

A yellow CAT excavator is the central focus, positioned on a dirt and gravel site. The excavator's arm is raised, and it appears to be in the middle of a task. In the background, there is a large body of water, possibly a reservoir or a lake, with a rocky shoreline. The sky is clear and blue. The overall scene suggests a large-scale engineering or construction project.

AECOM

CANADIAN CONSULTING
engineer

2019

**CANADIAN
CONSULTING
ENGINEERING
AWARDS**

**TUNDRA MINE
REMEDICATION**

1 Project Summary



Following abandonment of Tundra Mine, site ownership was transferred to the federal government. This remote, northern site was left with multiple environmental liabilities, including extensive waste rock and arsenic impacted tailing materials. AECOM was contracted by PSPC and CIRNAC to complete additional studies,

redraft the design drawings and specifications, and provide construction inspection and administrative services for the project. With the remediation completed, the liabilities are contained, and a clean water course has been re-established.



Geomembrane Installation over TCA

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Introduction

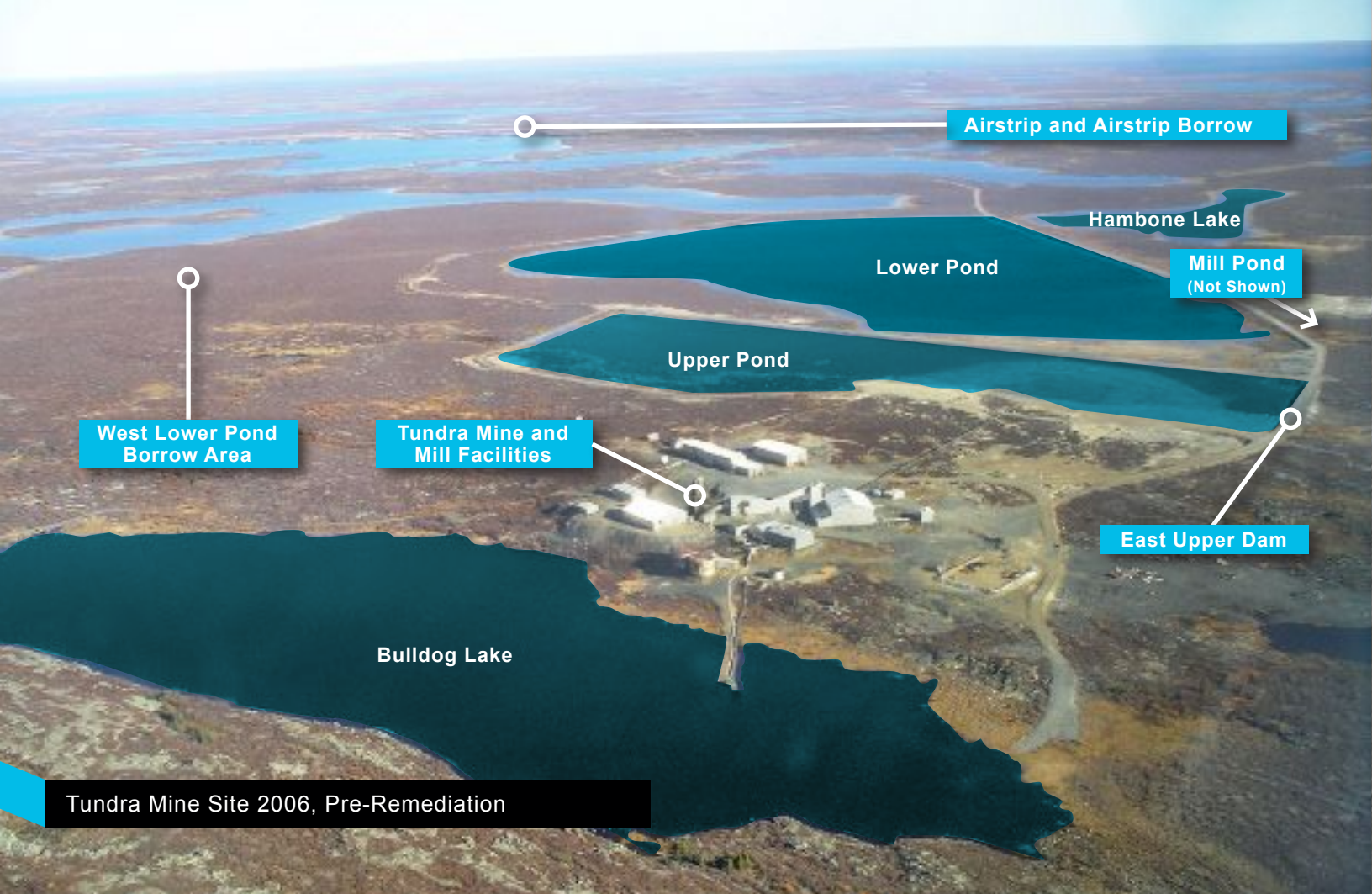


Tundra Mine was operated as an underground gold mine from 1964 until 1968, and supported operations at the nearby Salmita Mine from 1983 to 1987. During its lifetime, Tundra Mine produced some 3,250 kg - or 104,476 troy ounces - of gold and milled ~100,000 troy ounces from Salmita Mine. In 1987, mine operations ceased and the site was abandoned, and in 1999, the mine reverted to the Crown when the mine's owner went into receivership. Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), formerly Indigenous and Northern Affairs Canada (INAC), is currently the custodian of the site.

Tundra Mine is located approximately 240 kilometres (km) northeast of Yellowknife, NWT. The mine site is situated on the east side of Matthews Lake, which is located in the Lockhart River watershed that ultimately discharges into the east arm of Great Slave Lake. The site is remote and lies within the Akaitcho Territory, the Wek'eeshii and Monwhi Goga De Nittae areas of the Tliche Land Claim Agreement and North Slave Métis traditional lands. The site is only accessible by air and ice road, contributing to the challenges of completing a large scale earth works remediation program.

With custodianship of the site under CIRNAC, the guiding principles for remediation of Tundra Mine were consistent with other federal contaminated sites and included: taking immediate action for protection of human health; protecting the environment; meeting legal obligations and developing remediation solutions that were technically sound and fiscally responsible; and minimizing future obligations for maintenance where possible.

Prior to remediation of Tundra Mine there were a number of health, safety and environmental liabilities. The mine site contained tailings and contact water contaminated with a variety of substances, most notably arsenic. Mine operations had left multiple site hazards, including: mine openings, decrepit buildings containing hazardous materials, arsenic contaminated tailings and water within two tailings ponds, spilled tailings in other areas of the site, potentially acid-generating (PAG) waste rock, and petroleum hydrocarbon (PHC) contaminated soil. It was determined to split the remediation program into two phases: Phase I focused on the contaminated infrastructure demolition, closing of mine openings and off-site transport of hazardous materials; Phase II remediation focused on water treatment, re-establishing drainage between natural water bodies, site erosion control, and consolidating and containing the contaminated materials.



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Project Timeline



Phase 1 remediation took place between 2007 and 2008, prior to AECOM's contract with PSPC, and included the following:

- Sealing of all surface openings to the mine;
- Removal and disposal of all non-hazardous waste materials from buildings and equipment in the on-site landfill;
- Demolition of buildings and disposal of non-hazardous materials in the on-site landfill;
- Disposal of non-salvageable equipment in the on-site landfill;
- Disposal of asbestos and non-leachable lead-based paint on site;
- Disposal of mill sludge on site; and
- Transport and off-site disposal of leachable lead-based paint, reagents and hydrocarbon sludge.

AECOM's contract with PSPC started with Phase II remediation and focused on addressing the main environmental issues remaining at the site including:

- Extensive waste rock and arsenic impacted tailings materials
- PHC soils
- Contaminated water
- Erosion potential across the site

The project site was generally split between four main areas of activity:

- Former Mill Area which continued to serve as the equipment laydown and camp area throughout Phase 2 remediation.
- Tailings Containment Area (TCA) which originally included Upper Pond to the south and Lower Pond to the north. During remediation, tailings, PAG waste rock and debris were transported from Upper and Lower Ponds and consolidated in the central TCA, which was covered with a geomembrane and granular cover. Upper and Lower Pond were subsequently covered with erosion protection material and continue to serve as drainage and flow-through areas for clean surface water.
- West Lower Pond Borrow Area (WLPBA) which was used during Phase II remediation as a source of borrow material for the tailings cap and erosion control in other site areas. Stabilization of the WLPBA was a major work component of the Phase IIB contract.
- Airstrip Borrow which is located southeast of the site airstrip and was utilized as an additional source of granular borrow for the tailings cap and erosion control in other site areas.

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Project Highlights



4.1 Innovation

AECOM's design for the remediation project included containment and management of extensive waste rock and arsenic impacted tailings materials, petroleum hydrocarbon (PHC) soils, contaminated water, and erosion potential across the site.

The innovative application of engineering techniques was applied in many areas with the remediation design. For example, through remediation, over 1,400,000 cubic metres (m³) of contaminated water was successfully treated and discharged to clean water bodies. An on-site water treatment plant was built and operated by the contractor, with quality assurance provided by AECOM, which precipitated arsenic and other heavy metals out of solution by reacting with Ferric Sulphate, and lime to adjust pH. Polymers were injected in the treatment train to promote colloid aggregation, and the resultant precipitate flocs were separated by Geotubes®.

For the arsenic impacted tailings, the design included relocating tailings from two large areas and consolidating into one Tailings Containment Area (TCA). Waste rock and debris were also placed into the TCA. The cover design included a bituminous geomembrane (BGM) liner, cushion non-woven geotextiles, and granular covers for physical protection and erosion control. The consolidated TCA covered an area of approximately 250,000 m² which added complexity to the design and the shipping, handling and installation of the geosynthetic materials. Borrow material was produced on site for the TCA granular cover and for other areas on site.

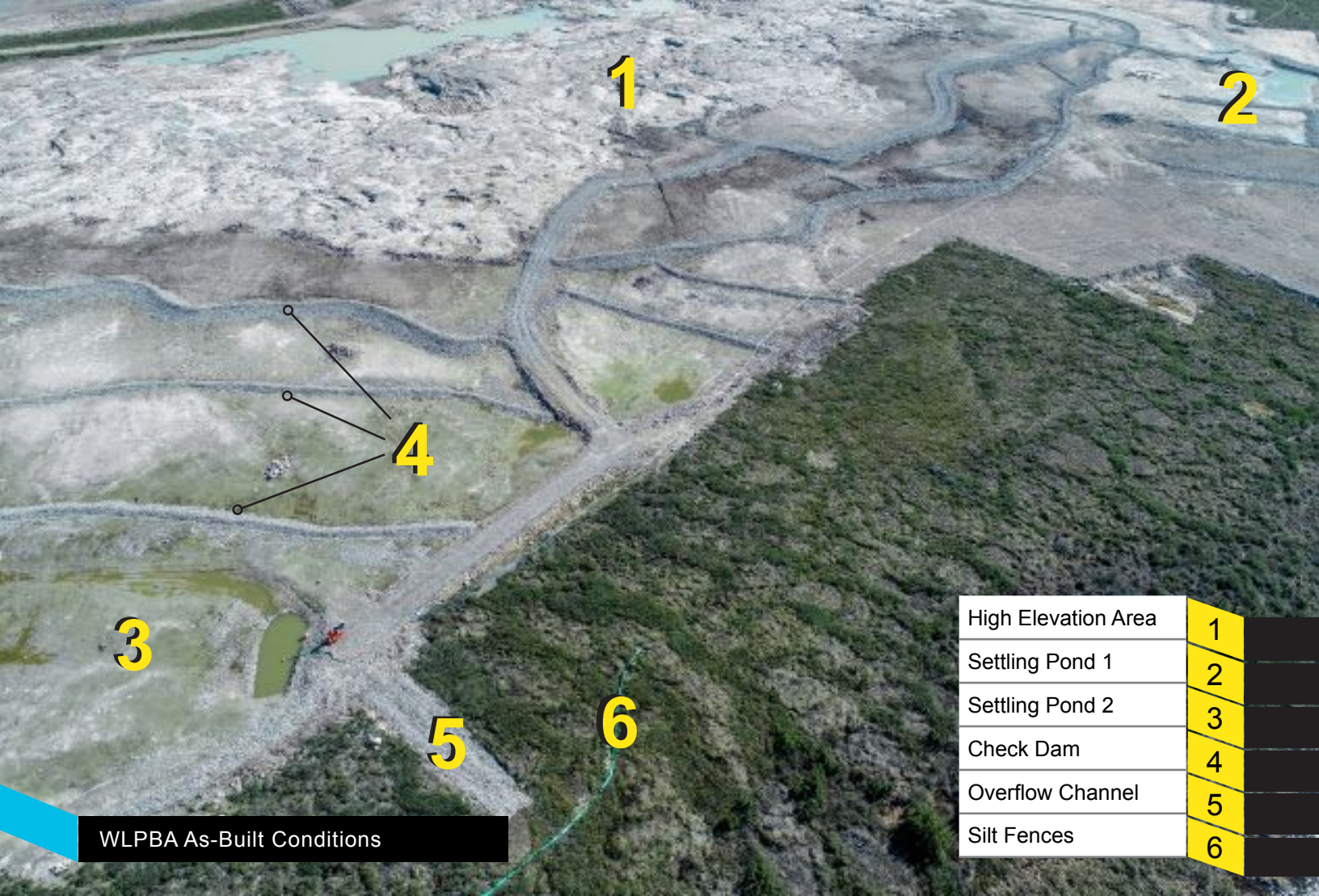
The Tundra Mine remediation project is distinguishable from other projects of its type due to the remote location of the site and the complexity of remediating a site with limited available borrow sources. For equipment, fuel and camp mobilization, access was only available via ice road during the winter season. Personnel, parts, and food were flown into site during the summer construction periods. For the TCA cover design, over 400,000

m³ of granular materials was produced from on-site borrow sources. This required borrowing in previously undisturbed areas, which then necessitated stabilization of the borrow areas. Through all phases of the design, multiple options for remediation were reviewed, with risk-analyses completed for each option.

4.2 Complexity

The unknown extents of tailings materials, PHC soils and buried debris presented significant challenges to the project. For example, around the perimeter of the TCA, the extent of buried tailings was very challenging to accurately delineate. Drilling programs uncovered tailings areas that were previously unknown, and the TCA cover design was revised between construction phases for more comprehensive coverage.

- In the Airstrip Quarry area, the remediation contractor uncovered buried debris during construction in a key borrow area that was previously unknown. The project team had to efficiently adapt to this issue which resulted in completing an electromagnetic survey to delineate the buried debris extents and construct a granular cover over the consolidated waste materials that were exposed.
- An unfavourable result of quarrying in the WLPBA was exposing highly silty borrow material, creating a situation likely to generate runoff with unacceptably high suspended sediments. AECOM and OKC completed a stabilization study and design which resulted in reshaping the borrow surface material to reduce the runoff velocity of surface water and constructing riprap check dams at regular intervals to promote sediment settlement, thereby mitigating the potential for erosion. AECOM worked closely with the remediation contractor during construction and in many areas directed where the check dams and regrading work should be completed.



High Elevation Area	1
Settling Pond 1	2
Settling Pond 2	3
Check Dam	4
Overflow Channel	5
Silt Fences	6

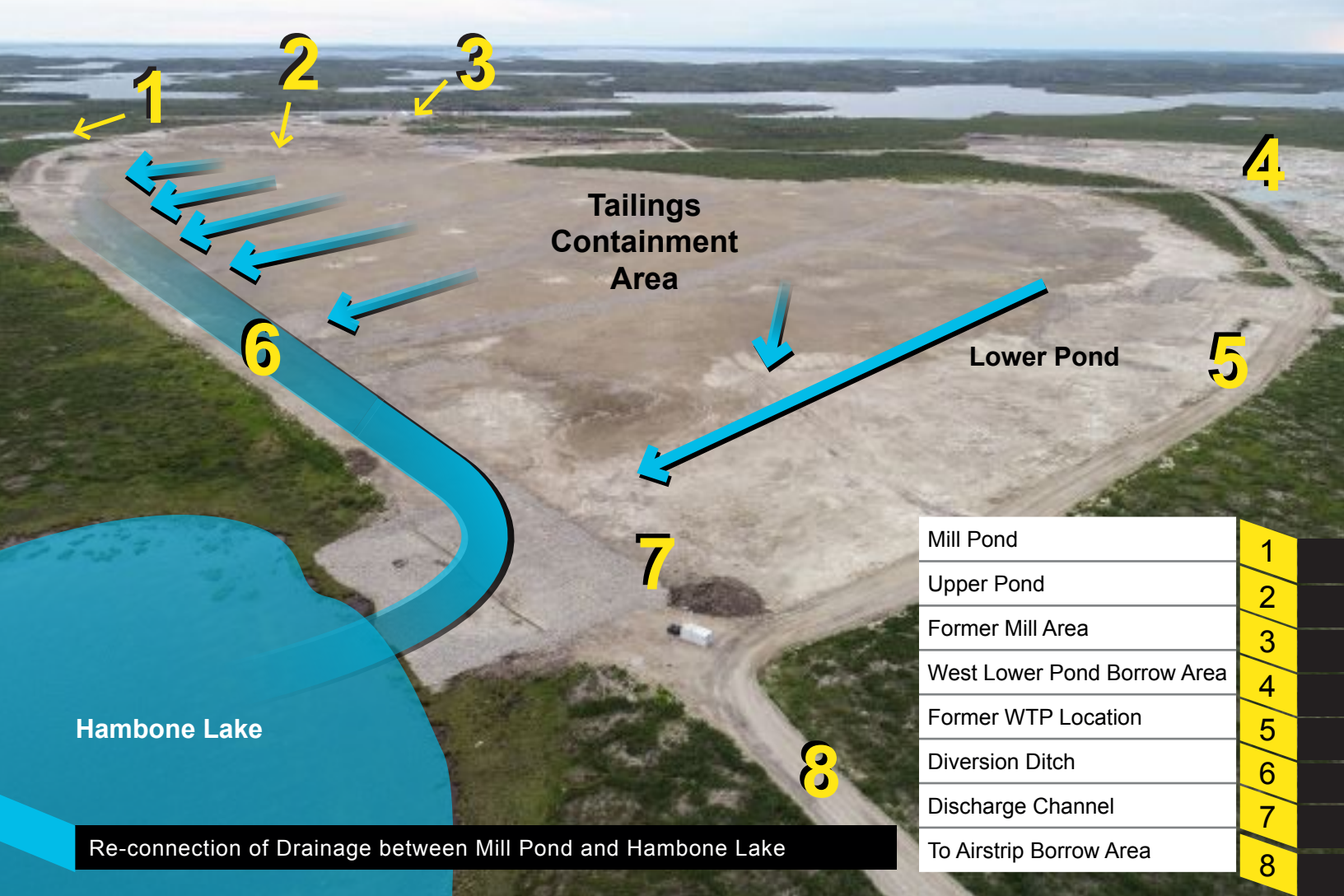
Another significant challenge with the project were the comparatively short construction seasons. AECOM worked with the remediation contractor to execute a variety of work activities over a 24-hour work schedule. Construction activities in the final year of remediation extended into late November, with limited daylight and extreme cold temperatures.

4.3 Social and/or Economic Benefits

When the Crown took over as custodian of the Tundra Mine site, the guiding principles for remediation of the site were to: take immediate action for protection of human health; protect the environment; meet legal obligations and develop remediation solutions that are technically sound and fiscally responsible; and minimize future obligations for maintenance where possible. With the project remediation complete, the guiding principles for remediation have been met, and the project will progress to the Adaptive Management Phase. This important phase of the project will confirm that the remediation works are performing in accordance with the design and to site-specific environmental conditions.

As part of the construction contract with the federal government, the remediation contractor was required to track the Aboriginal Opportunity Consideration (AOC) statistics, including the amount of labour, materials and direct fees that were subcontracted by Aboriginal persons and companies. The remediation contractor for the final phase of construction exceeded their AOC targets for labour and fee percentages.

A celebration was held in August 2018 to mark completion of the Tundra Mine remediation project. The Crown flew out about 20 representatives from the territorial government, Yellowknife Dene First Nation and the North Slave Metis Alliance to attend the mine site celebration. The celebration attendees were able to witness first-hand the reconnection of the Mill Pond and Hambone Lake water bodies and appreciate the site in its remediated condition.



Mill Pond	1
Upper Pond	2
Former Mill Area	3
West Lower Pond Borrow Area	4
Former WTP Location	5
Diversion Ditch	6
Discharge Channel	7
To Airstrip Borrow Area	8

4.4 Environmental Benefits

From the onset of the Tundra Mine remediation project, the completion of each phase of the overall design has marked a significant improvement to the site and the surrounding environment. Removal and off-site disposal of hazardous materials, along with demolition and on-site landfilling of non-hazardous materials and derelict buildings was a critical first stage to ensure safe work conditions for the public and for subsequent work phases.

As noted, over 10,000 m³ of PHC soils were collected and treated throughout the Phase II construction period. Consolidating and containing tailings and other contaminated materials within the TCA will reduce the potential for surface water to become contaminated,

thereby keeping ‘clean water clean’. Consolidating the materials also limits the actual footprint where contaminated materials still exist on site. Ongoing treatment and discharge of over 1.4 million cubic metres of water was not only necessary to implement the remediation design, but secured an invaluable resource of the natural environment.

Successful stabilization of the borrow areas was a major component of the remediation design, with a noted priority of managing erosion potential of the exposed silty material, which is particularly prone to sedimentation. Finally, re-establishing the natural drainage path between Mill Pond and Hambone Lake marked a significant project milestone, but more importantly, adds tremendous value for the natural environment and First Nations’ stakeholders.

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Meeting Client's Needs

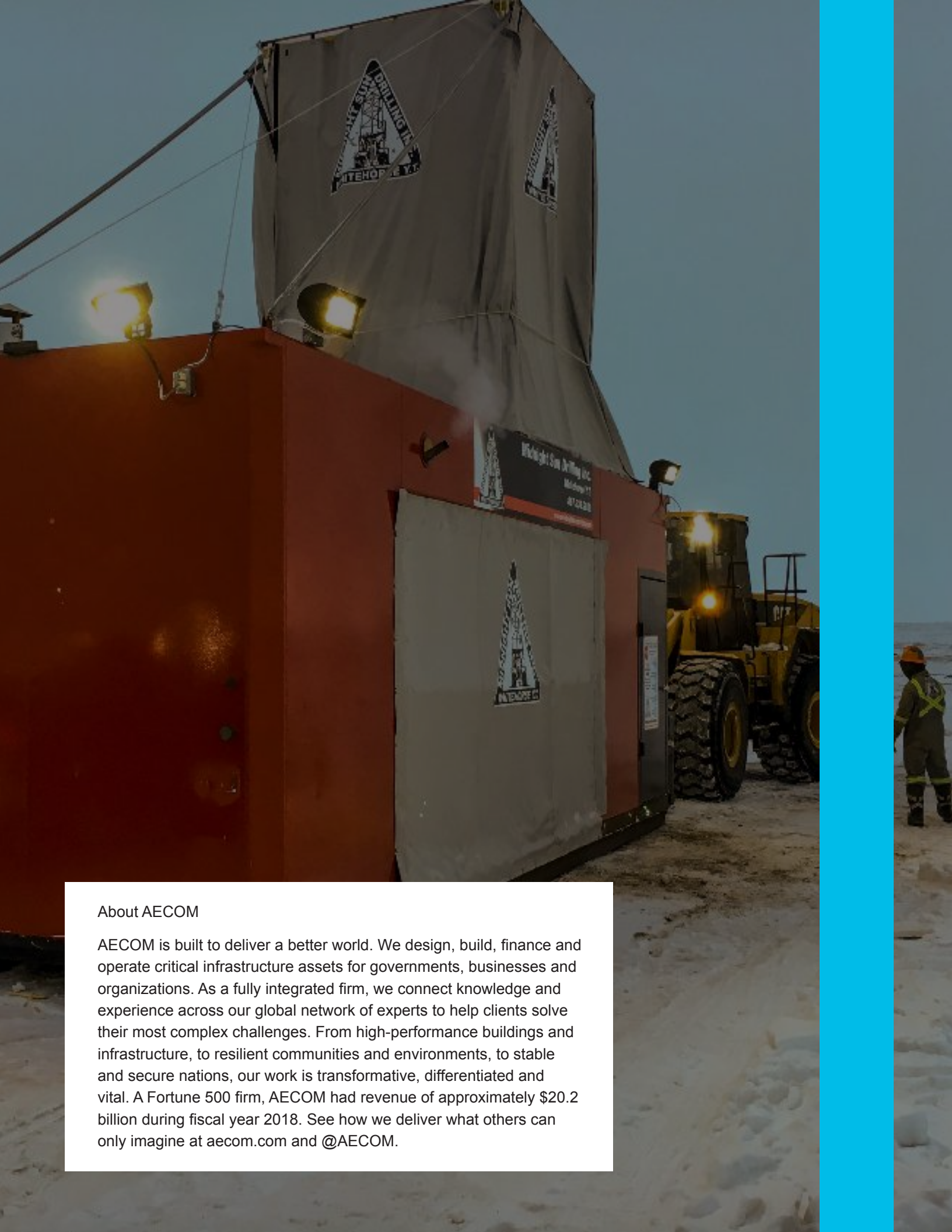


With the completion of the Tundra Mine remediation project, immediate risks to the public have been minimized; the environment is protected in a manner consistent with the Water Licence and Land Use Permit; and the remediation design is technically sound and is expected to limit maintenance of the site.

AECOM has played an instrumental role with this Federal Contaminated Sites Action Plan (FCSAP) funded remediation project. Design studies completed by AECOM and supported by OKC provided a site water and chemical mass balance; optimized the TCA design and provided a better understanding of the anticipated TCA performance; and limited further disturbance with a WLPBA stabilization design.

The consolidation of tailings materials and installation of the TCA liner and granular cover, armoring of Upper Pond and Lower Pond, the WLPBA and Airstrip Borrow stabilizations, and reconnection of the natural drainage path between Mill Pond and Hambone Lake, have all contributed to the anticipated long-term stability of the site.

A major project milestone was reached in 2018 when the Tundra Mine remediation site progressed to the Adaptive Management Phase. AECOM completed the Adaptive Management report on behalf of the federal government which details the trigger concentrations and response framework for the short-term and long-term monitoring of the remediation site. This was a key component of the project to meet the terms of the Water Licence.



About AECOM

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