roots now firmly taking hold in the communities surrounding the mine.

In the early years of the project, project representatives met with local communities to better understand their needs and interests in the future diamond mine. Community people voiced their concerns and Aboriginal elders impressed upon Diavik the need to protect the land, the water, and the wildlife, and the need to look forward to providing for future generations. Young people made their desire for training and jobs known. Local companies and development corporations expressed their need for new business opportunities.

Part of the Bathurst caribou herd migrates through the Lac de Gras area twice yearly. Throughout the life of the mine DDMI will continue to monitor caribou and ensure their safe passage through the area.

A fully wired house! An industrious pair of ravens recycled wiring offcuts to build a home for their four offspring on the steps of one of Diavik's fuel storage tanks.

Jimmy Larkin joined the Diavik Diamonds Project during early resource drilling. During construction he gained heavy equipment experience through LDG then joined DDMI as Mine Foreman.

Diavik listened and then developed a plan to incorporate the communities' needs into the project. As construction unfolded, the project team implemented the plan – a plan that when looked at as a whole was a plan for sustainable development.

The land can be fragile; the waters of arctic lakes are pure; grizzly bears and vast herds of caribou roam the area. Several species of birds migrate nearby. A cornerstone was protection of the pristine environment.

Through comprehensive environmental management plans that included careful monitoring, sound construction practices, and environmental awareness training, workers at site became environmental protection team members. Despite trucking over 8,000 loads of fuel and construction materials to the site, quarrying 12 million tonnes of rock, and placing four million tonnes of it into a large arctic lake, handling over 10 billion litres of water, housing over 1,100 workers to construct the massive $1.3 billion industrial facility, the fragile environment was protected. In fact, said Site Environment Manager, Erik Madsen, "Diavik employees and contractors met, and often performed better than the limits set in permits, licenses, and authorizations." All this despite the challenges associated with constructing such a complex project in a remote arctic location.

To meet young people's desire for work, DDMI developed unique, community based training partnerships that saw over 200 candidates complete trades entrance training – with the majority of graduates finding employment with Diavik and other local employers. "As with most challenges, setting up this innovative community based training

Jackson Lafferty, right, of Diavik, congratulates training course graduate Maurice Zoe Fish at a ceremony in Wha Ti where trainees renovated and expanded a community hall. The hall would host the 2002 Dogrib Treaty 11 Council assembly.

Some 25 northerners, among them Peter Huskey, seated, completed Diavik's process plant training course in Fort Smith. The course prepared graduates for employment opportunities at Diavik. Looking on are DDMI Ore Process Plant Manager Harry Ryans and Diavik training team members Glenn Zelinski, Greg Hopf, and Bob Dawe, left to right.

In Kugluktuk, a community along Nunavut's arctic coast, DDMI pre-employment training courses included camp cooking and construction trades. Here, Beatrice Nivingalok, Mary Algona, and Irene Allukpik prepare the community meal which would be served at the training course graduation.

Among DDMI's first community-based training initiatives was a welding course in the Dogrib community of Rae-Edzo. These pre-employment courses were the result of DDMI partnering with businesses, governments, and the North's Aurora College. Here, former DDMI President Stephen Prest, right, takes a keen interest as welding instructor Doug Philips works with Richard Rabesca.

partnership had its rewards. Seeing people discover new opportunities and gain new confidence and then go to work for Diavik, made it all worth it," says DDMI Training Manager Glenn Zelinski.

Training played an important role in DDMI exceeding its commitment to employ northerners during construction. "We actually reached 44 per cent northern employment, with about half of these Aboriginal. With a workforce that peaked at 1,500 workers, this was a lot of jobs," said DDMI Contractors Training Development Coordinator Jackson Lafferty.

DDMI also recognized the project had the potential to generate significant business opportunities for northern firms. Northern Aboriginal joint venture companies participated in construction as did other northern businesses. The aggressiveness and interest of northern businesses saw DDMI double its northern commitment in this area. "Of our $1.1 billion in contracts, we spent over $750 million with northern and Aboriginal firms, a previously unheard of achievement in northern Canada," said DDMI Venture Development Manager Eric Christensen.

Throughout construction, the Diavik team opened its site to local community representatives to show them what they were doing, and to seek their advice. The Diavik Communities Advisory Board helped Diavik find training, employment and business opportunities. The Environmental Monitoring Agreement Board oversaw the work, and provided advice to Diavik in addressing environmental challenges. And, "Through the five participation agreements with local Aboriginal groups, we had an additional mechanism for effective communication and cooperation that strengthened our relationships. This resulted in mutual support and benefits for all parties," said DDMI Community Affairs Vice President Darryl Bohnet.

As one looks forward to operations, one sees similar commitments to building a sustainable business – commitments that were set in the project's development and construction years.

Operations training is building tremendous team skills to run an efficient operation. Diavik's work with Performance Associates has put in place a multi-million dollar computer-based training package "that provides workers with the opportunity to take apart and re-assemble – on screen – virtually every piece of equipment on the site. Armed with that knowledge, work on the actual equipment becomes a snap, saving time and money," according to DDMI Training Superintendent Bob Dawe.

Not gold, but diamonds, sit at the end of this rainbow.

On the business side, Diavik provides opportunities that will be attractive to a diverse group of companies. "Our intensive construction program provided a challenging training ground for new northern business ventures, and we saw their business capacity grow throughout. As a result, we will see a strong and able northern business presence continuing into operations," said DDMI Senior Manager, Operations Support, Ron Hampton.

And so the construction chapter in the Diavik story concludes, but the building of Canada's premier diamond mine continues through attention to social well-being, ecological integrity, and economic prosperity – the building blocks of sustainable development.

Lost at DEN

In January 2000, a group of 13 bewildered Aboriginal trainees – five Dogribs, three Yellowknives Dene, three Inuit, and two Chipewyan – tried to come to terms with Denver International Airport, or as it's more commonly known, DEN. When the most complex airport you have ever seen is Yellowknife's, the soaring sails of DEN and its unmanned underground rail system between terminals are bound to cause anxiety for anyone.

The group, under the protective wing of DDMI Manager of Industrial Relations Sean Willy, a Metis of Chipewyan descent, was en route to Tucson, Arizona, to attend Caterpillar's 777 rock truck operator training school. The young trainees made up for their inexperience with their enthusiasm to learn. In fact, they won high praise from their "Cat" instructors.

Vic Crapeau, Alfred Liske, David Drybones, James Sayine, and George Betsina, among the course participants, between DDMI's Sean Willy, left, and Caterpillar trainer Ivan Fogerty in Arizona.

Given DDMI's northern and Aboriginal hiring policy, it was inevitable that a significant number of workers would be quite inexperienced on large construction sites. If there was ever a fear that this inexperience would create a safety hazard, the statistical facts at the end of the project indisputably refute such an argument.

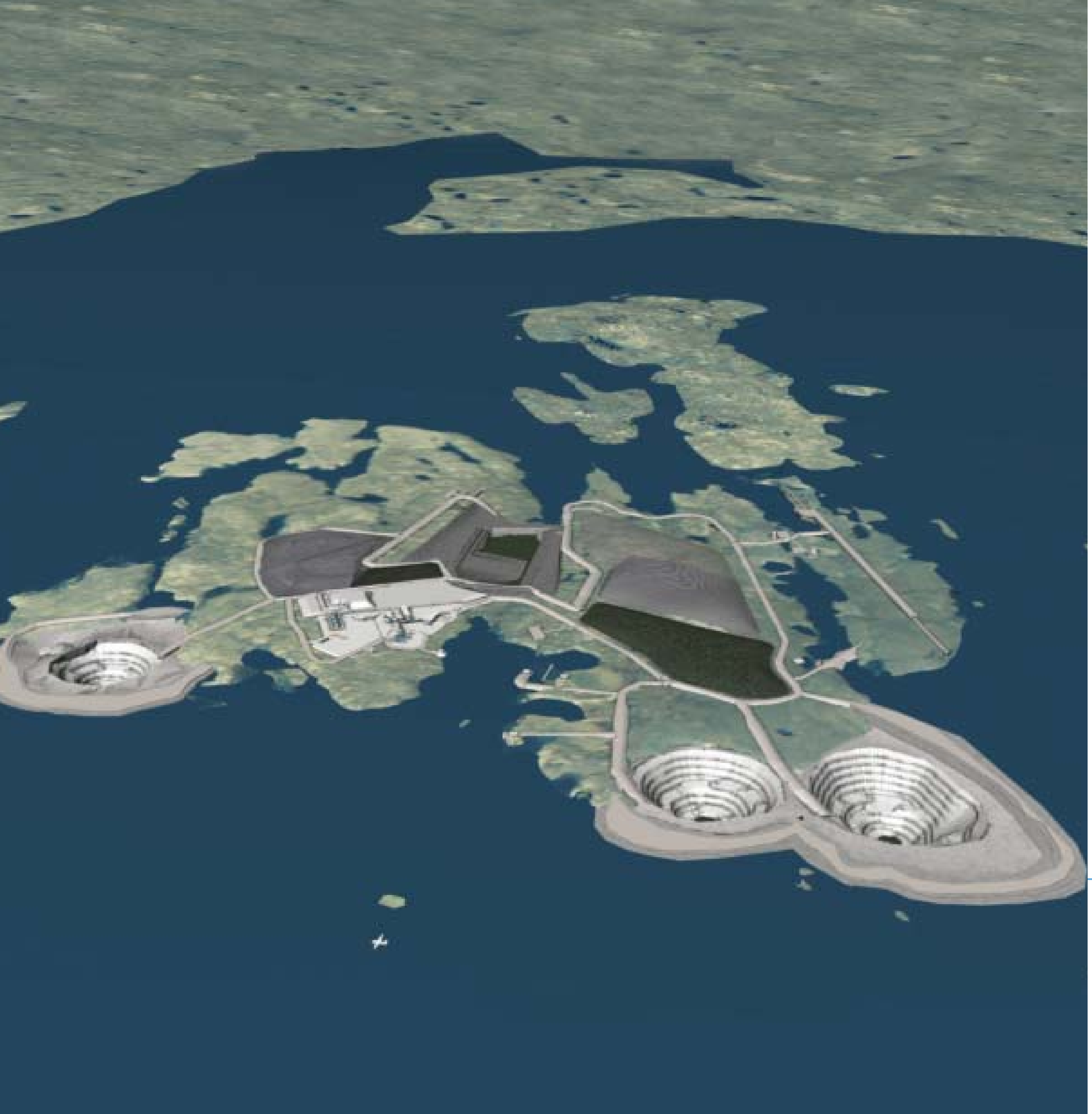
Sean attributes the favourable results to a willingness to learn, to an absence of ingrained bad work practices, and to the keen visual perception and awareness of the trainees.

With Sean's helpful steerage, the workforce on the project reached 44 per cent northern with about half of the 44 per cent being Aboriginal. Apart from DDMI's obligations under the terms of its various agreements, the company had a vested interest in encouraging contractors to achieve high levels of Aboriginal employment. Many of these workers, who were gaining skills and experience with the contractors during construction, were destined to become the core of DDMI's operational workforce. Fully 75 of the 100 operators in the mine have come to DDMI from LDG.

For example, Frank Michel, a Dogrib from Rae-Edzo, started as a truck driver with LDG in 2000. Never missing a shift, he was trained to operate dozers and excavators. He is now a key equipment operator at Diavik.

Likewise, Fred Drygeese, of the Yellowknives Dene First Nation at Dettah, has graduated from LDG to operate Diavik's heaviest loader.

Most striking is the story of Margaret Hanak, an Inuit from Kugluktuk. Joining LDG's sub-contractor, Nahanni Construction, as a carpenter, she looked for every opportunity to learn more, to diversify her skills, and to increase her income. She trained as a driller, then a truck driver, and is now moving up to operate a 218 tonne haul truck at Diavik.



A computer generated image of East Island, Lac de Gras, depicting the Diavik Diamond Mine at full development in 2015. During the mine construction phase, only the dike around the A154 pit, right, was constructed.

Epilogue

Throughout this story of the construction of the Diavik project, the theme has been constant, a theme of coming together.

Certainly the physical pieces all came together – the steel, the concrete, the timber, and the wiring. In a more particular way the participating companies came together. Despite their individual interests, they worked cheek to jowl as they jostled for space to execute their tasks. Seeing the success of the project as their own success, they put aside their momentary frustrations to achieve the common goal.

Finally, and most emphatically, it was the people who came together in this most remote corner of our immense country. They came not only from local communities but also from every province and territory of Canada, and they came from the United States, from Europe, South America, Africa, Asia, and Australia. Together they met and laboured in the homeland of our First Nations.

Together all have achieved a result that surpasses the hopes and expectations of Diavik Diamond Mines Inc. and Aber Diamond Mines Ltd. May they long take pride in what they have achieved here.

Consultants

Appendix One

Consultant	Description
ABR Consultants Fairbanks, AK, USA	Reclamation
Acres International Ltd. Oakville, ON	Engineering
Aurora Geosciences Ltd. Yellowknife, NT	Exploration Ground Geophysical Survey
A.W. Fraser & Associates Edmonton, AB	Recruiting
Bryant Environmental Yellowknife, NT	Environmental Management Plans

After eight weeks of pumping, the silty lakebed within the dike is exposed. By late September 2002 only residual ponds remained within the dike enclosure. Although there was capacity to pump more quickly, the engineers insisted on a rate of 400 millimetres per day to allow pore water pressure in the dike to dissipate. This ensured the strenght and integrity of the dike.

Consultant	Description
Coastal and Ocean Resources Inc. (Brian Bornhold) Sidney, BC	Bathymetry
Dillon Environmental Consultants Yellowknife, NT	Fisheries Related Monitoring Projects
EBA Engineering Yellowknife, NT	Geotechnical Services
Geochimica (Mark Logsdon) Ojai, CA, USA	Geochemistry
Golder Associates Yellowknife, NT Calgary, AB Saskatoon, SK	Environmental Services
Hatch Associates Ltd. Mississauga, ON	Document & Management Services
International Tsunami Research Inc. (Brian Bornhold, Isaak Fine, Evgueni Kulikov, Alexander Rabinovich, Rick Thomson) Sidney, BC	Environmental Services

Consultant	Description
Lawson Lundell Vancouver, BC Yellowknife, NT	Legal Services Environmental Permitting
McIntosh Engineering Inc. Tempe, AZ, USA	Prefeasibility Review- Underground Mining
Mike E. Necula Consulting Inc. Edmonton, AB	Industrial Relations
Nishi-Khon/SNC-Lavalin Yellowknife, NT Montreal, QC	Engineering, Procurement, and Construction Management
Sala Groundwater Inc. (David Blowes) Waterloo, ON	Geochemistry

Contractors & Subcontractors

Appendix Two

Contractor	Description
A&A Technical Ltd. Yellowknife, NT	Dam Lining
Adam Clark Yellowknife, NT	Sewage, Water Treatment Plants, Process Plant, Power Plant, Boiler Plant
ADCO North Yellowknife, NT	Boilerhouse, Sewerage Plant, Fuel Tank Piping
Air Tindi Yellowknife, NT	Air Transport
Arctic Divers Ltd. Yellowknife, NT	Diving Services
Arctic Sunwest Yellowknife, NT	Air Transport
Argo Industrial Projects Edmonton, AB	Accommodation Complex Building

In late August at Lac de Gras, bearberry blankets the tundra.

Contractor	Description
Bauer Spezialtiefbau GmbH Schrobenhausen, GFR	Cut-off Wall Equipment & Accessories & Jet Grout Equipment for Cut-off Wall
Buffalo Airways Ltd. Yellowknife, NT	Air Transport
BXL Bulk Explosives Ltd. Calgary, AB	Explosives
Canadian North Airlines Yellowknife, NT	Air Transport
Clark Builders Yellowknife, NT	Various Buildings
CRP Products & Manufacturing Ltd. Edmonton, AB	HDPE Piping
Denesoline Western Explosives Yellowknife, NT	Explosives
Ek'ati Services Yellowknife, NT	Catering & Camp Services
First Air (Bradley Air Services) Yellowknife, NT	Air Transport
Fraser River Pile & Dredge New Westminster, BC	Dredging
G&G Expediting Yellowknife, NT	Expediting, Off Site Receiving, Freight Forwarding, Passenger Processing

Contractor	Description
Gem Steel Edmonton, AB	Bulk Fuel Tanks
Golder Associates/Kugluktuk HTO Yellowknife, NT/Kugluktuk, NU	Small In-land Lake Fishout
Great Slave Helicopters Yellowknife, NT	Helicopter Services
H.A. Simons Ltd. Vancouver, BC	Construction Management
I.P. SEP Networks Incorporated Vancouver, BC	Network Integration
Jacques Whitford Environment Ltd. Yellowknife, NT	A154 Fish Salvage Review of EMS Systems
Kingland Ford Hay River, NT	Light Vehicles
Lac de Gras Constructors Joint Venture (Peter Kiewit Sons' Inc./Nuna Logistics) Yellowknife, NT	Prime Civil Works, Concrete, Mine Pre-stripping
Laprairie Crane (Alberta) Ltd. Grimshaw, AB	Crane Rental
Major Midwest Drilling Yellowknife, NT	Geotechnical Drilling Services
Medic North Yellowknife, NT	Medical Services
Metcon Yellowknife, NT	Pipelines & Pump Stations

Contractor	Description
Mullen Trucking Inc. Aldersyde, AB	Transportation
Nahanni Construction Yellowknife, NT	Civil Construction
Ninety North Yellowknife, NT	Accommodation Complex, Product Splitting Facility
Norpo Yellowknife, NT	Overhead Power Distribution
Northern Communications & Navigation System Yellowknife, NT	Radio Communications
Northwestern Air Lease Ltd. Fort Smith, NT	Air Transport
NWT Rock Services Yellowknife, NT	Quarry Drilling & Blasting
NWT Rock Services/Advanced Construction Techniques Ltd. Yellowknife, NT/Maple, ON	Curtain Grouting
Pacchiosi North America Inc. Montreal, QC	Jet Grouting
Reid Crowther (EarthTech) Yellowknife, NT	Surveying
Rescan Environmental Services/Gameti Development Corp. Yellowknife, NT/Gameti, NT	Water Quality Monitoring
RTL Robinson Enterprises Ltd. Yellowknife, NT	Transportation

Contractor	Description
Scott Steel Edmonton, AB	Structural Steel Various Buildings
SecureCheck Yellowknife, NT	Security Services
Siemens Canada Ltd. Burlington, ON	Airstrip Navigation Aids, Approach Lighting
SimplexGrinell (Division of Tyco International) Mississauga, ON	Security Systems
Summit Air Charters Ltd. Yellowknife, NT	Air Transport
Supreme Steel Edmonton, AB	Structural Steel Utilidors, Bins, Cladding
Tli Cho Landtran Yellowknife, NT	Ground Transportation
Tli Cho Logistics Yellowknife, NT	Site Services
Vantel Ltd. Vancouver, BC	Site Communications

Major Suppliers

Appendix Three

Major Supplier	Supply	Location
ABB Bailey (Canada) c/o BG Controls	pH Analyzers	Port Coquitlam, BC
ABB Inc.	Variable Frequency Drives, Motors	Milton, ON
Acitec Inc.	Review of HF Acid Process	North Royalton, OH, USA
Acklands Grainger Inc.	Workshop Equipment	Yellowknife, NT
Adroit Automation Inc.	Weighing, Packaging Equipment	Denver, CO, USA
Alberta Sales Co	Hydraulic Vehicle Hoist	Edmonton, AB
Algoma Steel Inc.	Steel for API Tanks	Calgary, AB
Altex Heat Exchanger Ltd.	Heat Exchangers	Edmonton, AB
Anixter Canada Inc.	Fibre Optic Cable & Accessories	Edmonton, AB
Ashbrook Corp	Sewage Treatment Plant	Houston, TX, USA
Atlas Copco Compressors of Canada	Air Compressors	Delta, BC
B&F Manufacturing Ltd.	Workshop Equipment	Nanaimo, BC
Baker Process	Slimes Thickener	Mississauga, ON
Bell Pole Co	Telephone Poles	New Brighton, MN, USA
Bently Nevada Canada Co	Vibration Meter	Edmonton, AB
Berg Chilling Systems Inc.	Water Chiller	Scarborough, ON
BG Controls	Thermowells, Orifice Plates	Port Coquitlam, BC

During the brief northern summer, Arctic cotton flourishes on the tundra.

Major Supplier	Supply	Location
Blower & Vacuum Technology Ltd.	Spillage Handling System	Edmonton, AB
Bonar Inc.	HF Acid Tote Bin	Lindsay, ON
Bond-O Communications Ltd.	Radio Modems	Stettler, AB
Bran+Luebbe Inc.	Chemical Preparation & Feed System	Roselle, IL, USA
Breaker Technology Inc.	Rock Breaker	Thornbury, ON
Brytex Building Systems Inc.	Pre-Engineered Steel Buildings	Edmonton, AB
Burkert Contromatic Inc.	Solenoid Valves	North Vancouver, BC
Burnaby Insulation Supplies Ltd.	Insulation - Jacketed Fibreglass	Burnaby, BC
Canadian Process & Control Ltd.	Control System I/O Panels	Port Moody, BC
Canco Cranes & Equipment Ltd.	Hoists	North Vancouver, BC
CB Engineering	Pressure & Temperature Transmitters	Calgary, AB
CG Industrial Specialties Ltd.	Isolation Valves	Edmonton, AB
Chamco Industries Ltd.	Modules & Water Barges	Calgary, AB
Chemical Lime Co	Hydrated Lime	Langley, BC
Chubb Lock & Safe	Vault Doors	Vancouver, BC
CIBA Specialty Chemicals, Canada	Process Chemicals	Mississauga, ON
Cleaver Brooks c/o CANNEP	Power Plant Supplementary Heating Boilers	Delta, BC
Colony Management	Cold Warehouse Facility	Vancouver, BC
Comco Pipe & Supply Co	Steel Pipe & Fittings	Calgary, AB
Con-Cur West Marketing Inc.	Booster Water System	Port Coquitlam, BC
Continental Conveyor & Equipment Co	High Angle Conveyors	Winfield, AB, USA
Corporate Express Canada Inc.	Office & Industrial Furniture	Edmonton, AB

Major Supplier	Supply	Location
Corrigan Canada Ltd.	Baggage X-ray Scanners & Security Metal Detectors	Georgetown, ON
Cutler Hammer	Unit Substations	Richmond, BC
Cyclonaire Corp	Pneumatic Conveyors	York, NE, USA
Daam Galvanizing Inc.	Steel Galvanizing	Edmonton, AB
Degrémont Infilco Ltée	Clarifier / Filter Package	Baie d'Urfe, QC
Delpro Industrial Sales Inc.	Valves	Langley, BC
Diversified Construction Co	Hand Sort Glove Boxes	Yellowknife, NT
DMS Powders	Ferrosilicon	Meyerton, South Africa
Drexel Western Ltd.	Pressure Gauges	Burnaby, BC
Driltech (A Sandvik Company)/	Rotary Drills	Alachua, FL
KCL West Holdings Transwest Mining Systems Division		Edmonton, AB
Eecol Electric Inc.	Cable, Conduit & Electrical	Surrey, BC
Endress+Hauser Canada Ltd.	Magnetic Flow Meters	Edmonton, AB
EnviroTest Laboratories	Water & Aquatic Analysis	Edmonton, AB
Eriez of Canada Ltd.	Vibrating Feeders, Tramp Metal Vibrating Feeders, Diamond Sorting Feeders	Mississauga, ON
Eskimo Steel Ltd.	Fabricated Platework	Edmonton, AB
Evans Consoles Inc.	Control System Furniture	Calgary, AB
F. Drexel Western Ltd.	Pressure Switches	Burnaby, BC
Fabricated Plastics Ltd.	Neutralization Sumps & Lime Make-up Tanks	Maple, ON
FFE Minerals	Degrit Cyclone Assembly & Rotary Scrubber	Vancouver, BC

Major Supplier	Supply	Location
Finning Canada Ltd.	Diesel Generator Sets & Controls, Switchgear	Yellowknife, NT
Fisher Scientific	Laboratory Equipment	Ottawa, ON
Fountain Tire	Tire Management	Kamloops, BC
Fynsort Technology Ltd.	X-ray Sorters	Northbridge, Australia
Gisbirne Industrial Const'n Ltd.	Watermist Fire Protection System	Burnaby, BC
GIW Industries Inc.	Pumps	Calgary, AB
Glenridge Equipment Corp	Vertical Lift Fabric Doors	Waterloo, ON
Guillevin International Inc.	Relief Valves	Burnaby, BC
Harrison R Cooper Systems Inc.	Slurry Sampler	Bountiful, UT, USA
Hitachi Construction Machinery Co. Ltd./	Excavators	Bunkyo-ky, Tokyo, Japan
Wajax Industries Ltd.		Edmonton, AB
Imperial Oil	Bulk Diesel Fuel	Hay River, NT
Industrial Equipment Co	Belt Feeder	Delta, BC
Ingersoll Rand Canada Inc.	High Pressure Air Compressors	Delta, BC
Inproheat Industries Ltd.	Incinerators	Vancouver, BC
International Process Systems Inc.	Wet Magnetic Separators	Golden, CO, USA
ITT Flygt, Division of ITT Industries	Submersible Pond Water Pumps & Pit Dewatering Pumps	Surrey, BC
ITT Industries	Centrifugal Solution Pumps	Surrey, BC
John Sherman Agencies Ltd.	Thermal Anemometer	Vancouver, BC
KAL Tires	Tire Supply	Edmonton, AB
Kinecor Inc.	Pumps	Yellowknife, NT
King Manufacturing	Shop Fab Tanks (AWWA) & (API)	Hay River, NT

Major Supplier	Supply	Location
Kone Inc.	Electric Traction & Hydraulic Passenger Elevators	Edmonton, AB
Komatsu Mining Systems Inc./	Haul Trucks & Other Equipment	Vernon Hills, IL, USA
KCL West Holdings Coneco Equipment Division/		Edmonton, AB
KCL West Holdings Transwest Mining Systems Division		Edmonton, AB
Konecranes Canada Inc.	Overhead Cranes	Lachine, QC
Kraft Industrial Supplies Ltd.	Valves	North Vancouver, BC
Krupp PolysiusCorp	High Pressure Roll Crusher	Atlanta, GA, USA
LeTourneau Inc./	Wheel Loader	Longview, TX
Wajax Industries Ltd.		Edmonton, AB
Levitt Fire Protection Systems	Clean Agent Fire Extinguishing	Edmonton, AB
Lochhead Haggerty Eng & Mfg Co	Audit Plant Module	Delta, BC
Lockerbie & Hole Contracting Ltd.	Fuel Handling Module	Edmonton, AB
Lorax	Diffuse Samplers	Vancouver, BC
Magnetrol c/o Wescan Systems	Flow Switches	Coquitlam, BC
Marsulex Inc.	Dry Alum	Fort Saskatchewan, AB
Megatech Engineering Ltd.	Screw Feeder	Surrey, BC
Meridian Specialties Inc.	Check Valves	Richmond, BC
MetOcean	Turbidity Buoys	Halifax, NS
Metrovan Hotsy Equipment Ltd.	Hot Water Cleaners	Surrey, BC
Metso Minerals (Nordberg Machinery Ltd.)	Jaw & Cone Crushers	Milwaukee, WI, USA
Micropul Canada Inc.	Dust Collectors & Scrubbers	Mississauga, ON
Miller Instruments Ltd.	Testing Equipment	Burnaby, BC
MMD Mineral Sizing Inc.	Primary Sizer	Fort McMurray, AB

Major Supplier	Supply	Location
M-Squared Instruments	Ground Temperature Cables	Cochrane, AB
Multotec Process Equipment	Cyclones	Kempton Park, South Africa
National Process Equipment	Sewage Lift Pump Stations & Treated Water Tank Feed Pumps	Coquitlam, BC
Nedco, Division of Westburn Inc.	Alarm/Warning Switches, UPS System	Richmond, BC
Norpac Controls Ltd.	DCS Computer Equipment, Control System Hardware & Control Valves	Burnaby, BC
Northern Transportation Company Ltd.	Temporary Fuel Storage Tanks	Hay River, NT
Northern Steel Ltd.	Fabricated Platework	Prince George, BC
Nu-Tech Systems Ltd.	Exhaust Stacks & Ventilation Fans	Richmond, BC
Ohmart-Vega c/o BG Controls	Ultrasonic Level Transmitters	Port Coquitlam, BC
Olympic International Agencies Ltd.	Electric Pressurization Units	North Vancouver, BC
Outokumpu Technology Inc.	Magnetic Separator	Jacksonville, FL, USA
Parkson Corp	Process Water Filter	Dorval, QC
Peacock Inc.	Pumps & Strainer	LaSalle, QC
Peacock Instrumentation	Level Gauges	Coquitlam, BC
Pebco Inc.	Clamshell Gates	Paducah, KY, USA
Petro Canada Lubricants	Construction Lubricants	Camrose, AB
Pillar Fabricators	Supports for Heating Lines	Calgary, AB
Pinnacle Automation	Configuration Services	Lehi, UT, USA
Pronghorn Instrumentation Ltd.	Level Switches	Calgary, AB

Major Supplier	Supply	Location
Proquip Inc.	Agitators	Macedonia, OH, USA
Quantum Supply Ltd.	Balancing Valves	North Vancouver, BC
Reitech SA	Roller Gap Sizer	Cape Town, South Africa
RNG Controls & Instrumentation	Totalizing Flow Meters	Burnaby, BC
Ronan Eng Ltd. c/o Wescan Systems	Nuclear Instruments	Toronto, ON
Ronan Engineering Ltd.	Nuclear Weigh Scales	Toronto, ON
Ron's Auto Service & Equipment Ltd.	Sundry Equipment	Yellowknife, NT
Saft Nife Corporation	Battery Charging System	Calgary, AB
Sanitherm Engineering Ltd.	Sewage Treatment Equipment	North Vancouver, BC
Schneider Electric	Transformers	Richmond, BC
Scott Pump Service Ltd.	Cardlock System	Edmonton, AB
Screen Services	Sieve Bends	St. Albert, AB
Sepor Inc.	Laboratory Equipment	Wilmington, CA, USA
Southwell Controls Ltd.	Conductivity Level Switches	North Vancouver, BC
Strongco Engineering Systems Inc.	Belt Conveyors & Feeders	Calgary, AB
Svedala Industries Canada Inc.	Pumps	Mississauga, ON
TD Micronic Inc.	Float Level Switches	Surrey, BC
Teco-Westinghouse Motors (Canada) Inc.	Induction Motors	Richmond, BC
Tema Systems Inc.	Vibrating Banana Screens	Cincinnati, OH, USA
The Fairfield Engineering Co	DMS Concentrate Conveyor	Marion, OH, USA
Thermo Ramsey c/o BG Controls	Load Cell Weighing System	Port Coquitlam, BC
Thomas Skinner & Sons Ltd.	Workshop Equipment	Richmond, BC

Major Supplier	Supply	Location
Timeco-Marten Co Ltd.	Hydraulic Pumps	Edmonton, AB
Tli Cho Landtran	Bulk Diesel Fuel	Yellowknife, NT
Tracer Field Services Canada Ltd.	Electrical Heat Tracing	Calgary, AB
Trane British Columbia	Hot Water Unit Heaters, Air Handling Units, Building Management System	Burnaby, BC
USF Canada	Potable Water Treatment Equipment	Burnaby, BC
UV&IR Engineering (PTY) Ltd.	Concentrate Dryers/Coolers	Amalgam, South Africa
Van Waters & Rogers Ltd.	Heat Transfer Fluid	Edmonton, AB
Vancouver Teleport Ltd..	LAN/WAN & Communications Hardware	Langley, BC
Vanko Analytics Ltd.	Gas Detectors	Edmonton, AB
Vibramech (PTY) Ltd.	Horizontal Vibrating Screens & Vibrating Grizzly & Tube Feeders	Chamdor, South Africa
Wajax Process Technologies	Pumps	Delta, BC
Weir Pumps Canada	Pumps	Coquitlam, BC
Wescan Systems	Pressure Regulators & Rotometers	Coquitlam, BC
Wesco Distribution Canada Inc.	Transformers & Motor Control Centres	Edmonton, AB
Westburne Electric Supply (AB)	Leak Detection Devices	Edmonton, AB
Westcomm Pump & Equipment Ltd.	Pumps	Calgary, AB
Westech Engineering Inc.	Magnetic Separators	Salt Lake City, UT, USA
Westminster Boiler & Tank	Glycol Expansion Tanks	Burnaby, BC