Environment

Yukon Energy Corporation

Marsh Lake Fall-Winter Storage Concept Erosion Effects Workshop Report

Prepared by:

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Project Number:

60237818

Date:

February, 2012

AECOM
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February 7, 2012

Travis Ritchie
Manager: Environment, Assessment & Licensing
Yukon Energy Corporation
#2 Miles Canyon Road
Whitehorse, Yukon
Y1A 6S7

Dear Mr. Ritchie:

Project No: 60237818 Task 3.6.3

Regarding: Marsh Lake Fall-Winter Storage Concept Erosion Effects Workshop Report

AECOM is please to provide our summary of the Erosion Effects Workshop that was held at the Marsh Lake Community Centre on Saturday January 21st, 2012. Appended to this report are the minutes of the meeting, the list of attendees, a copy of the workshop agenda and presentations.

Sincerely,
AECOM Canada Ltd.

Heather Onsorge
Socio-Economic Specialist
Heather.Onsorge@aecom.com

EH/HO:ho
Encl. Meeting minutes
Attendance list
Workshop agenda
Copy of presentations

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Appendices

Overview

The Erosion Effects Workshop was hosted by Yukon Energy Corporation (YEC) on Saturday, January 21st, 2012 from 12:30 to 4:30pm at the Marsh Lake Community Centre. A total of 23 people attended the workshop including residents from a number of subdivisions in the Southern Lakes area. Six representatives from YEC and AECOM were present to deliver presentations, participate in discussions and address questions. Lunch was provided by YEC at the start of the workshop.

1. Workshop goals and objectives

The goal of the Erosion Effects Workshop was to provide information about the potential effects on erosion resulting from Yukon Energy's Marsh Lake Fall-Winter Storage Concept. Detailed information presented at the workshop included:

- Southern Lakes Fall-Winter Storage Concept presentation
  - Overview of current operations and conditions
  - Overview of proposed changes to water license;
- Summary of erosion investigations and current erosion conditions of the Southern Lakes;
- Overview of geomorphology fundamentals including landscape history of the Southern Lakes and Factors contributing to shoreline erosion;
- Presentation and discussion on findings from recent erosion investigations;
- Identified areas that will not be affected and areas that will likely be affected by proposed higher fall lake levels; and
- Discussion regarding mitigation measures currently utilized in the southern lakes and other possible mitigation options.

Workshop attendees were given the opportunity to ask questions, voice concerns and provide feedback throughout the workshop. These questions, comments and concerns are captured in the meeting minutes appended to this report in Appendix A. A detailed list of workshop attendees and workshop agenda are also included in Appendix A.

2. Workshop material and presented information

The following documents/handouts were made available at the workshop:

- Workshop agenda;
- The Big Picture Newsletter; and
- Posters of discipline studies undertaken to date.

Four presentations were delivered throughout the workshop by Forest Pearson and Jena Gilman of AECOM. Copies of the presentations are appended to Appendix B.

Presentations delivered are as follows:

- Southern Lakes Fall-Winter Storage Concept:

  This presentation provided an overview of the current water management regime on the Southern Lakes (Marsh, Tagish and Bennett Lakes), as well as an overview of proposed changes to Yukon Energy's water license for the Lewes Control Structure.

- Scope of Erosion Investigations:

  This presentation provided an overview of the geomorphology studies completed to date. The presentation described the scope of studies completed and existing erosion conditions in the Southern Lakes were discussed.

- Elements of Erosion:

  The purpose of this presentation was to provide an introduction to geomorphology fundamentals so workshop participants would have a better understanding of the existing erosion conditions and the mechanisms that cause erosion of the shorelines.

- Preliminary Assessment of Erosion Effects:

  The purpose of this presentation was to provide an overview of the effects assessment process and of preliminary assessment of the effects of the proposed operations on shoreline erosion in key areas.

3. Participant questions and discussion

Participants were invited to discuss, ask questions and seek additional information throughout and following the presentations. Several major themes and common questions developed throughout the workshop. These questions and comments will be used to gain a better understanding of the socio-economic effects for Yukon Energy's proposed Marsh Lake Fall-Winter Storage Concept.

4. Workshop outcomes

The following is a summary of the major outcomes identified by workshop participants through discussions:

- Overall, participants gained a better appreciation about where erosion is occurring now and where it is not occurring
- Participants recognize that feasible mitigation options exist, and are currently being used successfully by residents to control localized erosion
- Some residents expressed satisfaction that their concerns were being taken seriously and that these issues were being addressed
- Participants gained an appreciation of the complexity of the analysis required to predict the changes in erosion as a consequence of the project, and the fact that it is very site specific.

Appendix A

Meeting Minutes, Attendance Record and Agenda

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867 633 6321 fax

Minutes of Meeting

Date of Meeting	January 21, 2012	Start Time	12:30 pm	Project Number	60237818 - 3.6.3
Project Name	Marsh Lake Storage Concept				
Location	Marsh Lake Community Centre				
Regarding	Marsh Lake Erosion Effects Workshop				
Attendees	Travis Ritchie (YEC); Heather Onsorge, Forest Pearson, Kathleen Wood, Jena Gilman and Emilie Herdes (AECOM); Residents from Southern Lakes area (see attached for list of attendees).				
Minutes Prepared By	Emilie Herdes				

PLEASE NOTE: If this report does not agree with your records of the meeting, or if there are any omissions, please advise, otherwise we will assume the contents to be correct.

Intent of meeting

The intent of this meeting was to provide residents of the Southern Lakes with detailed information on Yukon Energy Corporation's (YEC) geomorphology (erosion) investigations, analysis and modelling that has been completed to date for the Marsh Lake Storage Concept. The workshop was also an opportunity for YEC to provide residents with an update on the Marsh Lake Storage Concept and to allow residents to ask questions and provide feedback.

The following is an outline of the meeting, beginning with introductory statements made by the organizers, including YEC and AECOM representatives. When an attendee could not be identified or otherwise, the comment or question is identified as originating from a "Resident".

The following documents were made available at the meeting:

1. Workshop agenda;
2. The Big Picture newsletter; and
3. Handout posters of discipline studies undertaken to date.

Copies of the presentations, agenda and list of attendees are appended.

Workshop Overview

Heather Onsorge welcomed the attendees and asked everyone to make sure to fill in the sign-in sheet before introducing Travis Ritchie.

Travis Ritchie thanked everyone for attending the erosion effects workshop and explained that it is the third in a series of four effects assessment workshops for the Southern Lakes Enhanced Storage Concept. He explained that this series of workshops are designed to provide an overview of the project and to explore specific impacts of the Marsh Lake Storage Concept, and provided an overview of the workshop goals and objectives.

Heather Onsorge introduced the AECOM representatives and went over the workshop agenda.

Presentation #1: Southern Lakes Enhanced Storage Concept

Forest Pearson presented an overview of current operations and of the proposed changes to the water management regime. He explained the hydraulic connection between the Southern Lakes (Marsh Lake, Bennett Lake and Tagish Lake). He noted that many attendees have probably seen the presentation at the groundwater effects workshop, and added it was important to understand the proposed changes in water management since this is what determines the effects. Some questions were asked throughout the presentation and are included in the Q&A section, below.

Discussion / Question Period

1. **D. Fulmer** – Asked Forest to show on the Marsh Lake historical level graph where the proposed FSL is.

   Forest Pearson – Showed where the proposed FSL would be on the graph and suggested he would draw it on a graph during the break. (*completed)*

2. **P. Savoie** – Asked whether the restriction of flow at Miles Canyon would cause one side of the lake to be higher than the other. *This question was unclear and was subsequently withdrawn by Mr. Savoie.*

3. **B. Thompson** – Asked Forest to clarify why the Lewes Dam gate closure dates won't need to be changed to achieve the proposed FSL.

   Forest Pearson – Explained that in low water years, the gates are closed earlier in order to reach the FSL, but in high water years, the gates aren't closed until the water level drops to the FSL. The earliest the gates could be closed is August 15th as per current water license. In most years the gates aren't closed until around early September. *Kathleen later explained that as there are 30 gates, it is not simply a matter of the dates at which gates are closed, but also the number of gates closed. In order to achieve the new FSL every year, the discharge out of Marsh Lake would need to be reduced by closing more of the gates in the same time frame.*

4. **L. Watson** – Asked about what would happen to the groundwater in high water years.

   Forest Pearson – Explained that the topic of groundwater was discussed in depth in the groundwater effects workshop on November. He said he could go over the main points with her at another time.

5. **B. Thompson** –Asked whether Marsh Lake would reach the proposed FSL every year under the proposed project.

   Forest Pearson – Explained that the lake would reach the proposed FSL every year to enable maximum power generation capacity.

6. **D. Fulmer** – Asked what the elevation difference is between Marsh Lake and Schwatka Lake.

   Forest Pearson – Approximately 3m difference in elevation, but this would be confirmed. *(Completed)*

7. **P. Savoie** – Asked if in a mild weather year, the extra power generated could be "stretched out" longer than in cold years if the project goes ahead.

   Forest Pearson – Explained that Marsh Lake functions as an annual reservoir, therefore the water available for power production is used up every year, but the enhanced Marsh Lake storage might allow for some water to be stored at Aishihik which is a multi-year reservoir.

8. **G. Pettifor** – Asked whether YEC was anticipating any water level changes at Marsh Lake as a result of glaciers receding rapidly around Atlin Lake (≈40% of the water in Marsh Lake comes from Atlin Lake).

   J. Streicker – Explained that no short-term changes are expected, that any changes in flow would be in the long-term. The Northern Climate Exchange will soon be publishing the results of glacier studies conducted in the southern lakes area.

9. **D. Fulmer** – Asked if studies are being done that compare CO_2 emission reductions from offsetting use of diesel generators vs. flooding a greater area.

   Forest Pearson – Explained that CO_2 emissions are associated with *new* hydro projects that involve new flooding of land. In northern environments, these levels only increase for the first few years after a hydro project is constructed, after which the emission levels decrease to those similar to a natural lake. As the proposed project will inundate land that already gets inundated periodically (~once every four years on average) it would not result in any increase in GHG emissions.

10. **B. Thompson** – Asked if there would be more extreme peaks in water levels with the proposed FSL.

    Forest Pearson – Explained that there wouldn't be, because the gates must remain fully open until the water level drops to the FSL, they cannot close earlier.

11. **M. Goudreau** – Asked if we had the historical data for water regulations for Lewes Control Structure dating back to the 1940s.

    Travis Ritchie – Explained that prior to 1958, Lewes control structure was only used for navigation, but for any additional information, he would have to look at YEC's records. The question was "parked" for later.

    Heather: Spoke with Mark at the break and agreed to send Mark requested data.

Presentation #2: Scope of Erosion Investigations

Jena Gilman presented an overview of the geomorphology studies conducted to date. She gave an introduction on her experience and her involvement in the project in the past years. She explained the current erosion conditions in the Southern Lakes and described how the key sites for erosion investigations were identified throughout the studies of the past two years. Some questions were asked throughout the presentation and are captured in the discussion / question period section below.

Discussion / Question Period

1. **G. Pettifor** –Does the modelling takes storms (i.e. waves caused by storms) into account.

   Jena Gilman –Yes, it does, and that she would cover the topic in the modelling section of the presentation.

2. **L. Watson** – Asked which eleven sites were chosen for the shoreline surveys and wave run-up modelling.

   Jena Gilman – Listed the eleven sites and pointed them out on a map.

3. **J. Streicker** – Asked whether some areas had multiple sites together.

   Jena Gilman – Answered yes, for example a number of shoreline surveys were completed in Judas Creek.

4. **S. Walton** – Asked how much erosion is caused by human activities around the Southern Lakes.

   Jena Gilman – Explained that erosion and accretion are often caused by activities, such as the presence of docks and shoreline reclamation projects. There are so many variables and they can't all be included in the model. Variables in the model are carefully chosen.

5. **J. Streicker** – Asked about the fine-grained soil experiments in the" tubs" and where the soil samples came from.

   Jena Gilman – Explained that small samples were taken from some of the sites (i.e. Judas Creek subdivision) to observe the effect of wave action on the soils.

6. **B. Thompson** – Noted that when the water is agitated in front of his place (Tagish Beach), the water gets turbid for approx. 10 m out from shore.

   Jena Gilman – Agreed; Explained that this is likely the sediment on the bottom getting moved around.

7. **S. Walton** – Asked if there are ways to increase or encourage accretion of shorelines to save the beaches around the Southern Lakes. For example, she observed that when a boat was moored offshore, they observed accretion of the beach.

   Jena Gilman – Explained that this topic will be addressed later and suggested to "park" it for now.

8. **L. Watson** – Asked whether riprap/bulkheads help to protect shorelines.

   Jena Gilman – Confirmed that bulkheads (riprap, gabians) work really well to protect shoreline from wave run-up. More details will come in a later presentation.

9. **G. Pettifor** – Asked if YEC is planning to look at the shoreline protection people have added to their properties at Army Beach and let residents known whether it will be sufficient. He added that Army Beach lost a lot of sand in 2005 and 2006.

   Jena Gilman – Explained that mitigation measures will be discussed later in the final presentation.

   G. Pettifor – Stated that he believes property owners should get refunded for the shoreline protection they add to their properties, but that they shouldn't get financial help until after the improvements are made, in order to protect their neighbours' properties.

M. Dunn – Expressed that when she and others bought their properties on Marsh Lake, they knew that there would be erosion of the shorelines. Erosion has been occurring here for hundreds of years. She thinks that individual property owners should pay for any shoreline protection they choose.

G. Pettifor – Explained that he purchased his property based on a known risk and now YEC is proposing to change by increasing the lake level. He thinks YEC should cover the cost of shoreline protection where it is needed.

Heather Onsorge suggested moving on to the next presentation and continuing the discussion later.

Presentation #3: Elements of Erosion

Forest Pearson and **Jena Gilman** provided a presentation on elements of erosion. They gave an overview of soil types and the landscape history which caused the deposition of sand and silt in the Marsh lake area. They explained that accretion is occurring in some areas of the Southern Lakes (e.g. Carcross Beach, California Beach) and gave an overview of mechanisms that cause shoreline erosion around the Southern Lakes. Some questions were asked throughout the presentation and are included in the discussion / question period section below.

Discussion / Question Period

1. **J. Streicker** – Asked if the isostatic rebound effect has any bearing on the proposed project.

   Forest Pearson – Explained that isostatic rebound is a rapid geological process, albeit very slow in human terms, and that the lakes will uplift along with the surrounding land.

2. **M. Goudreau** – Asked what the gradient is between Marsh Lake and Carcross (Bennett Lake) and whether the water level in Bennett Lake would increase by 0.3 m as well with the proposed projects.

   Forest Pearson – Explained that at FSL, in the fall, Tagish Lake, Marsh Lake and Bennett Lake all have the same water level. In the spring, there is an elevation difference between lakes. The question was “parked’ for later.

3. **D. Fulmer** – Asked if the erosion modelling takes into account year-round winds or just summer winds.

   Jena Gilman – Explained that considering the biggest changes resulting from the proposed project would occur in October and November, winds in those months were used for the model. She noted that the prevailing winds are from the south in October and November.

4. **P. Savoie** – Asked if the depth of the lake bottom affects the size of waves.

   Jena Gilman – Explained that the depth is an important factor in the creation and size of waves.

5. **Residents** – Discussed the 2007 flood and the atypical low-wind conditions in the fall of that year.

   Jena Gilman – Stated that the 2007 flood was interesting from a coastal engineer’s perspective because of the low winds, making it difficult to analyze.

6. **G. Pettifor** – Asked how the proposed 0.3 m increase in water level would compare to 2007 water levels.

   Forest Pearson – Showed 2007 levels and the proposed FSL on the lake level graph.

7. **K. Barr** – Expressed concern about groundwater problems in Carcross in 2008 and 2009.

   Forest Pearson – Agreed to look into it.

8. **P. Savoie** – Asked if accretion can occur in the winter and described the five foot pressure ridge on Army Beach this year.

   Jena Gilman – Explained that any accretion occurring in the winter would be an exception, because soils are generally covered and hard to move. As for the pressure ridge, there appears to be a thin layer of sand under the ice and we will need to look into it further.

Presentation #4: Preliminary Assessment of Erosion Effects

Kathleen Wood and **Jena Gilman** presented an overview of the effects assessment process and of the preliminary findings of the erosion studies. They stressed that the presentation isn't a complete analysis of results, but will provide some insight on the main effects being considered for the assessment. The presentation covered assessment methodology, the results of the wave modelling and key findings. Mitigation options and next steps in the effects assessment were discussed. Several questions were asked throughout the presentation and are captured in the discussion / question period section below.

Discussion / Question Period

1. **D. Fulmer** – Asked what would happen if the water level was to increase to above the toe of an eroding slope in the absence of wave action.

   Jena Gilman – Explained that the water has to be moving to cause erosion.

2. **M. Dunn** – Asked about groundwater flow direction.

   Forest Pearson – Explained that groundwater flows from high elevations to lower elevations. He agreed to go over groundwater basics with her later, because a lot of time was spent on it already during the groundwater effects workshop.

3. **G. Pettifor**– Asked again if and how extreme winds were covered in the modelling and analysis.

   Jena Gilman – Explained that extreme winds were taken into account. She referred to the sections of the presentation covering this.

4. **M. Goudreau** – Asked why south winds were used for the modelling. He thinks the winds are predominantly from the north in November.

   Jena Gilman – Explained that the data showed that November winds are predominantly from the south, but that the data is from Whitehorse and it is possible that winds at Marsh Lake may follow slightly different patterns. However, as long as the same analyses are done pre- and post-project, the comparison can be made.

5. **Resident** – Asked to convert wind speeds from m/s to km/hr.

   Forest Pearson – Gave the example of 15 m/s that is equivalent to 54 km/hr.

6. **P. Savoie** – Asked what the minimum depth is for a wave to be considered a shallow wave.

   Jena Gilman – Explained that this depends on the period of the wave.

7. **B. Thompson** – Explained that in 2007, the toe of the bluff at Tagish Beach got higher.

   Jena Gilman – Said she thought that the soil that came off the bluff deposited at the toe and agreed to discuss with him more in depth later.

8. **D. Fulmer** – Asked whether the proposed FSL is higher than the toe of the bluff at North M'Clintock.

   Jena Gilman – Confirmed that the proposed FSL is higher than the toe of the bluff at her property at North M'Clintock.

   Kathleen Wood – Explained that the idea is to compare baseline conditions to predicted wave heights under the proposed project. (The toe of the slope at this property is just about the same elevation as the current FSL 656.3m)

9. **J. Mooney** – Asked if the five sites for which results were presented were included in the eleven sites previously discussed.

   Jena Gilman – Answered that yes, they are the same sites. She added that if there are questions on the other sites, she can answer them, but they couldn't all be included in the presentation.

10. **G. Pettifor**– Asked about the causes of the ice pressure ridge in front of his property this winter and whether it would happen every year.

    Forest Pearson – Noted that this year has been a low water year and water levels are well below average, so increased water levels aren't what caused the pressure ridge. He said he had looked into it briefly, and that November 2011 was one of the coldest on record and December 2011, one of the warmest. The issue of pressure ridges is still being looked into.

Wrap Up

Travis Ritchie - Concluded the workshop by thanking everyone again for attending and for their sharing their input. He described the next steps for YEC: looking more closely at the areas of concern, engaging residents and looking at options for mitigation. The studies should be concluded by the end of the year (2012). He stated that the proposed project has the potential to displace $1.5 (sic) $1.9 million in diesel, and that YEC is still working on a benefit-cost analysis for the project. He stressed that the proposed project does not involve any new construction, that the costs are relatively low and that good options exist for mitigating any negative effects.

11. **L. Watson** – Asked to summarize what happened with YEC's proposed Atlin project.

    Travis Ritchie – Explained that Atlin Lake has been given the Parks designation and this caused the project studies to be stopped.

12. **Resident**– Asked how much has been spent to date on Marsh Lake studies.

    Travis Ritchie – Answered that $2 to $2.5 million was spent so far on the studies.

Travis Ritchie - Announced that the aquatic and terrestrial effects workshop will be on February 4th, 2012 from 10 to 4 pm at the Marsh Lake Firehall, and that lunch will be provided. Door prizes were handed out.

	Action
Look into groundwater issues in Carcross in 2008 and 2009	Forest
Leona Watson requested a copy of the groundwater effects presentation	Heather
Deborah Fulmer requested elevation difference between Marsh Lake and Schwatka Lake	Forest
Mark Goudreau requested historical data on water regulations dating back to 1940's	Heather
Follow-up with Brian Thompson regarding bluff erosion around Tagish	Jena/Forest

Marsh Lake Fall-Winter Storage Concept
Erosion Effects Workshop

YUKON ENERGY

AECOM

Date: January 21, 2012
Time: 12:30pm to 4:30pm
Location: Marsh Lake Community Centre

Contact Information				
Name	**Phone Number**	**Email**	**Community / Organization**	**May we contact you if we have questions relating to this workshop? Yes or No**
KAREN ANDERSEN	660 4550	andersens@northwestel.net	JUDAS CK SUBD.	YES
GARY PETTIFOR	334 6685	gpettifor@northwestel.net	ARMY BEACH	YES
KEITH KENDALL	660 4403	KKR@NORTHWESTEL.NET	OVDIS CR	YES.
WAYNE HUFFMAN	660-4000	whuffman@northwestel.net	JUDAS CREEK	YES
CRISPIN GUPPY	~~668~~ 633-2762	CRIS@ECOFOR.CA	WHITEHORSE	YES
JAMES MOONEY	668-6600	james@ecofor.ca	WHSE	YES
RICH MARTIN	633 5804	Richmar@Klondiker.com	Whitehorse / Tagish	YES.
ROB LEWIS	667-7670	ramal64@gmail.com	"	YES
Jean Kapala	660-5101	jKapala@northwestel.net	Marsh Lake	Yes
Mary Reddoch	660-4307	amreddoch@gmail.com	old constabulary	yes.

Contact Information				
Name	Phone Number	Email	Community / Organization	May we contact you if we have questions relating to this workshop? Yes or No
LEONA WATSON	660-5152	leona.barry@northwestel.net	ARMY BEACH	YES
Brian Thompson	633 3871	thompson@klondiker.com	Tagish Beach.	Yes.
PERRY SAVOIE	660-5116	PJMASAVOIE@NORTHWESTEL.NE	MARSH LAKE	YES
JODY MACKENZIE-GROVE	393-4788	jody_mg@hotmail.com	Mt. Lorne.	Y.
Marc Goudreau	660-5545	marcfj.goudreau@gmail.com	Marsh Lk.	Yes
Kevin Barr	3937050	kevin.barr@yla.gov.yk.ca	Mount Lorne MLA Southern Lakes	yes
Marg Dunn	660-4300		Marsh Lake OLD Constr.	Yes
A.J. (Drew) Dunn	660-4300	madunn@northwestel.net	Marsh Lake - Old Constab	Yes
Deborah Fulmer	660-5611	deborah.fulmer@gmail.com	Swan Haven	Yes.
GEORG SAURER	333 9530	KELLIOT@NAVIGONET.COM	JACKSON LAKE	YES
BLAIR CORLEY	660-4311	bjcorley@email.com	MARSH LAKE	YES
John Stricker	660-4113	john.stricker@gmail.com	Judas Creek	Yes
Susan Walton	660-4113	onefish@bcgrizzly.com	Judas Creek	Yes

Yukon Energy's Erosion Effects Workshop

Saturday, January 21, 2012 (12:30 pm – 4:30pm)
Marsh Lake Community Centre

Agenda

1. **Meet and Greet** …….... (10 mins)
   Lead: Yukon Energy and AECOM

2. **Workshop Overview** ……..……..…. (10 mins)
   Lead: Travis Ritchie, Yukon Energy
   - Introductions
   - Review workshop schedule
   - Workshop goals and objectives

3. **Southern Lakes Fall-Winter Storage Concept** ……..……(45 mins)
   Lead: Forest Pearson, AECOM
   - Concept Presentation
     - Overview of current conditions
     - Overview of proposed changes
   - Discussion / question period

4. **Scope of Erosion Investigations**……..……(45 mins)
   Lead: Jena Gilman, AECOM
   - Purpose
   - Reconnaissance survey and mapping
   - Current erosion conditions in the Southern Lakes
   - Bathymetric and shoreline transect surveys
   - Discussion / question period

5. **Elements of Erosion**……. ……...(45 mins)
   Lead: Forest Pearson and Jena Gilman, AECOM
   - Landscape history – erodible soils
   - Wind and waves
   - Lake levels
   - Discussion / question period

6. **Preliminary Assessment of Erosion Effects** ……..... (60 mins)
   Lead: Jena Gilman, AECOM
   - Weather analysis – wind direction and speed
   - Wave modelling
   - Summary of preliminary findings
   - Mitigation options
   - Discussion / question period

7. **Wrap Up** ……..……..…….(10 mins)
   Lead: Travis Ritchie, Yukon Energy
   - What's next for Yukon Energy
   - Door prizes

Appendix B
Workshop Presentations

Southern Lakes Enhanced Storage Concept

January 2012

YUKON ENERGY

Overview

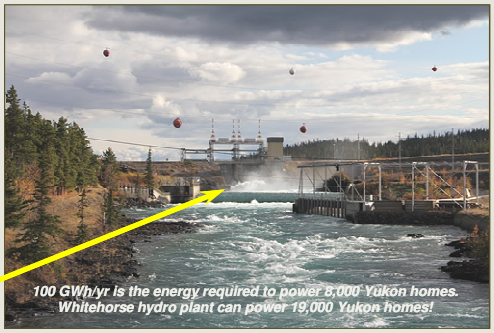
This presentation provides an overview of the Southern Lakes Enhanced Storage Concept. This concept generally consists of amending Yukon Energy's water license for regulating water levels in Marsh Lake (and Tagish & Bennett Lakes) during fall and winter months.

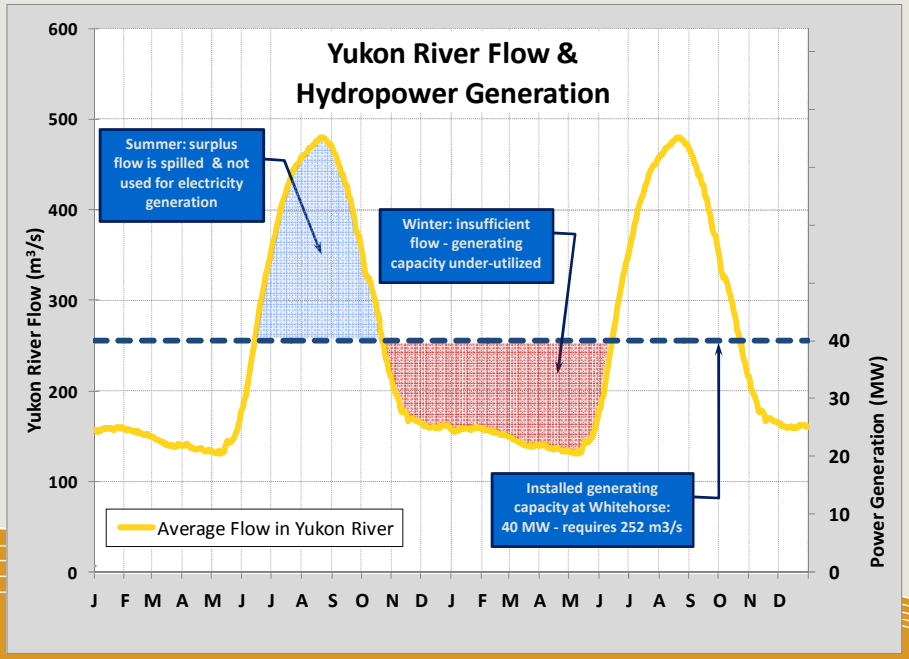
Presentation Overview

1. Existing Conditions
2. Proposed Change

Producing Electricity at Whitehorse Rapids

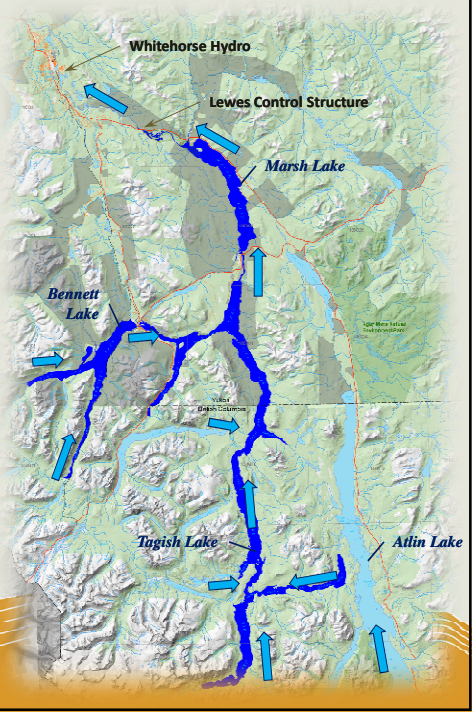
- Built in 1958, Whitehorse Rapids Hydroelectric Generating Station is the Yukon's largest renewable energy facility.
- Hydropower is by far the most sustainable & resilient of all renewable energy technologies.
- Whitehorse currently produces 240 GWh/yr, or 60% of the Yukon's renewable energy.
- Whitehorse has an installed generating capacity of 40MW, but in winter months there is only enough water flow to produce 25 MW on average.
- In summer months, there is excess water, which is "spilled"



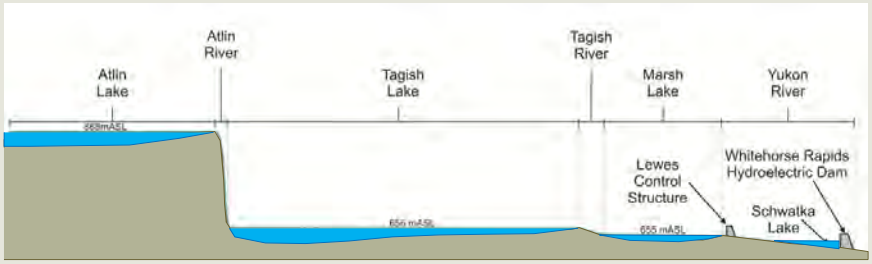


Water for Whitehorse Hydro comes from the Southern Lakes watershed

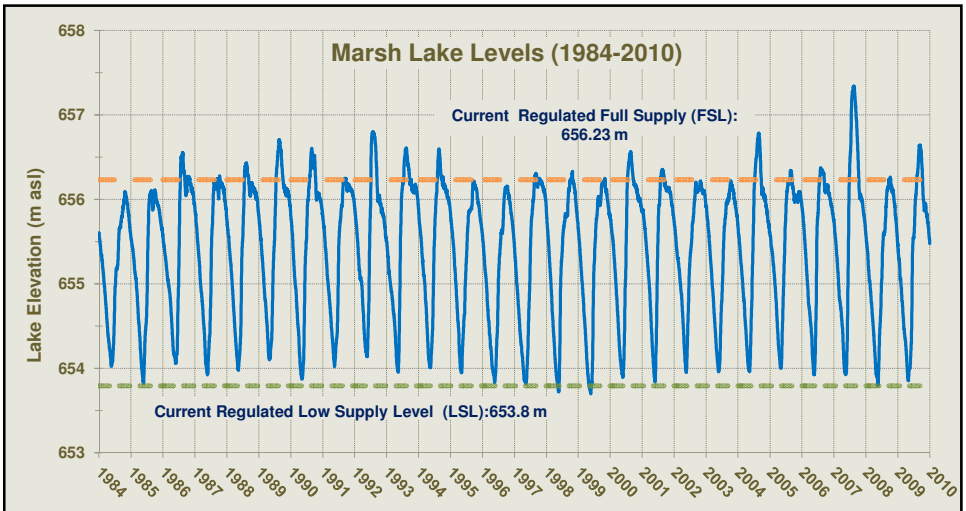
- Marsh, Tagish & Bennett Lakes are hydraulically connected.
- This means managing the outlet of Marsh Lake affects Tagish and Bennett Lakes, allowing storage of water in those lakes as well.
- Water "stored" in the Southern Lakes is used for generating energy in the winter, when we need it the most.
- Flow & lake levels are largely controlled by snow and glacier melt.
  - Warmer years ➔ higher lake levels;
  - Cold years ➔ lower lake levels.



The Southern Lakes in Cross-Section



- Water levels in Marsh, Tagish & Bennett Lakes are affected by Lewes River Control Structure
- For 7 months of the year (mid-August to mid-February), Marsh, Tagish & Bennett effectively act as one lake.
- Atlin, Tutshi and the other Southern Lakes are NOT affected by control of Marsh Lake levels because they are at higher elevations (their connecting rivers have rapids or waterfalls!)



- On average, Marsh Lake levels are lowest in mid-May and peak in mid-August.
- Lake levels fluctuate between elevation 653.7 and 657.34 m above sea level (ASL) – 3.64 m (12 feet)
- 25% of years, peak lake level in Marsh Lake reach 656.6 m ASL or higher.
- Yukon Energy's current water license allows for regulation of the lake between **656.23** and **653.8** m ASL (Full and Low Supply Levels respectively). 2.43 m (8 feet)

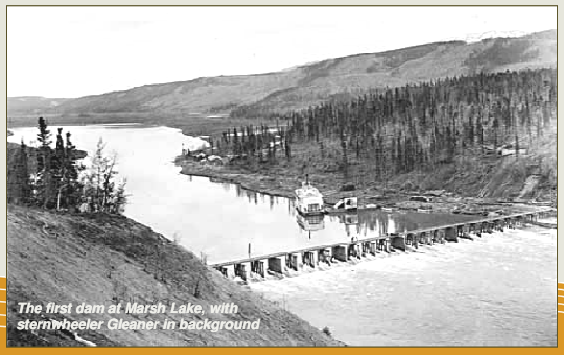
What does Lewes Control Structure Do?

- It regulates outflow from Marsh Lake during fall and winter.
- After August 15th, gates can be lowered to reduce flow in the river. Later in the winter, gates are raised to let more water out of the lake.
- Gates must remain open from May 15th to August 15th
- This structure effectively "stores" water in the Southern Lakes for use in the winter to generate hydropower at Whitehorse.

Lewes Control Structure in late winter with 12 gates closed

History of Lewes Control Structure

- Original wooden dam built in 1922 by British Yukon Navigation Co. (now White Pass) to hold water back until the spring to "flush" ice out of Lake Laberge for early-season steamship navigation on the Yukon River.
- Marsh Lake has been regulated for almost 90 years. Over the period of record, Marsh Lake has fluctuated within the same range.
- Dam rebuilt in the 1950s when Whitehorse hydro built.
- Current steel dam built in 1975. Innovative "sheet-pile" design



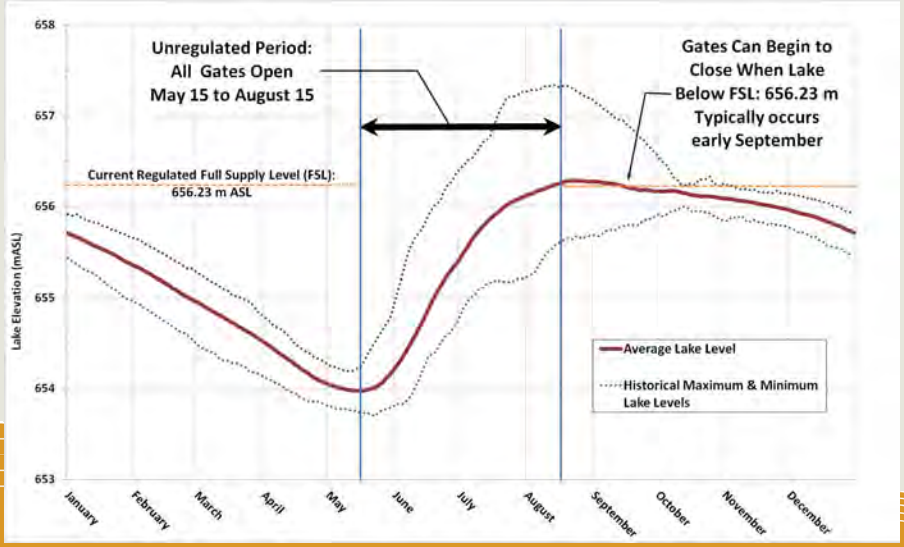
The first dam at Marsh Lake, with sternwheeler Gleaner in background

How is Marsh Lake Regulated?

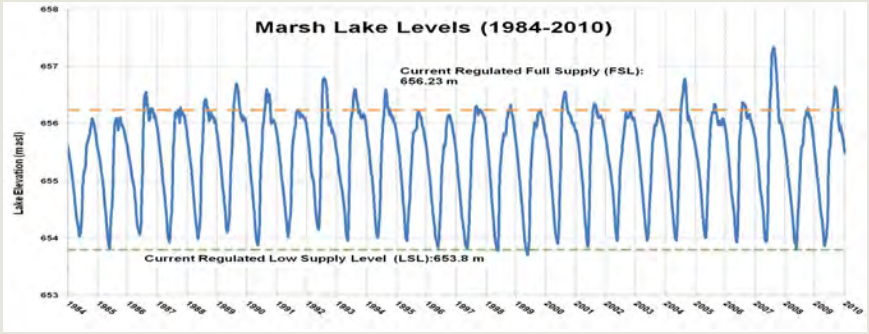
- Marsh Lake is regulated according to Yukon Energy's water licence HY99-010
- License to be renewed in 2025 (14 years left in the current license).
- Conditions in the licence state that:
  - Structure must be fully open (no restriction to flow) from May 15th until lake levels recede to elevation 656.23 m ASL, or August 15th whichever comes later.
  - Gates cannot be closed until lake levels drop to "Full Supply Level" of 656.23 m ASL.
  - On average, gates start to be lowered in early September.
  - On low lake level years (such as 2011), gates start to be lowered on August 15th to raise the lake to (or near) the Full Supply Level

Lewes Control Structure in summer with all gates open.

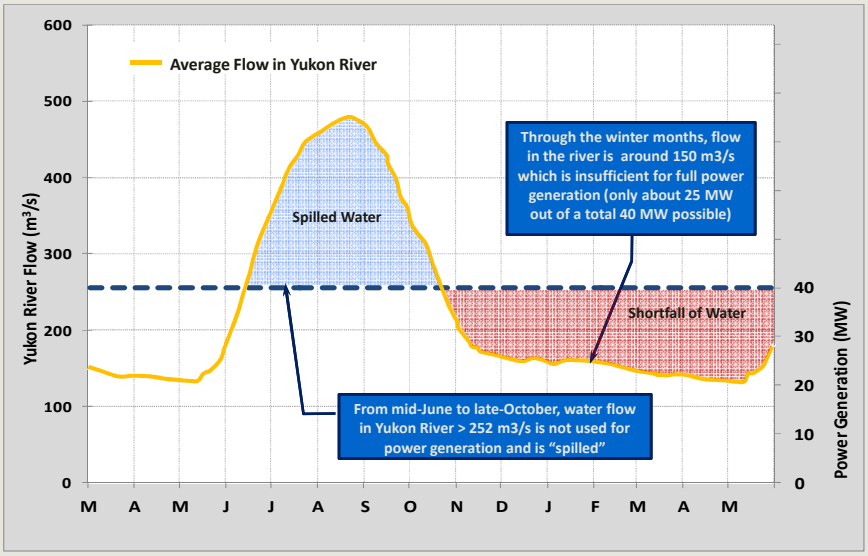
How is Marsh Lake Regulated?



Any questions about how Marsh Lake is currently managed?

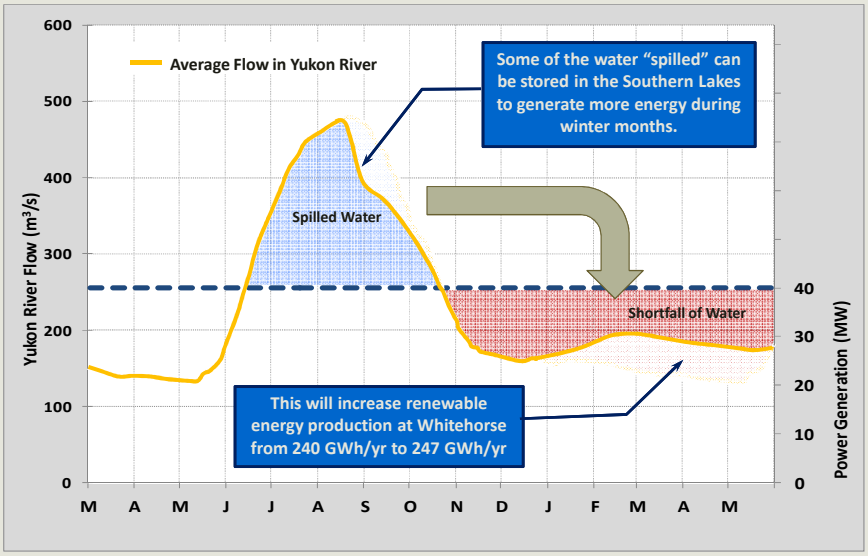


How can more hydropower be generated at Whitehorse?



Southern Lakes Enhanced Storage – Proposed Change

How can more hydropower be generated at Whitehorse?

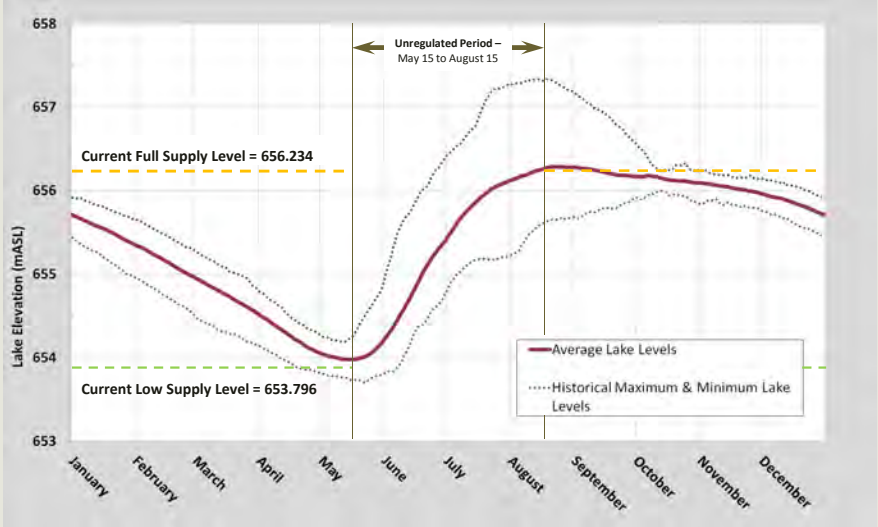


Southern Lakes Enhanced Storage – Proposed Change

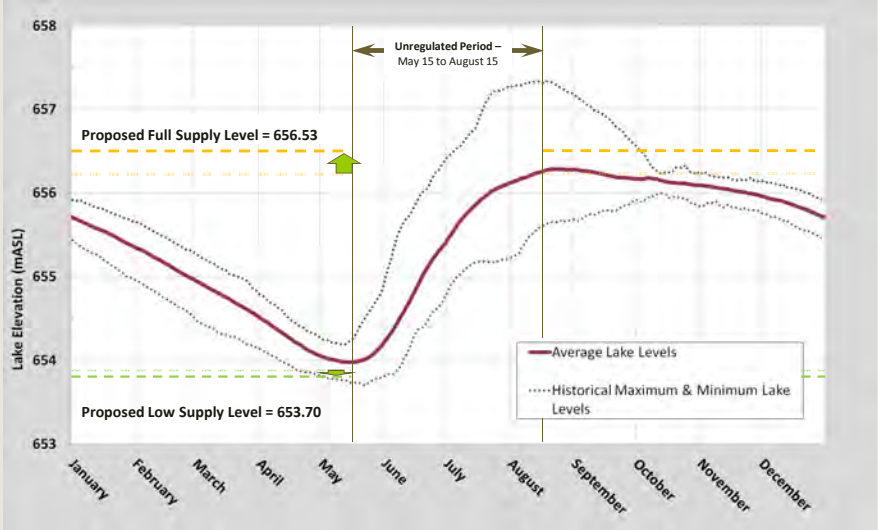
Summary of proposed changes to water licence :

- Increase regulated full supply level (FSL) by 0.3 m from 656.234 to 656.53 m ASL
- Lower low supply level (LSL) by 0.1 m from 653.796 to 653.70
- Gate closure rules may not need to change, but there may be environmental benefits to manage flows by adjusting gate closure rules.

Overview of proposed change to Marsh Lake water levels

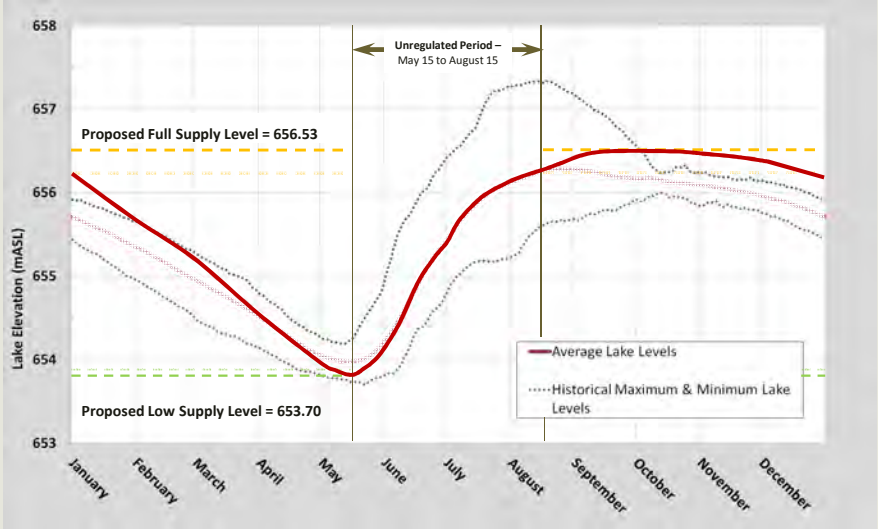


Overview of proposed change to Marsh Lake water levels



Southern Lakes Enhanced Storage – Proposed Change

Effect of proposed change on average Marsh Lake levels



Southern Lakes Enhanced Storage – Proposed Change

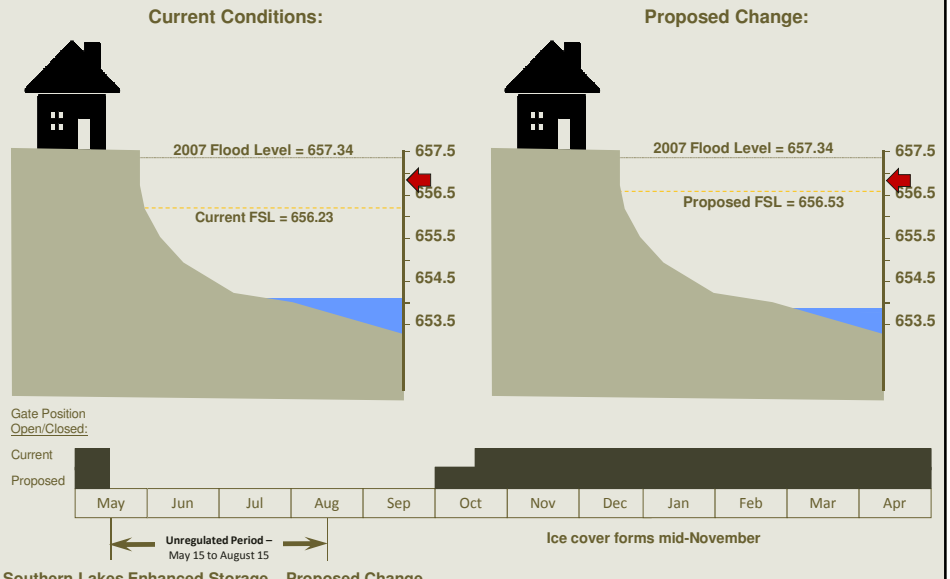
Illustration of proposed change in high water year

2004/05 selected as representative year for illustration purposes – peak lake level: 656.79 m

Southern Lakes Enhanced Storage – Proposed Change

Illustration of proposed change in high water year

2004/05 selected as representative year for illustration purposes – peak lake level: 656.79 m



Southern Lakes Enhanced Storage – Proposed Change

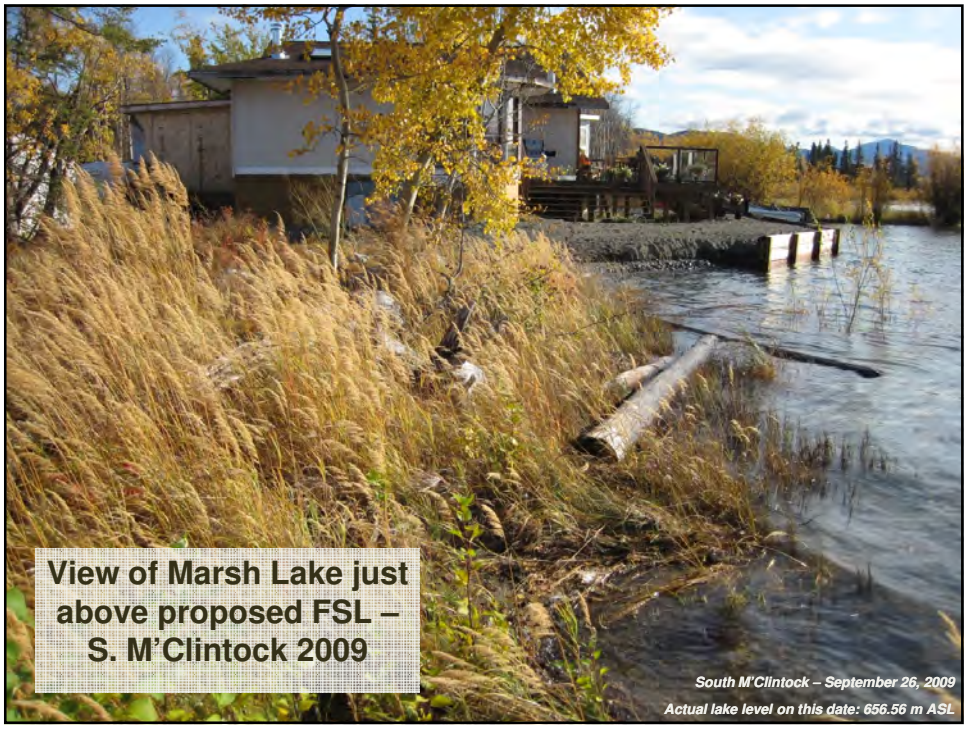

View of Marsh Lake just above proposed FSL – S. M'Clintock 2009
South M'Clintock – September 26, 2009
Actual lake level on this date: 656.56 m ASL


Illustration of Current Full Supply Level
Army Beach – October 22, 2010
Actual lake level on this date: 656.17 m ASL
Illustrated lake level: 656.23 m ASL (Current FSL)


Illustration of Proposed
Full Supply Level
Illustrated lake level: 656.53 m ASL (Proposed FSL)

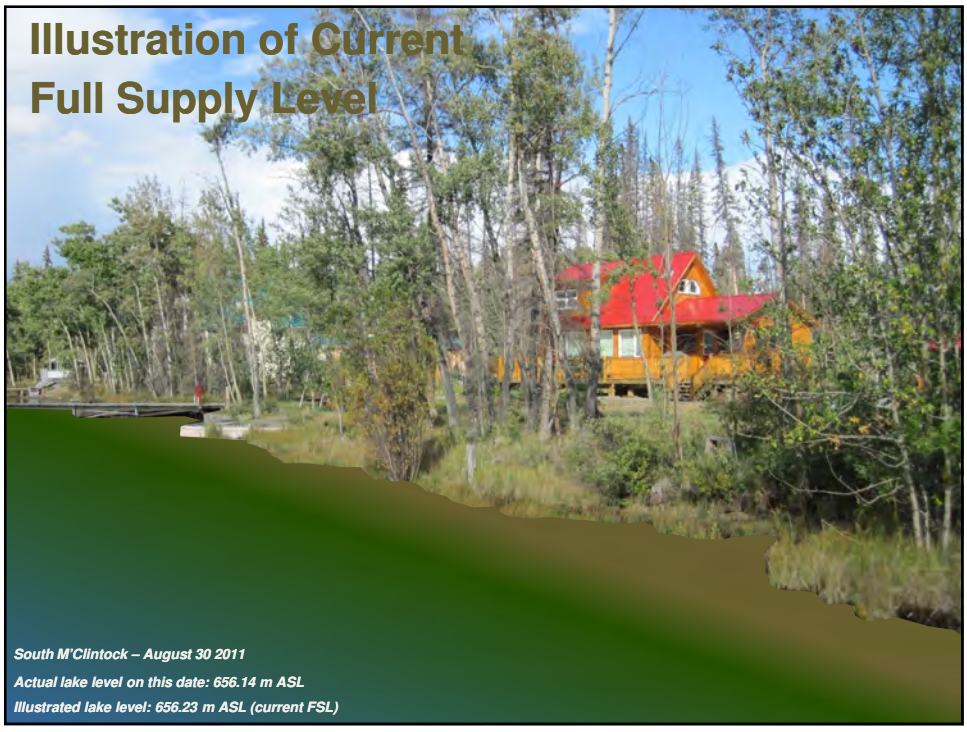


Illustration of Current
Full Supply Level
South M'Clintock – August 30 2011
Actual lake level on this date: 656.14 m ASL
Illustrated lake level: 656.23 m ASL (current FSL)

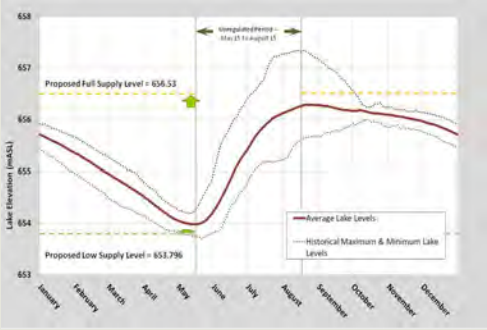
Illustration of Proposed Full Supply Level

Illustrated lake level: 656.53 m ASL (Proposed FSL)

Scope of Proposed Changes to Lewes Control Structure Water Licence

- Increase regulated full supply level by 0.3 m
- Lower low supply level by 0.1 m
- No change to gate closure dates necessary, but may be optimal.

- Water level changes extend to Marsh, Tagish & Bennett Lakes during the regulated period
- Water level changes in mid-August through March in most years.
- No change to water levels from June to mid-August

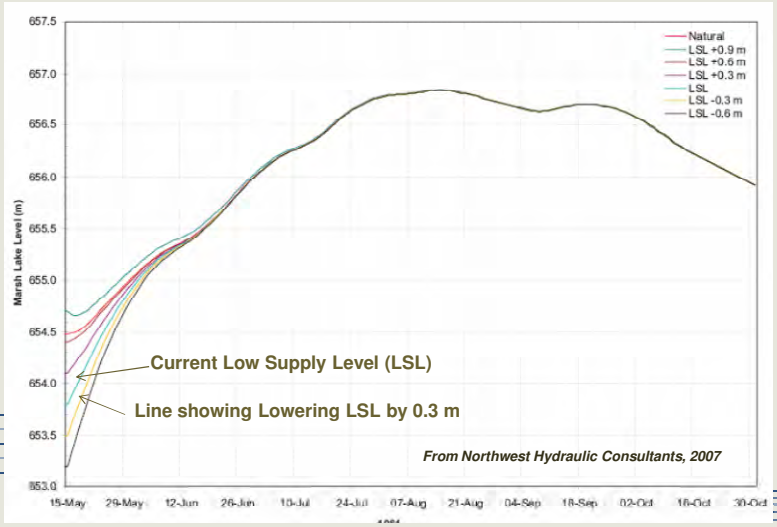


Questions?

End

Effect of proposed change to Low Supply Level by 0.1 m

- Affects only Marsh Lake and does not extend to other Southern Lakes
- Lake refills very quickly and effect only lasts a couple of weeks in May



Southern Lakes Enhanced Storage Workshop Series -

SCOPE OF EROSION INVESTIGATIONS

JANUARY 21, 2012

Scope of Investigations

Erosion Workshop Outline

- **Part 1. Overview of the Project Concept**
  Discussion & questions
- **Part 2. Scope of the Investigations**
  1. Purpose
  2. Reconnaissance Survey
  3. Site Specific Work

  Discussion break

  We are here
- **Part 3. Elements of Erosion**

  Discussion break
- **Part 4. Preliminary Assessment of Effects to Erosion?**
  Concluding Discussion

Scope of Investigations

AECOM

Purpose of Studies:

- To characterize shoreline conditions (e.g., soils, topography, aspect, etc.)
- To understand where, and under what conditions, shoreline erosion (and accretion) does and does not occur currently. What locations are erosion prone?
- To collect information necessary to model and predict potential changes to erosion related to higher fall lake levels.

Scope of Investigations

AECOM

Scope of Investigations:

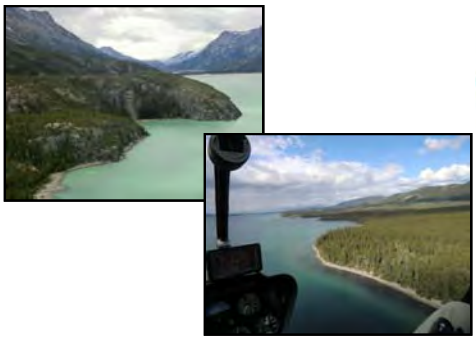
1. Over two years of field investigations, in the spring, summer & fall.
2. Complete shoreline erosion reconnaissance survey of Marsh, Tagish, Bennett Lakes, and Tagish River.
3. Site visits & soil sampling.
4. Shoreline transect surveys & bathymetric surveys.
5. Site visits and interviews with concerned residents.
6. Weather data compilation & analysis.
7. Wave modeling & analysis.
8. River erosion modeling(Tagish & M'Clintock R.)

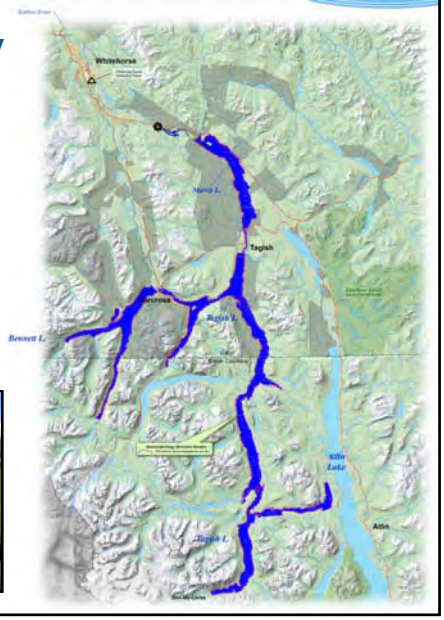
Scope of Investigations

AECOM

Aerial Reconnaissance Survey

Entire shoreline of Marsh, Tagish and Bennett Lakes were viewed from a helicopter to identify erosion prone areas. A total of ~770 km of shoreline was inspected.





Scope of Investigations

AECOM

Reconnaissance Survey Results

- Very little active erosion observed on Taku Arm, Windy Arm, Nares Lake and Bennett Lake.
- In these southern lakes, the landscape is more steeply sloped and rocky (bedrock or gravel).
- The landscape around the north end of Tagish Lake and Marsh Lake is defined by broader valleys and fine grained soils are more common.

Scope of Investigations

AECOM

Reconnaissance Survey Results

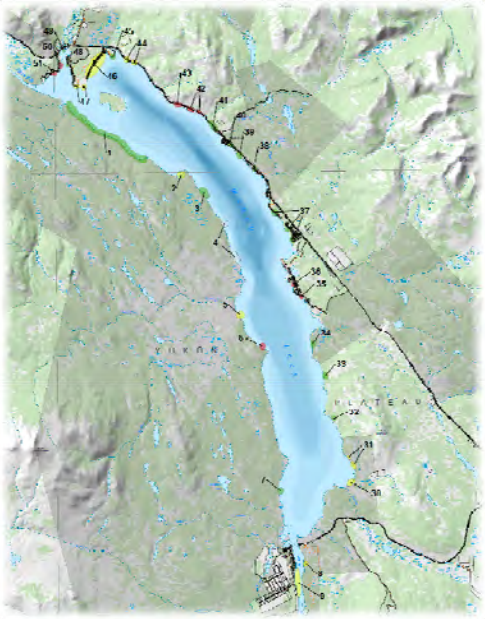
- Erosion is most evident on Marsh Lake and north end of Tagish Lake.
- River erosion observed on the Tagish River and at the mouth of the M'Clintock River.
- Erosion primarily occurs on south facing shorelines with erosion-prone soils (e.g. silt & clay bluffs).
- Areas of accretion identified as well (e.g. California Beach, Carcoss



Scope of Investigations

AECOM

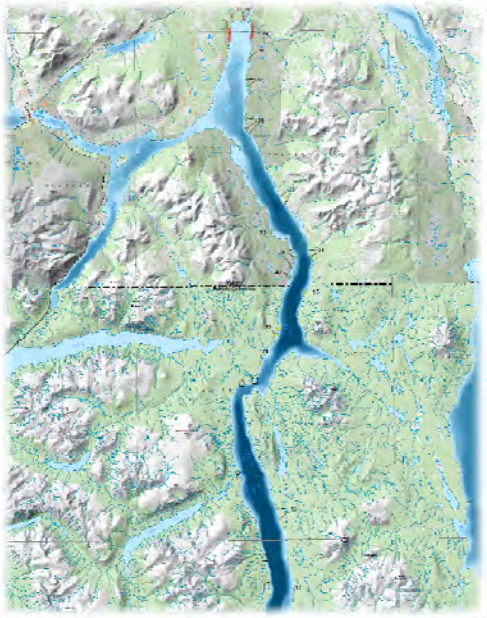
Erosion Mapping – Marsh Lake



Scope of Investigations

AECOM

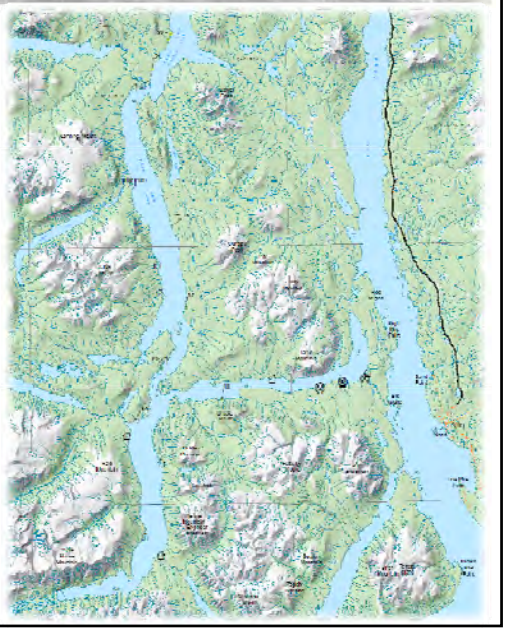
Erosion Mapping – Tagish Lake



Scope of Investigations

AECOM

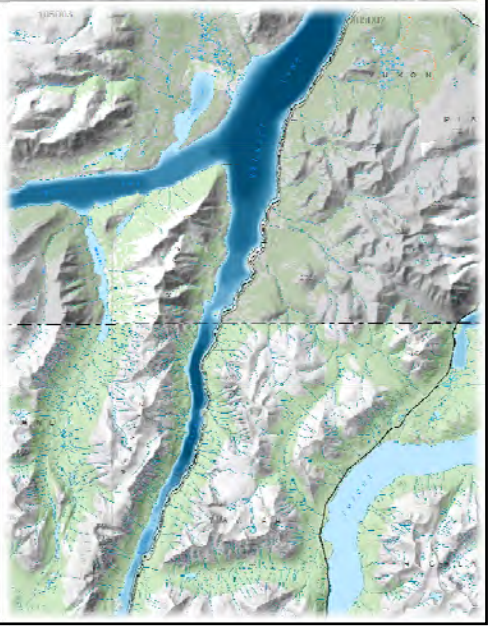
Erosion Mapping – Tagish Lake – Taku Arm



Scope of Investigations

AECOM

Erosion Mapping – Bennett Lake



AECOM

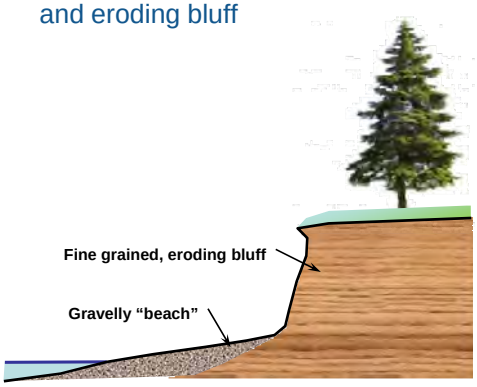
Typical Shoreline Settings for Sites Experiencing Erosion

Two general settings:

- Sites with a coarse grained (gravel) “beach” between the lake and the eroding bluff
- Sites with toe of eroding bluff at or below lake level during fall months (e.g. parts of North M’Clintock)

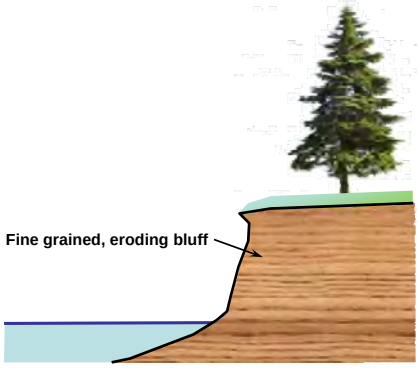
Typical Shoreline Setting for Sites Experiencing Erosion

1. Sites with a coarse grained (gravel) “beach” between lake and eroding bluff



Typical Shoreline Setting for Sites Experiencing Erosion

2. Sites where the toe of eroding bluff is at or below lake level during fall months (e.g. parts of North M’Clintock)



Scope of Investigations

AECOM

Spring Break-up Survey

Spring survey of ice break-up to assess related erosion potential.

- *Ice break-up in spring results in very little to no shoreline erosion due to nature of break-up and low spring lake levels.*

Scope of Investigations

AECOM

Current Conditions

A photo tour of existing erosion and shoreline conditions of the Southern Lakes.

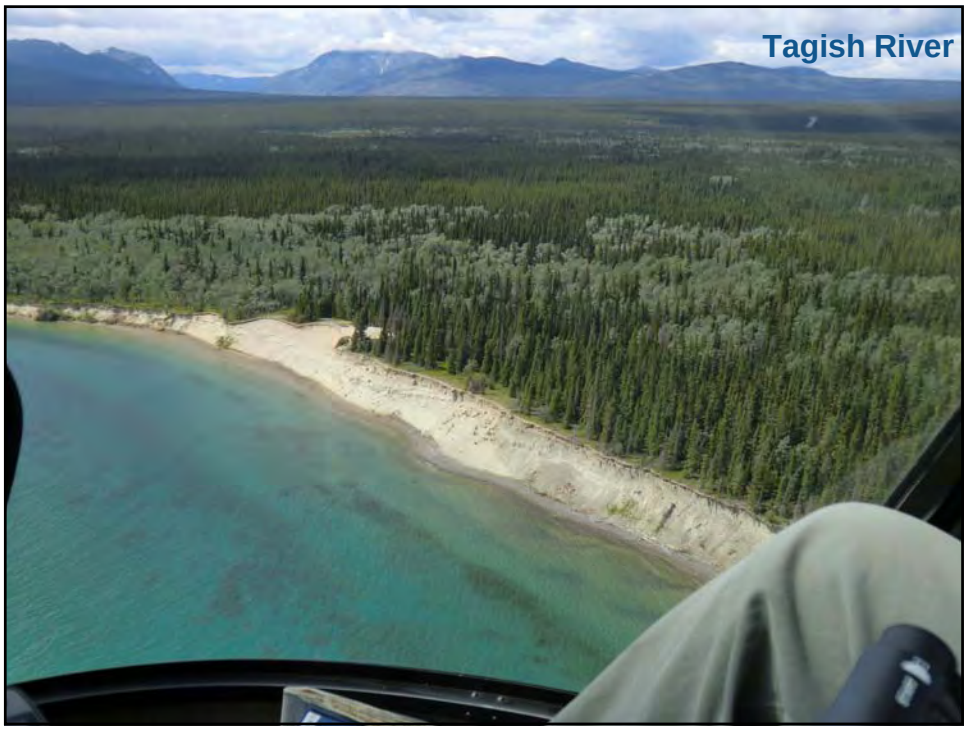
Tagish Lake –
Taku Arm

Tagish Lake –
east shore at north end


Tagish Lake –
at Taku Subdivision
C-GHZN


Tagish Lake –
California Beach at Tagish R.


Tagish Lake –
California Beach at Tagish R.


Tagish River

Marsh Lake –
at Judas Creek Subdivision

Marsh Lake –
at Judas Creek Subdivision

Marsh Lake –
along Alaska Highway

Marsh Lake –
along Alaska Highway

**Marsh Lake –
North M'Clintock**

Scope of Investigations

AECOM

Erosion Site Visits

Inspection of sites experiencing ongoing erosion, including:

- North M'Clintock (Swan Haven)
- Army Beach
- Alaska Highway/M'Clintock Place
- Judas Creek
- Tagish River/California Beach

+ soil samples for grain size analysis

Scope of Investigations

AECOM

Bathymetric Surveys

Surveys of lake bottom contours required for wave modeling. Detailed bathymetry mapping included

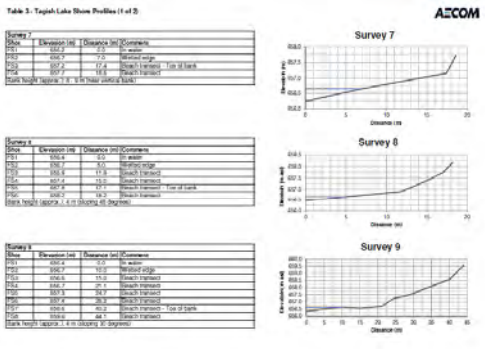
- *M'Clintock Bay*
- *Army Beach*
- *Judas Creek Subdivision shoreline*
- *California Beach & Taku Subdivision*

Scope of Investigations

AECOM

Shoreline Transect Surveys

Slope surveys of eleven shoreline sites required for wave run-up modeling.



Scope of Investigations

AECOM

Fine-grained soil physical erosion experiments

.

- Results show that highly-susceptible soils deteriorate quickly when exposed to waves.
- Armouring the shoreline (revetments) provides protection.

AECOM

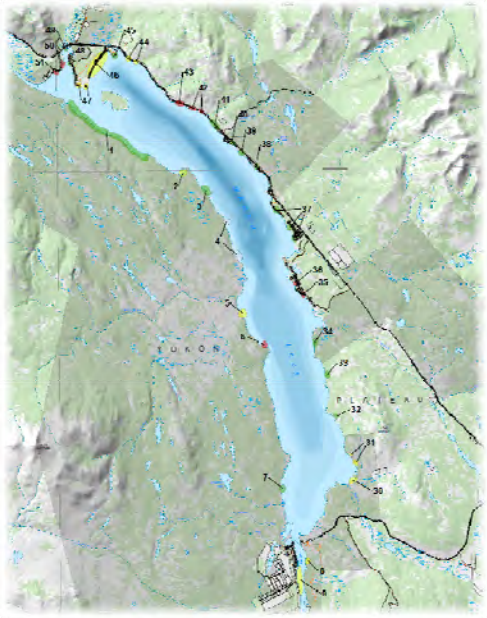
Erosion Studies Summary

- 766 km of shoreline visually surveyed and ongoing erosion sites were mapped.
- Site visits to key areas of ongoing erosion.
- Detailed bathymetric surveys of lake bottom contours for wave modelling & analysis.
- Shoreline surveys at 11 sites for wave run-up modelling


Scope of Investigations

AECOM

Discussion?



Southern Lakes Enhanced Storage Workshop Series -

ELEMENTS OF EROSION

JANUARY 21, 2012

Elements of Erosion

Erosion Workshop Outline

- **Part 1. Overview of the Project Concept**

  Discussion & questions

- **Part 2. Scope of the Investigations**
  1. Purpose
  2. Reconnaissance Survey
  3. Site Specific Work

  Discussion break

- **Part 3. Elements of Erosion**

  We are here

  Discussion break

- **Part 4. Preliminary Findings**

  Concluding Discussion

Elements of Shoreline Erosion

- For erosion to occur, there are three main components that have to exist:

1. Erodible shoreline soils
2. Wind & waves
3. Lake levels

Elements of Erosion AECOM

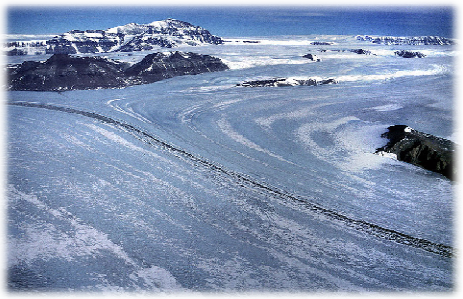
Elements of Erosion – Erodible Soils

- Shoreline soils must be fine grained (sand, silt & clay) to be susceptible to erosion
- Rocky shorelines or gravelly shorelines are much less erodible.

Elements for Erosion – Erodible Soils

- Erosion occurring on the Southern Lakes reflects the landscape history - a landscape that is very young, dynamic, and still in the process of stabilizing after the last ice age.

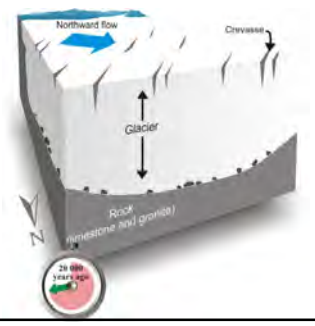
- Understanding our landscape history is important to understanding why erosion occurs in some areas, and not in others.

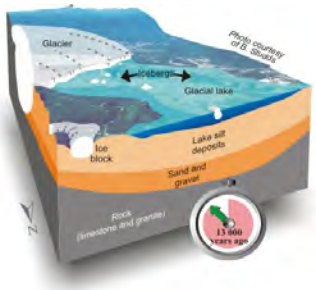


Elements of Erosion AECOM

Elements for Erosion – Landscape History

- The formation and distribution of erodible soils results from glaciation, and more importantly, de-glaciation (the melting of the glaciers).
- Ice covered the southern Yukon until 10,000 years ago. The story of the glacial retreat through the Southern Lakes region helps explain what we see today.

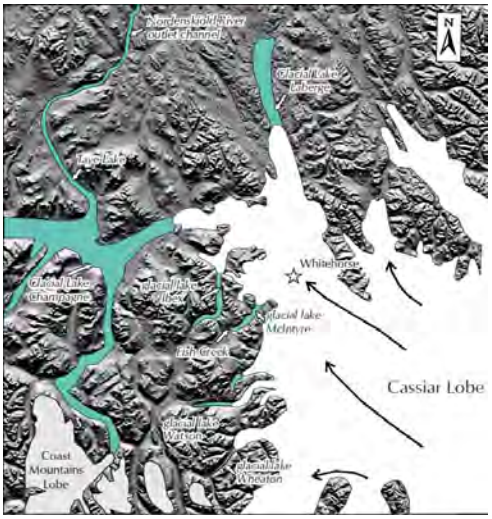




From Geoscape Whitehorse, http://www.geology.gov.yk.ca/geoscape.html

Elements for Erosion – Landscape History

- The most recent ice age started 24,000 years ago, and glaciers expanded from the south toward the north.
- During glacial maximum, up to 700 metres of ice covered the Marsh Lake Area.
- Melting of the glaciers was erratic, and there were periods when ice re-advanced. The ice could dam valleys, creating great glacial lakes, such as Glacial Lake Champagne and Glacial Lake Laberge.
- Massive quantities of silt, sand and clay were deposited in these lakes. These are called "glaciolacustrine" sediments.

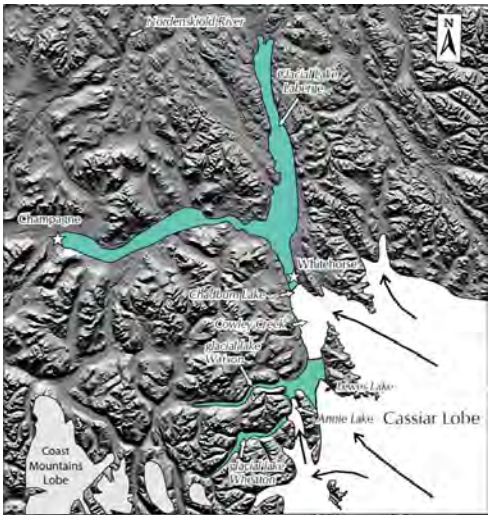


From Bond 2004, http://data.geology.gov.yk.ca/Reference/42672

Elements of Erosion AECOM

Elements for Erosion – Landscape History

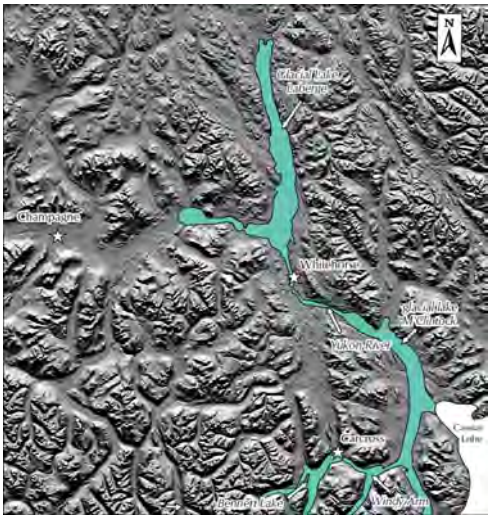
- At some point, the retreat of the glaciers paused (or "stagnated") and during this time great quantities of sand and gravel were deposited in the valley between Marsh Lake and Whitehorse. These deposits not only buried blocks of ice, but also helped "dam" the valley.



From Bond 2004, http://data.geology.gov.yk.ca/Reference/42672

Elements for Erosion– Landscape History

- As the ice retreated further, it dammed the M'Clintock valley, forming a lake in this valley.
- Glacial Lake M'Clintock expanded to fill the Marsh Lake valley as the ice continued to retreat, filling it with thick deposits of glaciolacustrine sediments.
- During the final stages of deglaciation, Glacial Lake M'Clintock and Glacial Lake Watson merged to form one large lake filling the valley.



From Bond 2004, http://data.geology.gov.yk.ca/Reference/42672

Elements of Erosion AECOM

Elements for Erosion – Landscape History

- The landscape continues to stabilize from the dramatic changes that occurred so recently (in geologic time).
- Southern Lake levels continue to drop as the outlets continue to down-cut through the soft glaciolacustrine sediments.
- For example, the current shoreline of Lake Laberge is only 2000-3000 years old!

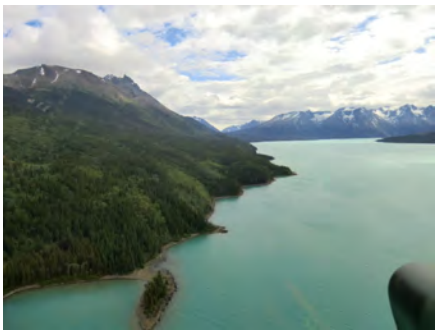
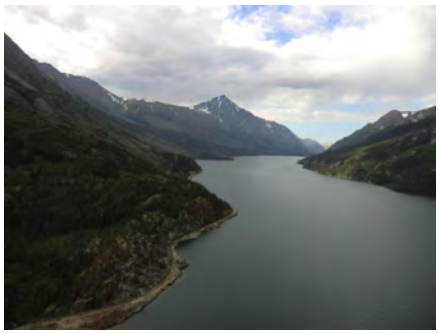
Former higher elevations of Marsh Lake shoreline can be seen above Army Beach.

Elements for Erosion – Landscape History

- The presence of large glacial lakes filling the Marsh Lake valley and northern portion of Tagish Lake valley caused the deposition of glaciolacustarine clays, silts and sand.
- These are the fine-grained soils that are susceptible to erosion.

Elements for Erosion – Landscape History

- The relatively steep, fjord like valleys of Taku Arm, Windy Arm and Bennett Lake did not become filled with glacial lakes, and have mostly gravelly or rocky shorelines.

Elements of Erosion AECOM

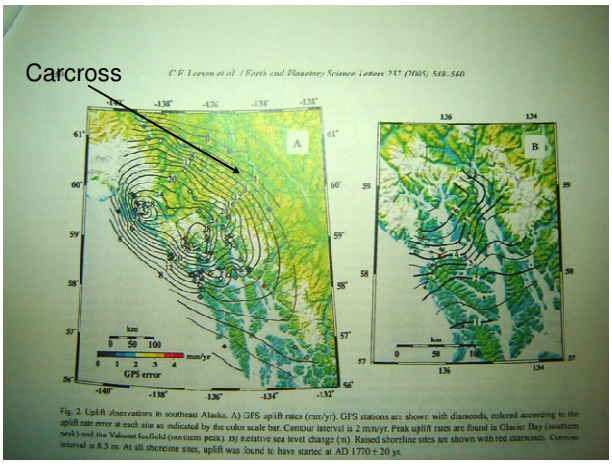
Elements for Erosion – Landscape History

- Other areas experience accretion as sand gets deposited and accumulates along the shore, expanding the beach.
- Carcross beach is a good example of accretion due to deposition of sand deposited from the Watson River.


Elements for Erosion – Landscape History

- Following the Little Ice Age (1700's), the landscape of Southern Yukon has been experiencing some of the fastest *isostatic rebound* on the planet.

- Isostatic rebound is the uplift of the earth surface after being depressed under a great weight, such as large glaciers.
- Currently, the Carcross area is rising at rate of 6 mm/yr, and Whitehorse is rising at 2 mm/yr!



Elements for Erosion – Landscape History Summary

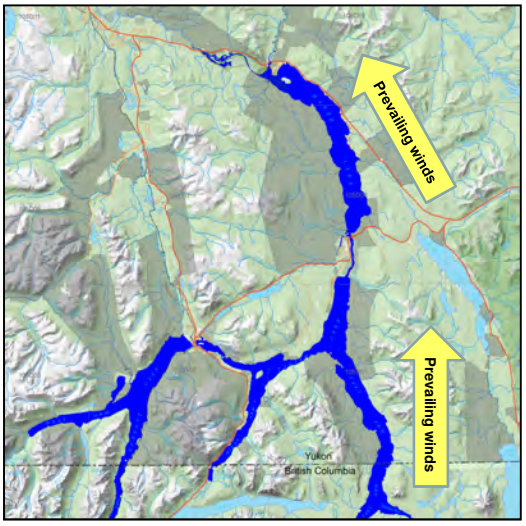
- The landscape of the Southern Lakes is dynamic, and still changing dramatically (in geologic context) after the last major glaciation.

- Areas that are currently eroding are those where there are fine grained soils that were deposited during the last ice age.
- The extent of shoreline erosion today is influenced by the location, orientation and relationship of these soils relative to the lakes.

Elements for Erosion – Wind and Waves

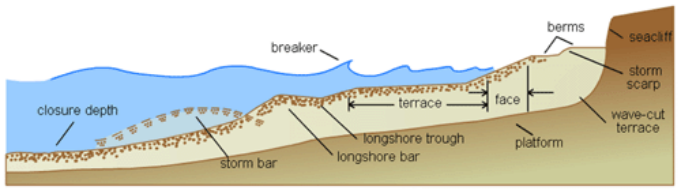
Waves are the primary mechanism for shoreline erosion

- Wind creates waves!
  - Open water season: mid-May to end November
  - Prevailing wind direction; long fetch creates higher waves
  - Most erosion-prone sites are south facing – into the prevailing winds and waves



Elements for Erosion – Wind and Waves

- Waves have energy!
  - Energy released when waves reach shoreline/shallows.
  - Wave height and period are key – higher and longer the wave, the more energy it has.
  - Bigger waves can run-up the beach to contact the bluffs.
  - Wave height is dictated by storm events.
  - Therefore shoreline erosion is driven by wind events.

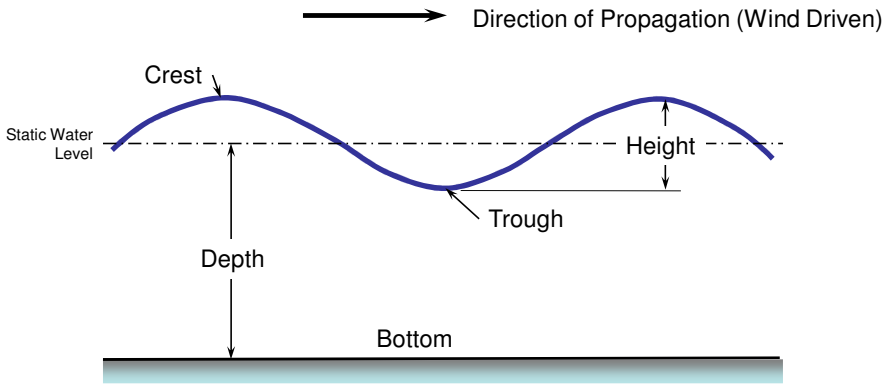


Strong Winds ⇨ High waves ⇨ Higher Run-up ⇨ Increased Erosion

AECOM

Elements for Erosion – Wind and Waves

- Wave Terminology



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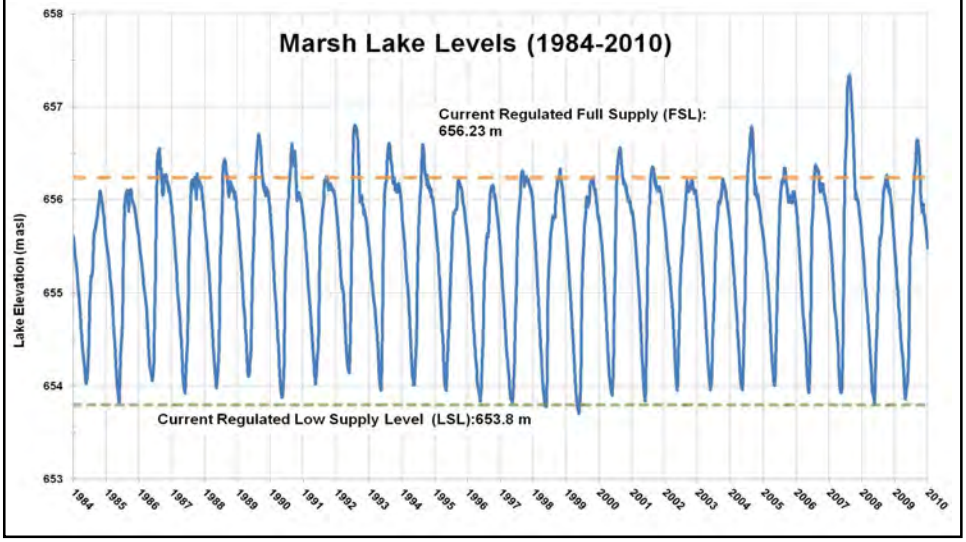
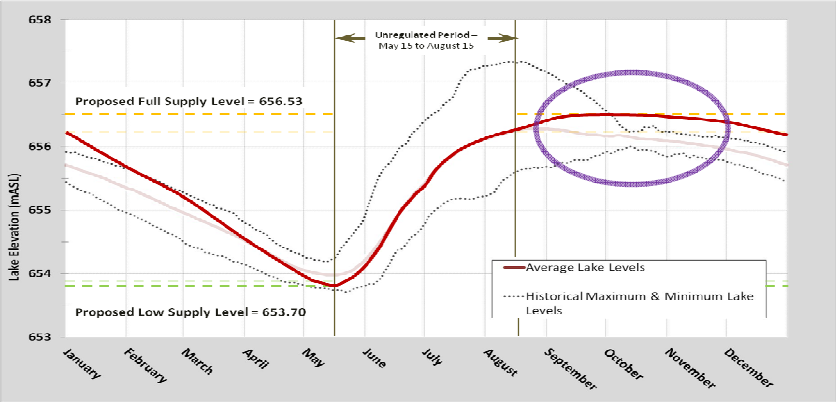
Elements of Erosion – Lake Levels



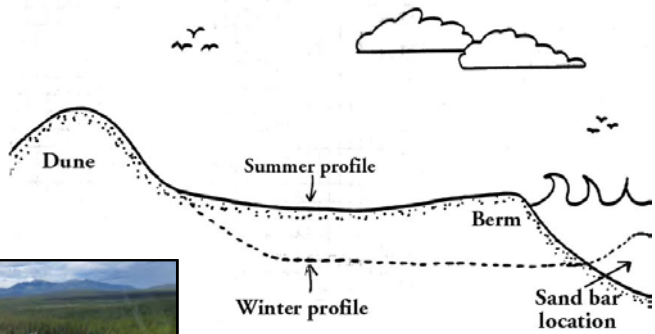

Elements of Erosion – Lake Levels

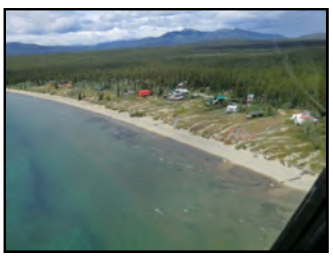
- Higher lake levels in fall increase exposure to wave-driven erosion in (primarily) south facing areas where there are vulnerable soils.



- October average lake levels: Historic 656.14, Proposed: 656.53
- November average lake levels: Historic 656.04, Proposed: 656.45


Discussion of Beach Processes

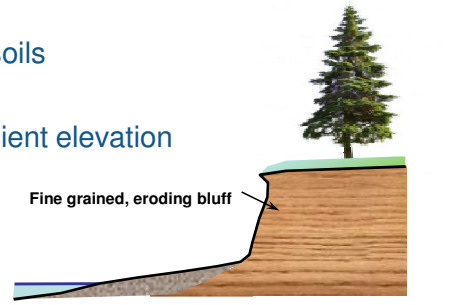




Summary of Elements of Shoreline Erosion

- Shoreline erosion is an ongoing process in the Southern Lakes
- For shoreline erosion to occur, there are three main components that have to exist:

1. Erodible shoreline soils
2. Wind & waves
3. Lake levels of sufficient elevation



Southern Lakes Enhanced Storage Workshop Series -

EROSION – PRELIMINARY FINDINGS

JANUARY 21, 2012

Erosion Workshop Outline

- **Part 1. Overview of the Project Concept**

  Discussion & questions

- **Part 2. Scope of the Investigations**
  1. Purpose
  2. Reconnaissance Survey
  3. Site Specific Work

  Discussion break

- **Part 3. Elements of Erosion**

  Discussion break

- **Part 4. Preliminary Findings**

  Concluding Discussion

We are here

Erosion – Preliminary Findings

AECOM

Preliminary Assessment of the Effects to Erosion

1. Effects Assessment Questions
   - Would the project affect erosion?
   - What is the mechanism for a change in erosion?
   - What specific areas are of interest?
2. How can the proposed change be assessed?
   - Wind & wave analysis
   - Wave run-up modelling
3. Preliminary Findings
   - Preliminary results
   - Examples of erosion control techniques

Erosion – Preliminary Findings

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What is an effects assessment?

An effects assessment predicts likely environmental and socio-economic effects associated with a proposed project, and, taking into account possible mitigation measures, determines the significance of effects.

- Effects assessments include the following steps:
  - Identification of valued ecosystem and socio-economic components
  - Identification of likely affects associated with the proposed project
  - Determine how those valued components may be affected by the project, and possible mitigation measures to reduce potential effects
  - Determination of significance of any residual adverse effects
- In Yukon, projects are assessed by the Yukon Environmental Socio-Economic Assessment Board (YESAB)

Erosion – Preliminary Findings

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Erosion Effects Hypothesis

- To assess proposed project effects on erosion, a hypothesis is developed and tested:

Hypothesis:

- *Sustained higher lake levels in the fall will result in waves occurring at a higher elevations.*
- *Waves at higher elevations will result in erosion where wave run-up reaches or exceeds the elevation of the toe of the bluff that is prone to erosion.*

Erosion – Preliminary Findings

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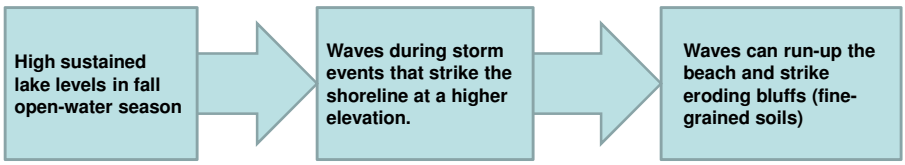
Pathway of Effect



Erosion – Preliminary Findings

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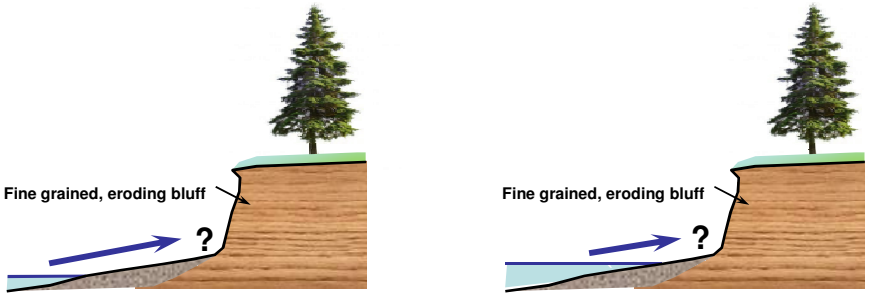
Pathway of the Effect

- Given the relative weak nature of the fine-grained soils in the study area, it is assumed that if waves strike the unprotected bluff, then erosion will occur.



Erosion – Preliminary Findings

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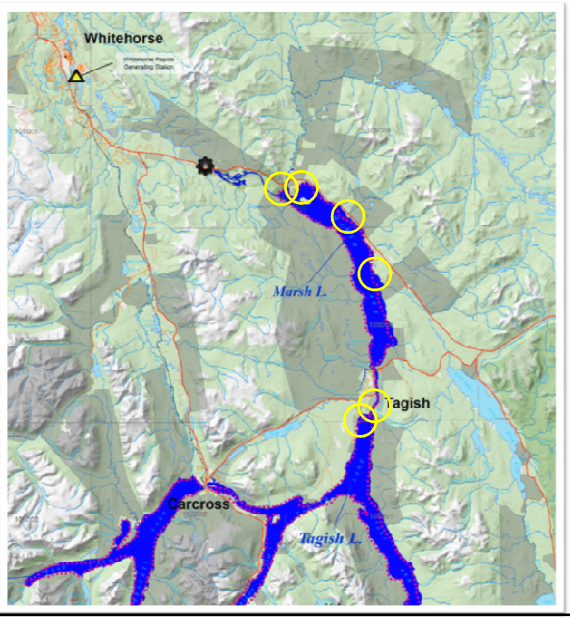
Key Areas of Interest

- North M'Clintock /Swan Haven
- Army Beach
- A location along Alaska Highway
- Portions of Judas Creek
- Portions of Tagish / Taku Subdivision
- Tagish River

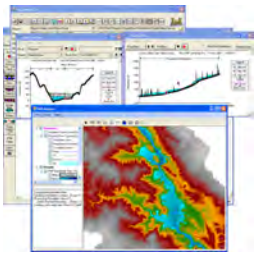


Erosion – Preliminary Findings

AECOM

Assessment of River Erosion Affects

- Bank erosion along the Tagish & M'Clintock Rivers is also being assessed using US Army Corps of Engineer's HEC-RAS model.
- HEC-RAS models the hydraulics of water flow through natural rivers and other channels.
- This work is in progress and results are not yet available.



Erosion – Preliminary Findings

AECOM

Assessment Methodology for Shoreline Erosion

The goal is to determine the wave-run up elevation at sites of interest during October and November under current conditions and under proposed conditions.

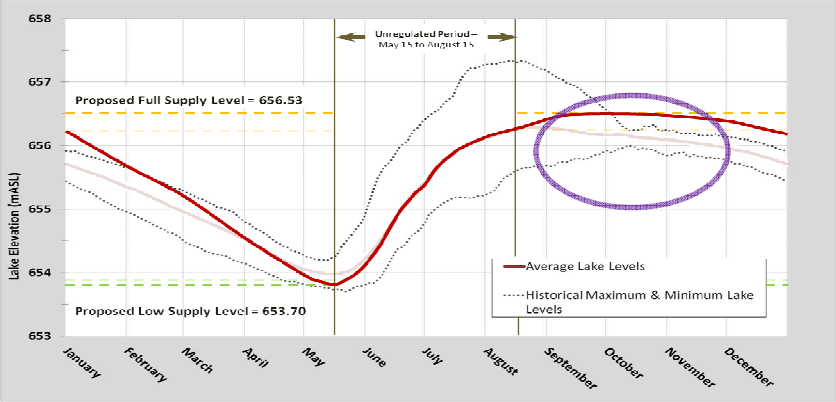
The following steps are undertaken:

1. Compile wind data.
2. Conduct extreme wind analysis and wind directions in fall.
3. Model wind-wave generation for sites of interest.
4. Calculate wave-run up based an shoreline profile and lake elevations.

Erosion – Preliminary Findings

AECOM

- October and November are the key months as this is when the lake levels would experience the most change relative to current conditions, and is the period of highest wind speeds in the open-water season.



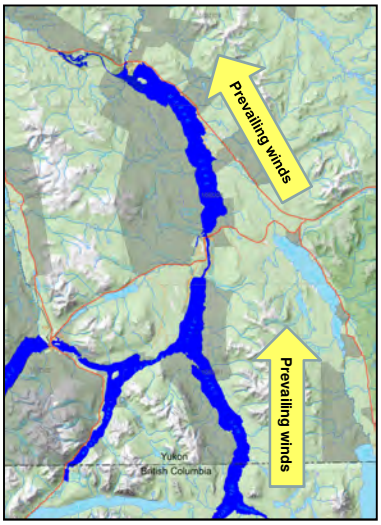
- October average lake levels: Historic 656.14 Proposed: 656.53
- November average lake levels: Historic 656.04 Proposed: 656.45

Erosion – Preliminary Findings

AECOM

Weather Analysis

- Wind Direction
  - Prevailing wind direction and lake orientation
  - How do we use this in model
- Extreme Wind Speed
  - How strong are these winds?
  - How do we utilize in model?

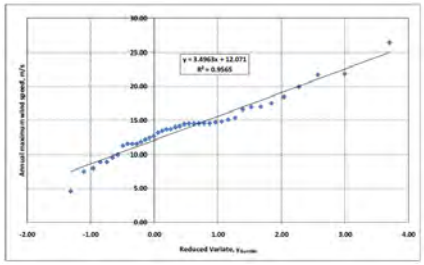


Weather Analysis

Extreme wind analysis for wave modeling

- Analysis conducted for 2, 5, 10 and 50 year storm return interval for October and November using 39 years of weather data from Whitehorse airport.

- Three primary wind directions used in the analysis:
  - 120-150 (wind from the southeast)
  - 150-180 (wind from south)
  - 300-340 (wind from north)



Wind, Waves, Erosion & Accretion
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Weather Analysis

Extreme Wind Speeds:

Table 1 Extreme wind speeds for October

	Sector		
	120°-150°	150°-180°	300°-340°
Return Period (Yr)	Wind Speed (m/s)		
2	13.3	15.6	8.55
5	16.8	18.6	12.1
10	19.1	20.6	14.5
25	22.1	23.2	17.5
50	24.3	25.1	19.7
100	26.5	27.0	21.9

Table 2 Extreme wind speeds for November

	Sector		
	120°-150°	150°-180°	300°-340°
Return Period (Yr)	Wind Speed (m/s)		
2	13.3	16.7	9.4
5	17.3	19.7	13.9
10	20.0	21.6	16.9
25	23.3	24.1	20.7
50	25.8	26.0	23.5
100	28.2	27.8	26.2


Wind, Waves, Erosion & Accretion

AECOM

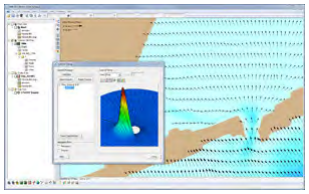
Wave Modelling

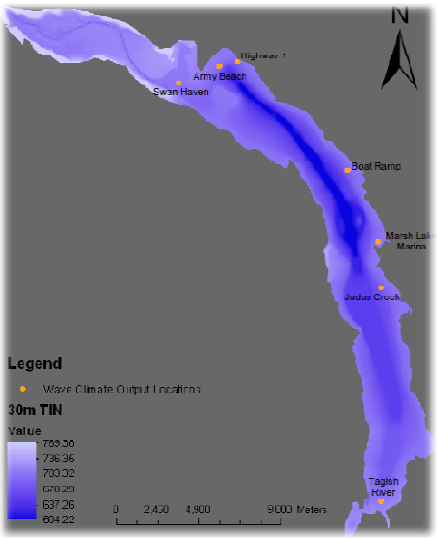
- Purpose of the wave model is to calculate wave heights under different extreme wind speeds with recurrence intervals of 2, 5, 10 and 50 years.
- Current and post project wave conditions can be modeled.
- US Army Corps of Engineers Steady-State Spectral Wave Model (STWAVE) was used.
- STWAVE uses depth-induced wave refraction and shoaling, current-induced refraction and shoaling, depth and steepness-induced wave breaking, diffraction, wind-wave growth, and wave-wave interaction and white-capping that redistributes and dissipates energy in a growing wave field.

Wind, Waves, Erosion & Accretion

AECOM

Wave Modelling






Example of Wave Modelling Results

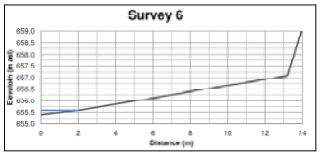
Wave height, in metres.

Return Period (Yr)	Month	Historical or Projected Lake Level	Army Beach				North M'Clintock			
			120-150	% Change	150-180	% Change	120-150	% Change	150-180	% Change
2	Oct	historical	0.57		0.60		0.38		0.29	
		projected	0.58	2%	0.61	2%	0.40	5%	0.29	0%
	Nov	historical	0.57		0.64		0.37		0.31	
		projected	0.58	2%	0.66	3%	0.40	8%	0.32	3%
5	Oct	historical	0.73		0.72		0.39		0.36	
		projected	0.74	1%	0.74	3%	0.47	21%	0.36	0%
	Nov	historical	0.76		0.75		0.41		0.38	
		projected	0.77	1%	0.77	3%	0.48	17%	0.39	3%
10	Oct	historical	0.84		0.79		0.42		0.41	
		projected	0.85	1%	0.82	4%	0.38	-10%	0.41	0%
	Nov	historical	0.84		0.83		0.40		0.43	
		projected	0.85	1%	0.86	4%	0.44	10%	0.44	2%
50	Oct	historical	1.08		0.95		0.49		0.47	
		projected	1.10	2%	0.99	4%	0.51	4%	0.47	0%
	Nov	historical	1.14		0.98		0.52		0.48	
		projected	1.15	1%	1.02	4%	0.54	4%	0.45	-6%

Wind directions:
120-150 – from the southeast
150-180 – from the south


Wave Run-up Modelling

- Beach profiles measured at key sites of interest:
  - North M'Clintock /Swan Haven
  - Army Beach
  - A location along Alaska Highway
  - Portions of Judas Creek
  - Portions of Tagish / Taku Subdivision



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Wave Run-up Modelling

Model output: predicted wave run-up

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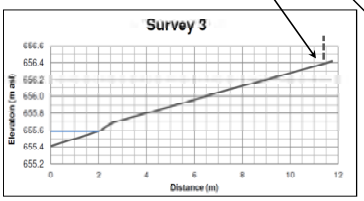
Preliminary Results - North M'Clintock

- Toe of Bluff elevation: 656.42m



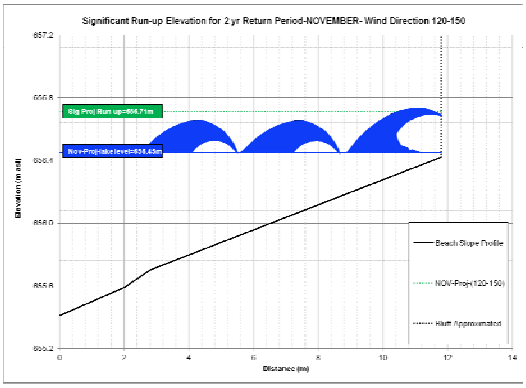
Toe of Bluff

Preliminary Results - North M'Clintock

	Current Conditions		
	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?
October	656.14	656.39	maybe
November	656.04	656.29	no

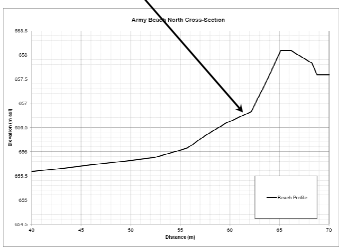
Proposed Conditions			
Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?	Change
656.53	656.79	✓	Yes
656.45	656.71	✓	Yes

Toe of Bluff elevation: 656.42m



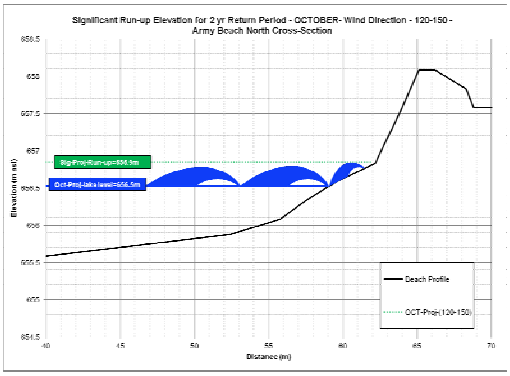
Preliminary Results – Army Beach

- Toe of rip-rap elevation: 656.83m



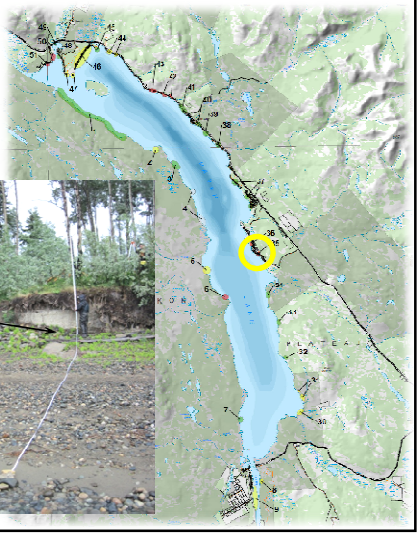
Preliminary Results – Army Beach

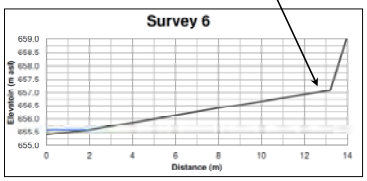
	Current Conditions			Proposed Conditions			
	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?	Change
October	656.14	656.5	no	656.53	656.9	✓	Yes
November	656.04	656.4	no	656.45	656.8	close	no



Preliminary Results – Judas Creek

- Toe of bluff elevation: 657.1m



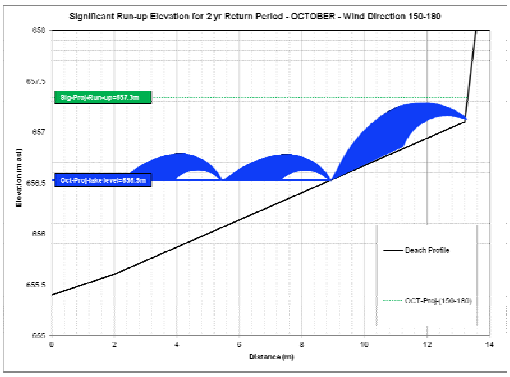


Preliminary Results – Judas Creek

	Current Conditions		
	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?
October	656.14	656.95	close
November	656.04	656.89	no

Proposed Conditions			
Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?	Change
656.53	657.34	✓	Yes
656.45	657.31	✓	Yes

Toe of Bluff elev.: 657.1



Preliminary Results – Judas Creek

	Current Conditions		
	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?
October	656.14	656.95	close
November	656.04	656.89	no

Proposed Conditions			
Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?	Change
656.53	657.34	✓	Yes
656.45	657.31	✓	Yes

Toe of Bluff elevation: 657.1

Judas Creek: 1-in-5 year wave run-up:

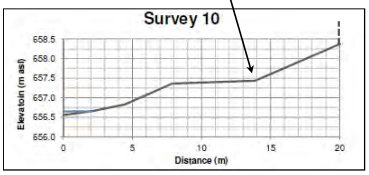
	Current Conditions		
	Average Lake Elev.	1-in-5yr Wave Run-up Elevation	Toe Wetted?
October	656.14	657.14	✓
November	656.04	657.08	close

Proposed Conditions			
Average Lake Elev.	1-in-5yr Wave Run-up Elevation	Toe Wetted?	Change
656.53	657.54	✓	No
656.45	657.5	✓	Yes

Preliminary Results – Tagish/Taku Subdivision- North

- Toe of bluff elevation: 657.4m

Toe of Bluff

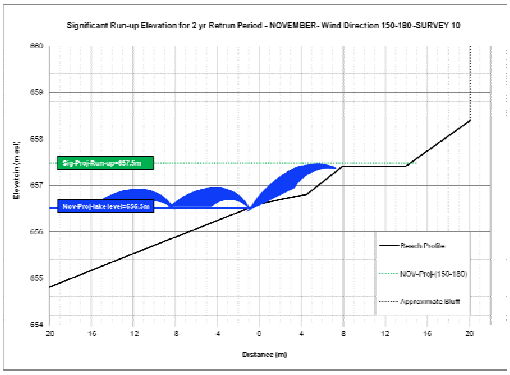


Preliminary Results – Tagish/Taku Subdivision- North

	Current Conditions		
	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?
October	656.14	656.9	no
November	656.04	656.9	no

Proposed Conditions			
Average Lake Elev.	1-in-2yr Wave Run-up	Toe Wetted?	Change
656.53	657.3	close	No
656.45	657.5	close	Yes

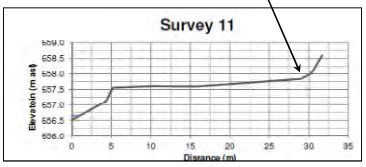
Toe of Bluff elevation: 657.4



Preliminary Results – Tagish/Taku Subdivision- South

- Toe of bluff elevation: 657.8m

Toe of Bluff

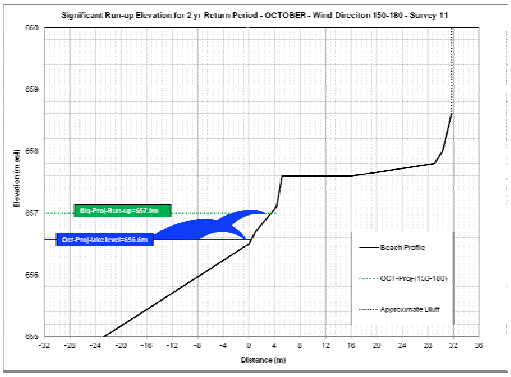


Preliminary Results – Tagish / Taku Subdivision - South

	Current Conditions		
	Average Lake Elev.	1-in-2yr Wave Run-up Elevation	Toe Wetted?
October	656.14	656.6	no
November	656.04	656.4	no

Proposed Conditions			
Average Lake Elev.	1-in-2yr Wave Run-up	Toe Wetted?	Change
656.53	657	no	no
656.45	657	no	no

Toe of Bluff elevation: 657.8



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Summary of Preliminary Findings

- Erosion already occurs in many areas along the lakes, and is an ongoing process. It will continue with or without the fall storage concept.
- Several specific areas have been identified where the combination of erodible soils, orientation, and beach profiles make these areas susceptible to wave-induced erosion at higher lake levels.
- With the project, these specific areas, all of which already experience wave erosion, will experience some increase in erosion.
- There are variety of technically and economically feasible measures used to control erosion. Here are examples.

Army Beach

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North M'Clintock

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South M'Clintock

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Tagish Cemetery

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Other

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Next Steps in the Effects Assessment

- Site-specific analysis where the project effect pathway has been identified to occur in the study area.
- This analysis to include detailed characterization of the effect (frequency, duration, magnitude etc.) under the storage concept, as compared to the existing conditions.
- To determine if and where erosion control measures are appropriate on a site-by-site basis.