Associated Engineering

Burnaby Lake Rejuvenation Project

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Burnaby Lake “Brought Back to Life”

Through an innovative and technologically ground breaking engineering design and process, Burnaby Lake was restored in an environmentally sustainable manner back to it status as a significant ecological resource and public facility in the region.

“ One of the most technically and environmentally challenging projects undertaken by the City of Burnaby. ”

Lambert Chu, P.Eng., Director Engineering, City of Burnaby

Burnaby Lake Rejuvenation Project

Associated Engineering led and completed a complex and innovative process to sustainably restore the pristine environment of Burnaby Lake, which had deteriorated after 30 years of natural infilling and sedimentation. The team overcame a series of projected and unplanned environmental challenges and developed original technological processes which helped to protect endangered species, and meet the strict criteria for dredging, dewatering, and reusing sediments as fill, and treating and recycling water back to the lake, all of which has advanced the field of environmental engineering. The Burnaby Lake Rejuvenation project has restored the lake's valuable ecosystem for fish, wildlife, and the community.

Project Background

Over the past thirty years, natural sedimentation, and development and construction activities in the 7,300 hectare Brunette River watershed, in which Burnaby Lake resides, resulted in the steady accumulation of heavy layers of contaminated sediments on the bottom of Burnaby Lake. This led to the gradual disappearance of the lake's precious, open water characteristics. The lake experienced accelerated degradation of its aquatic quality.

In 1997, the City of Burnaby began an early evaluation of rejuvenation options, followed by subsequent assessments and requests for government funding.

Then in 2009, with the approval of $20 million in funding, supplied jointly by the City of Burnaby and the Province of British Columbia, the City launched this significant project to restore Burnaby Lake.

Complexities and Challenges

The seasonal environmental window, the restricted regulatory conditions, and the cost efficiency of the operations all combined to demand a high level of dedication, collaboration, and innovation from the project team.

The team overcame the complexities and challenges of this project by effectively collaborating with stakeholders, addressing legal requirements, assimilating background studies, and coordinating with engineers, biologists, geophysicists, treatment specialists, and hydrographic surveyors. Those involved had to develop a treatment process to allow reuse of dewatered sediment, protect water quality, and allow safe return of treated effluent to the lake. The consultants also had to fulfill the requirements of fish and wildlife management, mitigate and protect migrating/juvenile salmonids, salvage and relocate fish, and shield bird breeding and foraging habitats.

Developing a Sustainable Solution

Several original approaches were developed to overcome the technological and environmental challenges. Notably, several advanced procedures and engineering methodologies created specifically for this project had never been previously implemented together on this type of project.

These included manufacturing a tailor-made train of technologies to dredge, transport, and process polluted and contaminated lake sediments. The team developed and deployed a unique application of a double turbidity barrier for dredging operations to protect both the quality of the lake's water and to isolate sensitive aquatic species. The group

Burnaby Lake Rejuvenation Project

developed a new wildlife detection program using Ground Penetrating Radar (GPR) and high resolution sonar camera technology to locate and protect endangered species prior to commencing dredging operations. They employed an advanced treatment technology that allowed treated wastewater effluent to be discharged back into the lake. The process included shaker screens, inline grinders, equalization/mixing tanks, centrifuges, centrate tank clarifiers, sand filters, flow return pumps, and a return pipeline. Lastly, lake sediments were recycled to use as the subgrade of a future sports field located nearby.

Resulting Restoration

The Burnaby Lake Rejuvenation Project provided immediate and long-term environmental benefits. The project reversed the effects of sediment infilling, increased the area of deeper open water, removed contaminated sediments for fish and wildlife protection, improved water quality conditions for salmonids, and improved the lake tributary for fish migration.

As a result of this project, 945,000 cubic metres of lake dredgeate and garbage were cleaned and processed, comprising contaminated sediments, automobile tires and parts, wire cables, metal poles, used beverage containers (cans, plastic bottles) and other plastic and paper waste.

By constructing an on-site, electrical substation at the treatment plant for power, instead of using diesel generators, the team effectively reduced the total carbon emissions released during the course of the project.

Social & Environmental Benefits

A number of social and economic benefits resulted from this project. Burnaby Lake Park has been revitalized as an attractive natural environment, and transformed into a destination spot popular with Burnaby's families, and sports and wildlife enthusiasts.

As well, reusing the lake sediments for the sports field sub-grade provided excellent fill and saved tens of thousands of dollars in material and trucking costs for the City.

Finally, the lake has been re-established as a world-class rowing venue and facility, with the Burnaby Lake Rowing Club once again considered a top training facility in North America.

Satisfied Client

"I am very proud of this project and its outcomes," says Derek Corrigan, Mayor of the City of Burnaby. "Its successful completion required innovation and perseverance to overcome unique technological and environmental challenges."

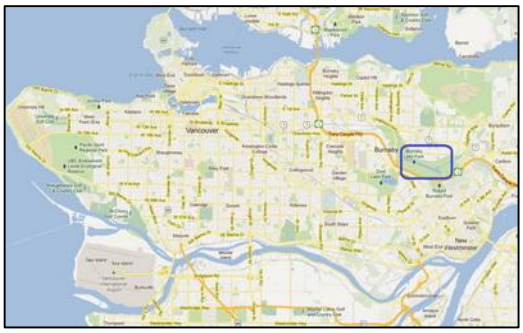
The project was completed within the original 24 month schedule. Work was also completed outside of the original scope, from which the engineering community gained new insights and knowledge.

"The City is pleased with the outcome of the project and appreciates the excellent effort of Associated Engineering and the project team in overcoming the significant challenges this project presented," says Lambert Chu, Director of Engineering for the City of Burnaby.

These innovations and integrated watershed management tools have made the Burnaby Lake Rejuvenation Project a truly remarkable achievement for the City of Burnaby. Restoring Burnaby Lake will benefit the environment, citizens, naturalists, and rowers for many years to come.

The Early Beginnings & Future Vision

Formed by an ancient glacier over 12,000 years ago, Burnaby Lake is a 300-hectare natural environment situated in the heart of the Vancouver bedroom community of Burnaby, BC. The surrounding ecosystem serves as the home to over 400 varieties of plants and wildlife, 16 of which are rare and endangered species. In addition, Burnaby Lake annually hosts over 300,000 recreational park users, and is a popular destination for hiking, birdwatching, and water-based boating activities.



Over the past thirty years, the gradual infilling of Burnaby Lake caused by natural sedimentation and various developmental and construction activities, dramatically altered the environment for waterfowl and other aquatic animals and negatively affected the entire ecosystem. The gradual disappearance of the lake's precious open water characteristics and accelerated degradation of its aquatic quality was endangering the future sustainability of the lake's valuable ecosystem.

A rowing venue was initially created on Burnaby Lake in the early 1970s. Over the next twenty years, the lake was used for watercraft activities and even supported the 1973 Canada Summer Games. In its heyday, the lake hosted major rowing and kayaking competitions and was recognized as one of the best venues on the North American circuit, as it was the only course that met international standards. Notable Olympic rowing and kayaking medallists such as Tricia Smith, Kathleen Heddle, and Renn Crichlow, all previously trained here.

The lake soon became too shallow for competitive rowing events. While it continued to serve as a rowing venue until the later part of the 1980s, the disappearance of the open water severely impacted the manner in which the lake was able to support the birds, fish and wildlife in the habitat.

Since then, the City of Burnaby committed to preserving Burnaby Lake for its environmental value. The City adopted an integrated watershed management approach to improve the management of stormwater runoff to reduce urban erosion and sedimentation into the storm runoff and urban pollutants in the water.

From the mid-1990s, the City initiated studies to investigate engineering solutions to reverse the lake infilling process in an environmentally-friendly manner. These studies and a small scale pilot dredging project in 1999 became the foundation of the Burnaby Lake rejuvenation project. The project was subsequently approved under a joint provincial and federal Environmental Assessment process in 2001.

The City's overall vision for Burnaby Lake was to protect and preserve the lake and its surrounding environment as a natural

Burnaby Lake Before the Start of Dredging

gathering place in the region for all of its citizens to enjoy.

"Burnaby Lake has a rich history of rowing competitions. This work will bring the lake back to the standard required for international rowing and kayaking competitions, as well as improve the lake's habitat for fish and wildlife and restore its stormwater management function."

Gordon Campbell, Premier of British Columbia, announcing funding commitment in June 2008

Several key objectives for the rejuvenation plan were identified:

Project Planning & Customized Engineering Solution Design

The City of Burnaby retained Associated Engineering to lead the team of consultants to develop an engineering design and complete a comprehensive environmental management plan.

Following this, the combined team undertook work on three main areas of the rejuvenation component of the total project:

1. Dredging, processing the sediment, and treating the water
2. Managing and monitoring the environment
3. Managing the residuals

The scope of the project included the removal of over 200,000 cubic metres of lake bed sediments, to restore the open water environment and remove invasive vegetation.

Initial water and sediment sampling conducted in the area scientifically affirmed the early suspicions concerning the poor aquatic quality and the risks to the future sustainability of the environment to serve as the grounds for the diverse natural inhabitants of Burnaby Lake.

To counter the effects of years of infilling by contaminated sediments from the lake's urban watershed, the engineering team designed a train of advanced engineering technologies to support sustainable dredging of the lake.

The engineered process train involved a complex process as follows:

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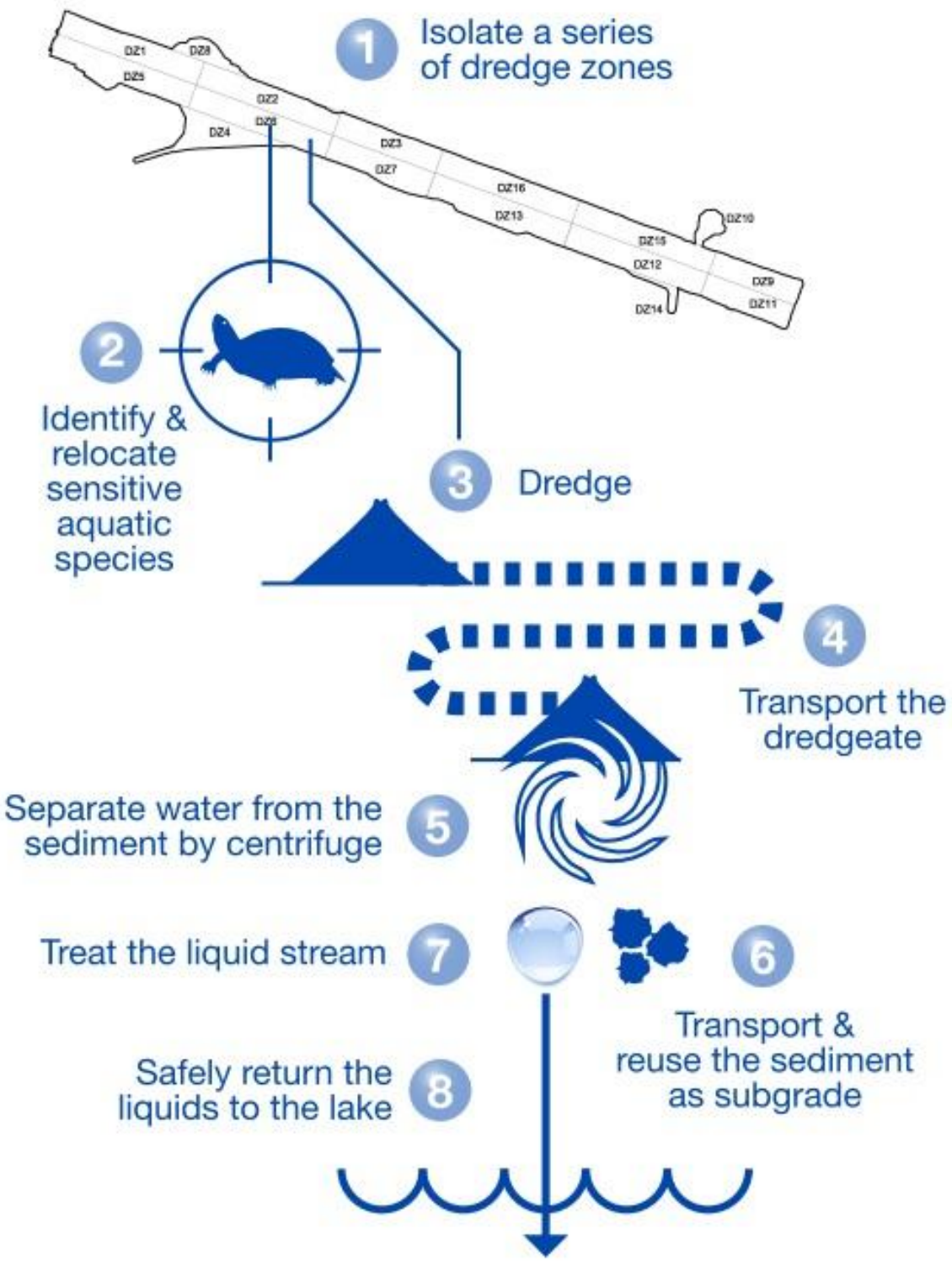
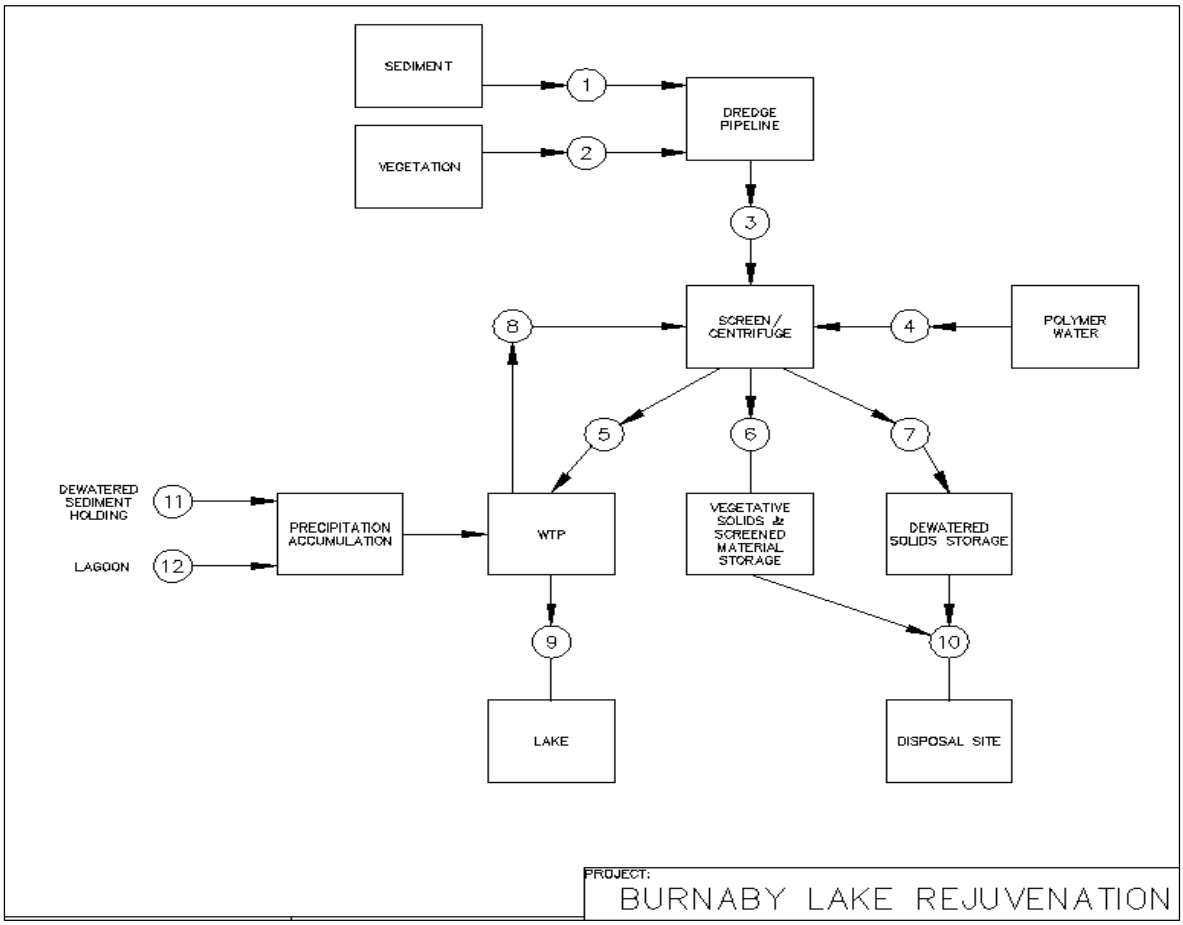


	Total Volume/Tonnes	Daily Volume/Tonnes (avg)	% Dry Solids	Comments
1	600,000 m3	3000 m3	6%	Based on 200,000 m3 in situ @ 18% solids
2	33,000 m3	150 m3	~	
3	633,000 m3	3150 m3	3 - 5%	Solids Content to vary between 2 - 15%
4	43500 m3	200 m3	0	Polymer Water 21.7 m3 / hr
5	640,000 m3	3,200 m3	150ppm	
6	2,000 Tonnes	10 Tonnes	1%	Screened material
7	140,600 Tonnes	650 Tonnes	30%	Solids Content +- 2.5%
8	4,340 m3	20 m3	2%	
9	640,000 m3	2,700 m3	<15ppm	
10	142,600 Tonnes	660 Tonnes	30%	
				Total Solids Estimate
				200,000m3 @ 1.17g/cm3 Density & 18%
				solids by weight = 42,120 BDT



Mass Balance Diagram

Multi-stage Dredging Operations

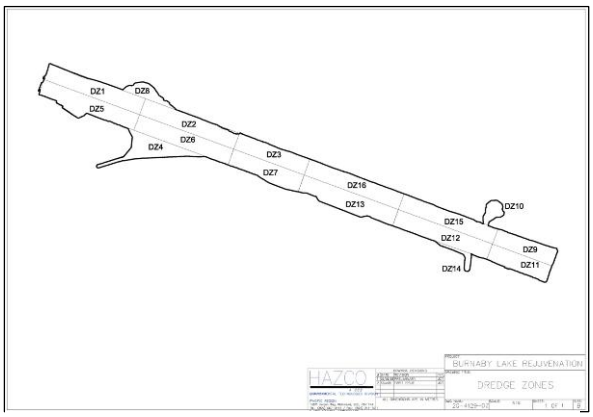
The overall challenge for Associated Engineering and its partners in this project was to develop an effective system to dredge Burnaby Lake and limiting impact to the environment.

Over the years, previous explorations of the lake, including a pilot dredging study, have been conducted. This work formed the process deisgn for the full scope project. Given the specific conditions of this location, the team suggested a hydraulic suction dredge with a cutter head auger to handle the removal of the vast quantities of aquatic vegetation. Additionally, the proejct team gave significant consideration to the need to protect the sensitive aquatic life, such as fish and turtles, during the actual dredging process.

Hydraulic Suction Dredge Cutting Through Shallow Water & Heavy Vegetation

Isolating a Series of Dredge Zones

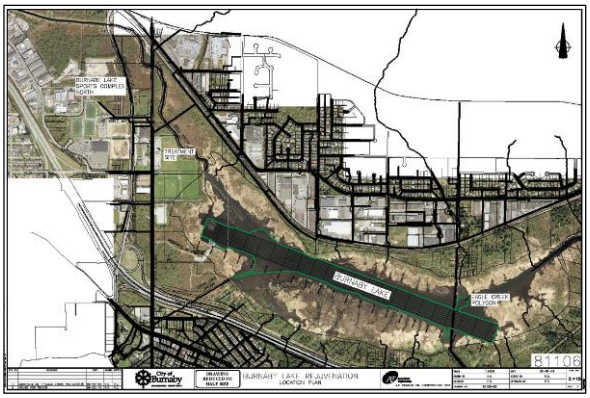
Engineers developed a customized approach, which divided the lake into 16 separate dredge zones, with each zone isolated by a double turbidity barrier.



Map of Dredge Zones

These barriers performed three major functions:

1. Aided in the capture and relocation of sensitive species prior to the dredging
2. Contained the turbidity caused by dredging
3. Enabled effective post-dredge monitoring of the lake water quality



Location Plan

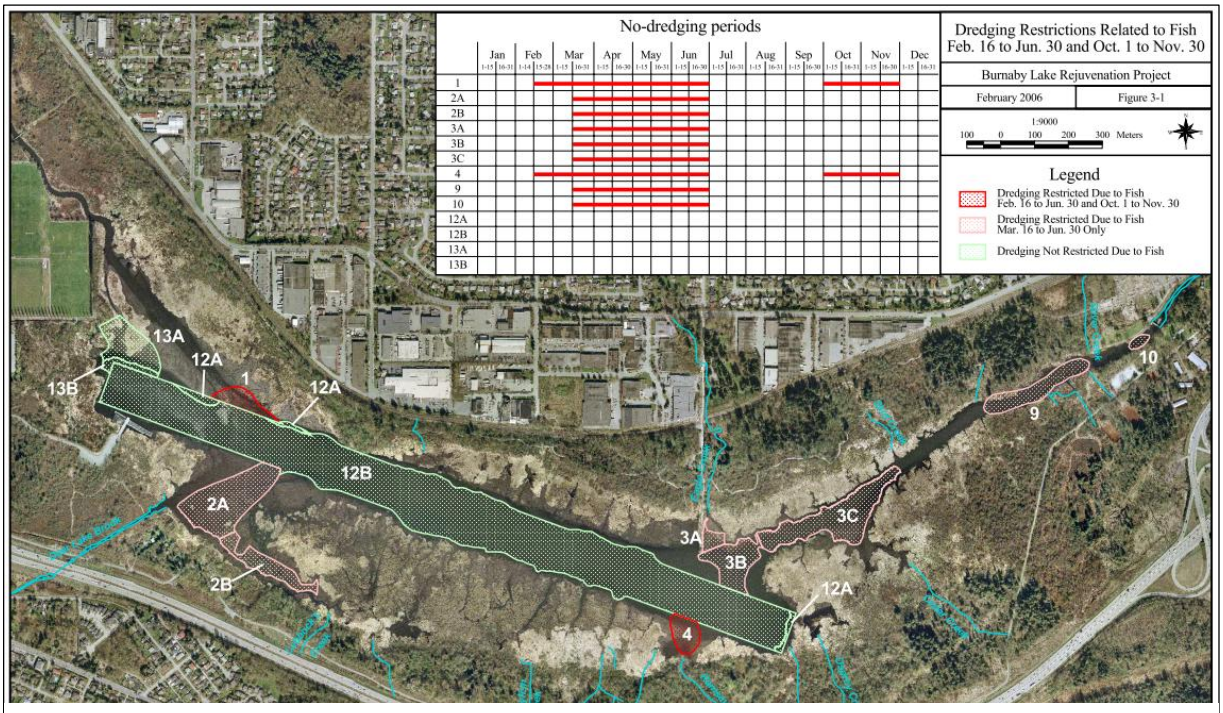
Staging of Turbidity Barriers

Minimizing Environmental Impact:

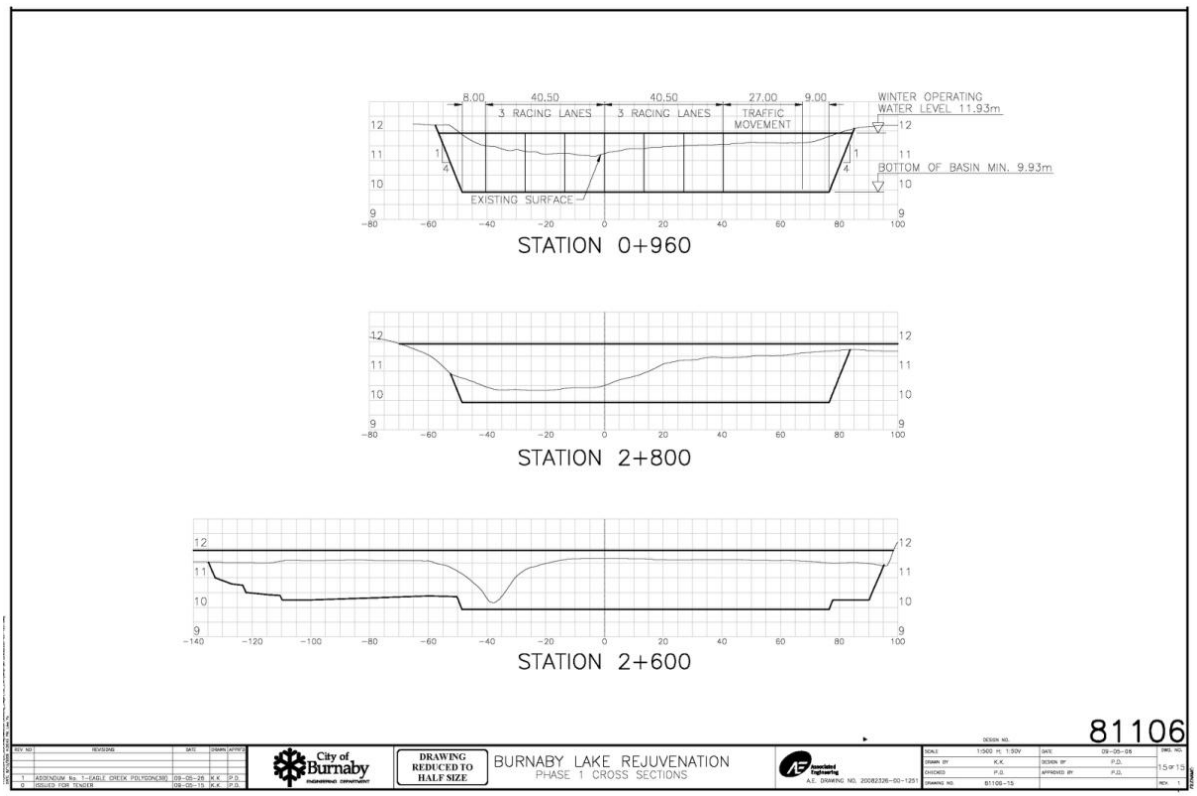
Furthermore, the monitoring of the sediments and the filtered water ensured environmental compliance before its release back into the environment.

Up to three zones were set up at any one time, to facilitate fish/wildlife capture, dredging, and post-dredging monitoring of completed work.

Also, the creation of these 16 zones protected the existing migratory routes for spawning salmonid species and allowed for continued access to the lake for recreational uses, while the dredging was taking place (in most cases at a depth of 2 to 3 metres).



Scheduling of Dredging and No-Dredging Periods (Fish Habitats)



Cross Section View of a Dredging Area

Identifying & Relocating Aquatic Species

The Western Painted Turtle garnered the greatest attention during this phase of the project, a locally red-listed species believed to be wintering in the bottom of the lake.

Divers Engaged in Underwater Recovery

The BC Ministry of Environment dictated the importance of this species, decreeing that they would not permit any dredging during the winter season, without confirmed certainty that the turtle population would not be in harm's way.

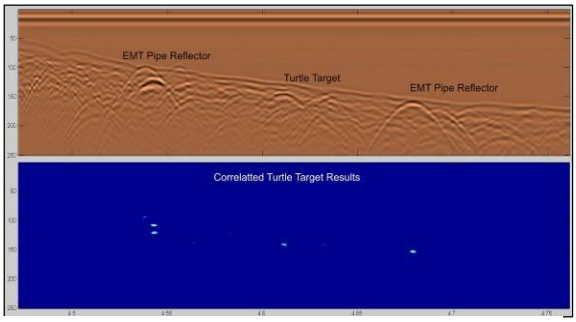
Western Painted Turtle

To satisfy the regulatory requirements, the project team researched, examined, conducted proof of concept testing,

validated, and implemented an innovative approach to detect the Western Painted Turtles in the lake sediments. The system was developed and tested, and then validated with a 90% level of accuracy, before being implemented in the winter of 2010.

GPR Equipment Encased in a Floating Platform

The approach involved the use of a high resolution sonar camera and a Ground Penetrating Radar (GPR) unit. The use of the sonar camera gave near-video quality images for inspection and identification of objects located underwater. The camera provided images of objects in range from one metre to over thirty metres within the water column.

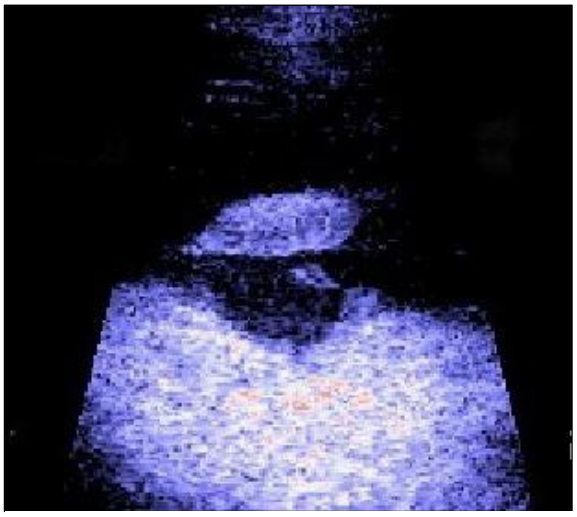


GPR Trace Showing the Location of a Turtle Target

The GPR unit could detect objects up to half a metre below the lake bed that had a similar size, shape, and profile of a turtle.

The GPR technology used pulses of electromagnetic energy transmitted into the water and the ground over a very short period of time. The echoes or reflections detected by the GPR equipment were recorded and interpreted by a professional geophysicist, for object identification.

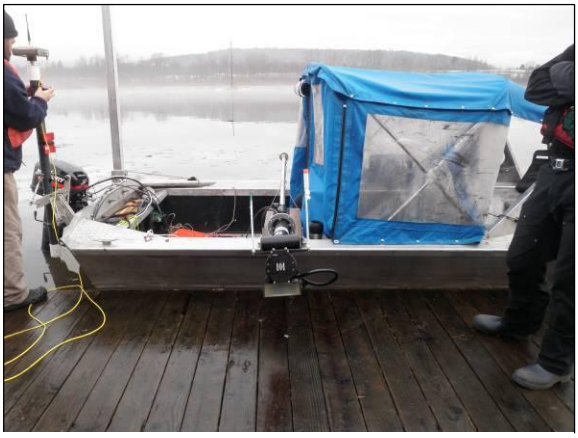
As a result of this innovative method, not a single endangered turtle was harmed during the course of dredging the lake.



Video Image of a Detected Turtle

In addition to the GPR turtle detection method, a turtle telemetry program was put in place to monitor the general behavior and migration pattern of the turtles.

A total of 45 Western Painted Turtles were tagged for the telemetry program and monitored during a 20 month period.



Sonar Camera Mounted on the Survey Boat

Based on the results of the telemetry program and the GPR program, the team proved, based on this definitive fact-based scientific investigation that the turtle population does not hibernate in Burnaby Lake and, in fact, remains active during the winter months.

Transporting the Dredgeate

Dredging in a Double Curtain Cell

Effectively managing the dredgeate, which was comprised of both contaminated sediments and water, was the next step in the overall process.

Lake Pipeline in Use

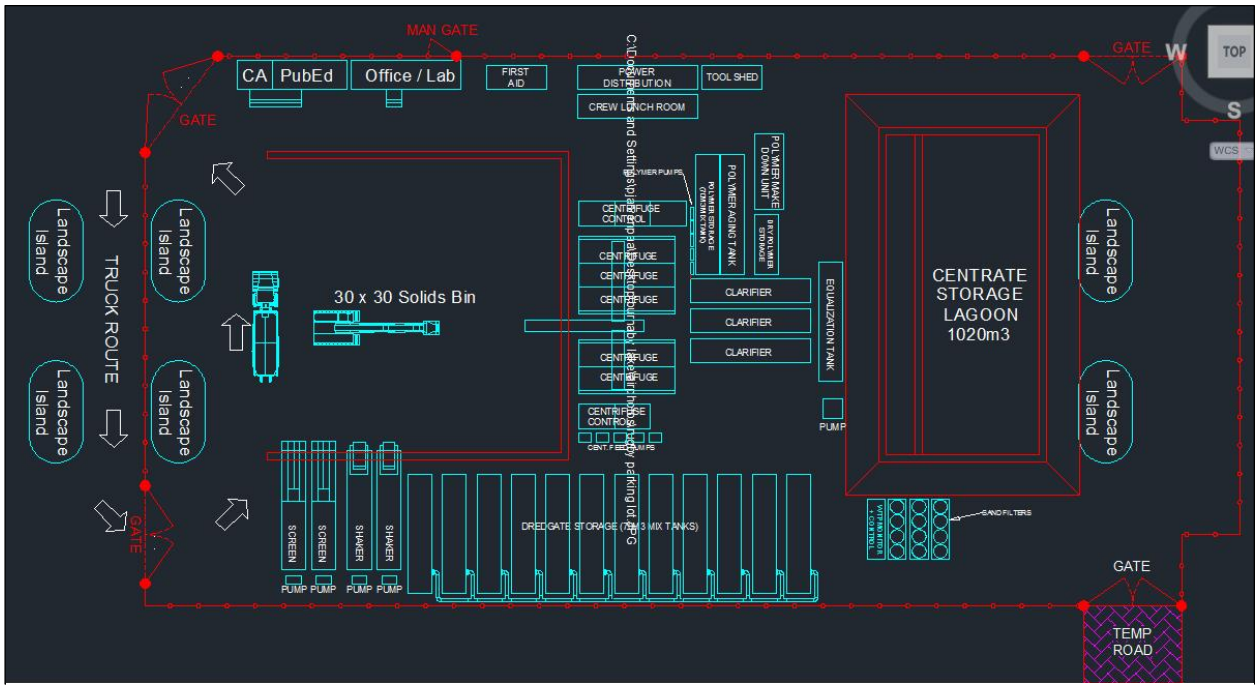
By using the suction dredge, lake and land-based booster pumps, and a flexible pipeline, the dredgeate was efficiently moved five kilometres away to the processing plant stationed in the parking lot in the western end of the lake.

Land-based Booster Pump

Using an electrical subtation for power, in lieu of a collection of diesel generators (typically used on such a project), the project team was able to protect the quality of the air, reduced the amount of noise pollution, and thus generated a smaller carbon footprint.

Land Pipeline Transporting Dregeate to the Upland Treatment Plant

Water Treatment Plant Set Up in Parking Lot



Processing Area Site Plan

Equilization Tanks at the Treatment Plant

A dredging and dewatering logistics plan was developed for each dredge zone. Each dredge zone was routinely examined with respect to fisheries, wildlife, and vegetation constraints.

Separating Water from the Sediments by Centrifuge

Overall, the plant processed on average 3,154 cubic metres of dredgeate per day, for a total volume of 945,000 cubic metres.

Centrifuges in Action

The key to managing the dredgeate was through a careful screening of organic matter and inorganic particles of varying sizes, grinding and centrifuging.

Clarifiers

Transporting & Reusing the Sediment

By adding an environmentally-safe, cationic polymer, the dewatering efficiency improved to produce a high quality dewatered sediment with a dry solids content of approximately 25%, which made it suitable for transporting and reusing.

Dewatered Sediment

The lake bed sediments, which contained cadmium, copper, and lead - attributed mainly to the historical use of the land and vehicle emissions - were tested to be acceptable for reuse as a subgrade material.

Trucks Loading and Hauling Away Sediment

The sediment was transported, spread and graded, and then contained under a protective buffer cap at a future sports field, located one kilometre from the treatment plant.

By using this material to bring the elevation of the site up to the future design level, another environmentally sustainable

benefit was attained by this project, not to mention the cost savings for the city achieved by using the solids portion of the dredgeate.

The recycling of the processed dry solids resulted in the sustainable reuse of over 15,700 truck loads (over 200,000 cubic metres) of dewatered sediments.

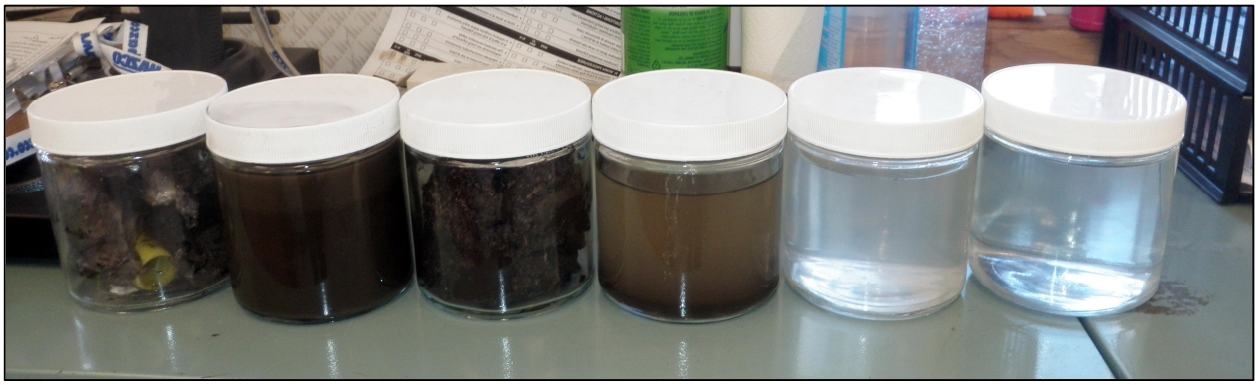
Spreading/Grading of Sediment as Subgrade

Treating the Liquid Stream & Safely Returning the Liquids to the Lake

On average, the water treament plant processed a daily average of 90 L/s. The centrate quality was also improved through

clarification to a level that allowed for its safe return to the active dredge zone in the lake for final stabilization.

The water treatment resulted in the fluid being transformed an aquatic standard with a total suspended solids level under 150 ppm that was deemed acceptable for release back into the lake.



Sample Testing (Filtered Decant, Clarified Centrate, Centrate, Dewatered Sediment, Dredgeate, Screened Debris)

Minimizing Environment Impact:

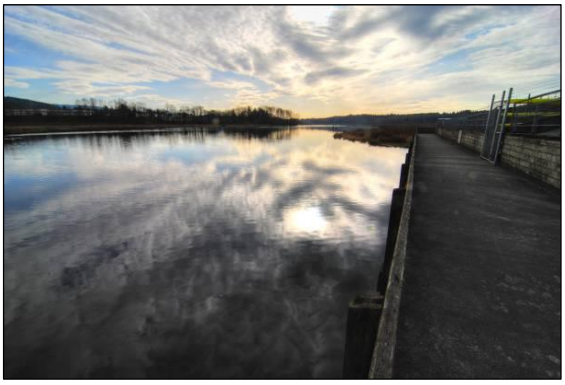
This output back into the lake also served as a sustainable end use for the treated liquid stream

Project Delivery

In the spring of 2011, the Burnaby Lake Rejuvenation project was successfully completed. 215,000 cubic metres of contaminated sediments from Burnaby Lake were removed, treated, processed, and re-used.

The success of this complex project was the result of effective collaboration between all involved parties, from project planning through to execution and follow up. With a focused approach, ground-breaking applications of engineering and science technologies with an emphasis on sustainability and environmental protection were undertaken to minimize impact on the natural surroundings.

The project team's design of an advanced, custom-built technology train achieved the City of Burnaby's objective to reverse the affects of decades of natural and man-made infilling of Burnaby Lake.



"This will help re-establish Burnaby Lake as one of the best world-class rowing facilities in North America. I want to thank all partners for working together to develop this facility that will be a legacy for current and future Canadian rowers."

Tricia Smith,
4-time Canadian Olympian
and Olympic medalist

Burnaby Lake has been revitalized, providing a healthier and cleaner environment, re-creating a deeper, open water environment that encourages oxygenation, and protecting fish and wildlife, including the endangered Western Painted Turtle.

The Burnaby Lake Rejuvenation Project has allowed nature lovers and rowers to return and use the natural environment at Burnaby Lake to its fullest potential.

Burnaby Mayor Derek Corrigan received a Green Champion Award from the Federation of Canadian Municipalities' Awards of Excellence on June 5, 2011. The Burnaby Lake Rejuvenation Project was cited as one of the projects under his direction, which demonstrated outstanding leadership and a commitment to implementing sustainable development initiatives within the community.

The City of Burnaby also received the 2011 APEGBC Environment Award for the Burnaby Lake Rejuvenation Project. The award recognized the project for outstanding contributions toward environmental protection, sustainable development and excellence in engineering and geoscience that involve new and unique applications of advanced technology.