From: Sent:	February 7, 2021 9:42 PM
To:	Burgess
Subject:	Re: Burgess 1 Dam EA , Bala ON
Subject.	Ne. burgess i Dain LA, bala ON
Caution! This message was se	nt from outside your organization.
Hi Hope all is well with you	
Wondered if there were any up	odates you might share regarding the Burgess Dam project in Bala.
Thanks	
On Wed Ave 5, 2020 et 11:24	ANA Fred Theorem with a review 207 O greatly agree where
Ok, thanks.	AM Fred Thompson < fthompson887@gmail.com > wrote:
No troubles at all	
Thanks	
On Wed, Aug 5, 2020 at 11:07	'AM Burgess < <u>burgess.ea@tulloch.ca</u> > wrote:
Hello	
	her and mail it out to you. Out of curiosity did you have difficulty with the website? If
there are any issues I would	like to report them to the Township so hopefully we can make it as accessible as possible
Thanks,	
Erik Giles	
Geotechnical P.Eng	
Project Manager	

Jackson Mercer



Tel: 705 789 7851 x438

Fax: 705 789 7891

TULLOCH Engineering Inc

80 Main St. West, Huntsville, ON P1H 1W9

erik.giles@TULLOCH.ca | TULLOCH.ca

Fror

Sent: August 4, 2020 6:25 PM

To: Burgess < burgess.ea@tulloch.ca > Subject: Burgess 1 Dam EA, Bala ON

Hello

Please mail me a hard copy of presentation and comment card to;

Thanks

--

Thanks,

--

Thanks,

Thanks,

Jackson Mercer

From: Burgess

Sent: July 4, 2021 8:49 PM

To:

Subject: RE: Burgess Hydro Plant Rehab

Thank you for expressing interest in the project. Yes currently we are in the process of the Environmental Assessment for Burgess. We are currently in the process of collecting the survey data polled from those who answered the online surveys and in the process of presenting our findings to the Township of Muskoka Lakes Council. We will be posting a notice of completion which will show all of our findings as well as our report which will be available to the public as per the Schedule B process.

To answer a few of your questions, there are currently two turbines in the plant, one of which was installed circa 2012 by the current tenant and the other turbine, the age is not exactly known however it is an older style francis turbine likely nearing the end of its design life.

Flow available to burgess dam is based on the allotment for the facility from the current operating agreement for the Muskoka watershed which is 4 m^3/s the 0.14 MW is the current combined capacity of the plant at this time.

There is also an FAQ page you may find useful which you can find here

https://engagemuskokalakes.ca/burgess-1-dam-environmental-assessment-study/widgets/62333/faqs

Warm Regards,

-----Original Message-----

From

Sent: July 3, 2021 9:29 AM

To: Burgess <burgess.ea@tulloch.ca> Subject: Burgess Hydro Plant Rehab

Visiting Balla on June 25, we noticed the new Hydro Plant, not generating, yet the Burgess Dam was operating. Saw the Tulloch sign re the EA process. I had not been aware of this process till now. Visited the website which was interesting. Also read the inspection report by Erik Giles, which is excellent engineering. Please note that on sketches the Tailwater elevation is incorrectly stated as 200.09 m - should be 220.09!!

In the report it says that plant is rated at 0.14 MW? Is that one turbine. How old is that equipment? There seems to be no mention of what flow is available to this plant and whether that water right expires in the future.

I recall the opposition to the redevelopment of Bala Falls, and am pleased that common sense prevailed. I would hope that redevelopment of Burgess will also be successful

From the 4 alternatives, which one is now recommended and what is the status of the current process.

I have worked for Acres since 1962, on many hydro plants throughout Canada and overseas, mostly very large turbines and am still interested in what happens in Ontario. Just toured the Canadian Niagara (Rankin) plant which I had been involved with over the years and now just opened as a museum.

Hope to hear back.

Sent from my iPad

Jackson Mercer

From:

Sent: October 25, 2021 11:54 AM

To: **Burgess**

Subject: RE: Burgess Dam Rehabilitation/Replacement

Warning! This message was sent from outside your organization and we are unable to verify the sender.

Thank you













From: Burgess <burgess.ea@tulloch.ca> Sent: Monday, October 25, 2021 11:37 AM

Subject: RE: Burgess Dam Rehabilitation/Replacement

Hello

Please forgive me for the delay on this reply, the preferred option is still under discussion with the Town of Muskoka Lakes at this time. TULLOCH presented the feedback from the survey and studies conducted for the EA for the council meeting conducted on October 13th, 2021.

Thank you,

From:

Sent: October 5, 2021 1:07 PM

To: Burgess < burgess.ea@tulloch.ca >

Subject: Burgess Dam Rehabilitation/Replacement

Warning! This message was sent from outside your organization and we are unable to verify the sender.

Good afternoon,

Can you please tell me if a preferred option has been selected for the Burgess Dam project and when it may be presented to the General/Finance Committee?

Thank you,













Jackson Mercer

From: Burgess

Sent: August 17, 2020 10:38 AM

To:

Cc: Tim Sopkowe; Burgess

Subject: RE: Burgess EA

Attachments: burgess presentation notes.pdf

First off I would like to thank you for your interest in this project and I hope you fill find the following satisfactory. I understand that the video is pretty quick, I have attached a pdf of the slideshow so you can perhaps review the drawings more thoroughly. We do not at present have photo mock-ups of the proposed design as we are still in the preliminary/planning phase. However, having said that, it is likely if an emergency spillway were to be selected for implementation as part of one of the larger planning alternative solutions that it would have to go along the south side of the property south of the powerhouse section as the site is not very big and that is the only real spot where a spillway could be feasibly constructed. This concept is illustrated on slide 23 in the attached PDF.

Our intent at this point is to not change the water flow directly downstream of the Burgess Dam but to retrofit the dam to address overtopping issues.

Thank you very much for your interest in this project. I would also like to direct you to the Township of Muskoka Lakes FAQ page that may also help answer any other questions you may have.

https://engagemuskokalakes.ca/burgess-1-dam-environmental-assessment-study/widgets/62333/fags#guestion1097

This page is also updated regularly to reflect new questions and aspect of feedback that we have received so far in this process.

Kind Regards,





Tel: 705 789 7851 x438 Fax: 705 789 7891

TULLOCH Engineering Inc 80 Main St. West, Huntsville, ON P1H 1W9 erik.giles@TULLOCH.ca | TULLOCH.ca

From:

Sent: August 12, 2020 9:00 PM **To:** Burgess <burgess.ea@tulloch.ca>

Subject: Burgess EA

Do you not have actual photos of the area to be designed as the spillway for a fixed damsite? I know the area and walked there recently but am having difficulty interpreting the drawings.

I am also interested in the guaranteed flow for the 'creek/falls' into the Moon under a fixed dam scenario.

Thank vou



Sent from Mail for Windows 10

Jackson Mercer

From:

Sent:

July 24, 2020 9:38 AM

To:

Subject:

Here is another response for the EA. I am not sure this requires a response as much as this is to be included in public comment. We will have to sort it out as we go. Maybe next week once we have had a few responses come in and work out some of these kinks (which I expected since it is the first time we have used this tool) we can have a chat to streamline our process for the this phase of the study. I think a quick phone call between us we should be able to come up with a plan.

Give me a call anytime next week -



Sincerely,



E-Mail Confidentiality Disclaimer

This communication is intended solely for use by the individual(s) to whom it is specifically addressed and should not be read by, or delivered to any other person. Such communication may contain privileged or confidential information that may be exempt from disclosure. If you have received this communication in error, please notify my office by phone at 705-765-3156 and permanently delete this communication. Thank you for your cooperation.

From:

Sent: Friday, July 24, 2020 9:17 AM

To:

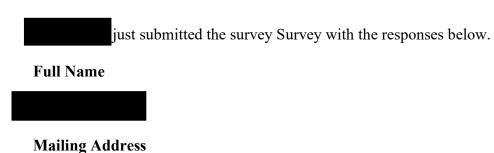
Subject:

From: Engage Muskoka Lakes < notifications@engagementhq.com >

Sent: Friday July 24, 2020 8:11 AM

To:

Subject



Email

Phone Number

Which alternative solution do you prefer?

Rehabilitate Dam and Powerhouse

Comments

Please replant and landscape for future generations. I have lived in Bala all my life and always swam at the falls. I am not able to access the water with new Hydro Dam it would have been nice if they had considered that as part of the design. Also the new building totally blocks the sunset when you come around bend from Purkes place. Please put a lot more consideration on landscape.. Hire a good landscape architect.. like a really good one. Deal with this new dam and problems with the most recent hydro installation

This email was Malware checked. Township of Muskoka Lakes

Jackson Mercer

From:

Sent: July 24, 2020 9:33 AM

To:

Burgess

Subject:

FW: RIverwood completed Survey

Here are some questions from the website. I am going to address the concerns about the survey response and not being able to submit questions without submitting a survey today and see if we can change this feature around to allow questions and comments without completing the survey.

Sincerely,



E-Mail Confidentiality Disclaimer

This communication is intended solely for use by the individual(s) to whom it is specifically addressed and should not be read by, or delivered to any other person. Such communication may contain privileged or confidential information that may be exempt from disclosure. If you have received this communication in error, please notify my office by phone at 705-765-3156 and permanently delete this communication. Thank you for your cooperation.

From

Sent: Friday, July 24, 2020 9:17 AM

Td

Subject: FW:

completed Survey

From: Engage Muskoka Lakes < notifications@engagementhq.com >

Sent: Friday, July 24, 2020 6:57 AM

Subject: completed Survey

ust submitted the survey Survey with the responses below.

Full Name

Mailing Address

Email

Which alternative solution do you prefer?

Rehabilitate Dam and Powerhouse

Comments

What is missing in this is information on how much power and revenue the existing dam generates, how much power/revenue would be created in each option, estimated cost to undertake the alternatives, where the power generated goes (does Bala benefit directly), how does this power generating station work in conjunction with the new dam. Would the dam continue to be owned by the township and leased out or could it be sold? The greatest impact from this dam would be felt by those on the Moon River, especially if it fails and yet the emphasis (wording) seems more concerned with those on Lake Muskoka. It is a comprehensive presentation, clearly outlining initial options but does not provide sufficient information for residents to have good input. NOTE that in order to complete the survey i had to cast a vote BUT I am having to do so with incomplete data which is not correct. Therefore my vote should not be counted or considered accurate. I would appreciate answers to the questions raised above. Thank you.

This email was Malware checked. Township of Muskoka Lakes From:

Sent: October 22, 2020 7:52 PM

To: Burgess

Subject: Burgess 1 dam

I might be mistaken but I thought you guys were going to share the results of the survey in September.

Any updates on the feasibility study for each option? Thanks.

Regards,

APPENDIX H

Council Presentation



ENGINEERING



MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT BURGESS 1 DAM

20-1051

Introduction - Project Location

 The Township of Muskoka Lakes (TML) has retained TULLOCH Engineering to conduct a Municipal Class Environmental Assessment (EA) for the Burgess 1 Dam located in Bala, Ontario.





What is an Environmental Assessment?



A planning procedure/tool that looks at potential impacts caused by the project and how to mitigate them

Communities

Environment/wildlife

Economic

Culture/Heritage

Public Safety



Allows for consultation of regulating bodies and the community for input into planning and design solutions

Members of the community

Regulatory bodies such as MNR, MECP, MTO



Standardized procedure that is repeatable and meets regulatory requirements that is tailored to individual projects

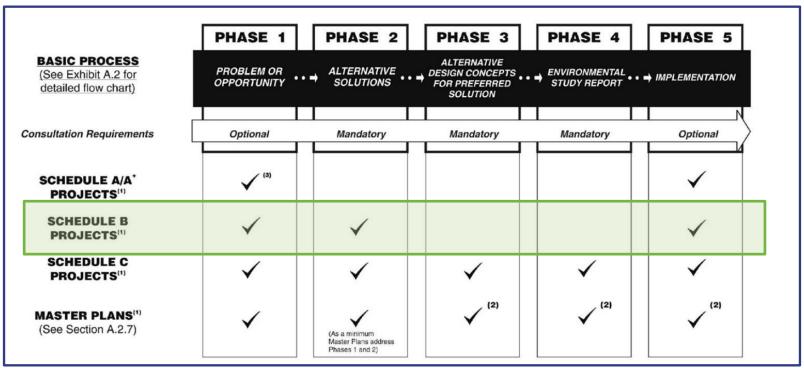


EA Class Schedules

B – Burgess Dam **A**+ Α - Generally includes - Similar to Schedule A - Generally includes - Generally includes the improvements and minor construction of new facilities normal or emergency Projects are Pre-approved expansions to existing facility operational and and major expansions to - Public to be advised maintenance activities existing facilities - Potential for some adverse prior to implementation environmental impacts - Minimal of project - These projects proceed - Proponent required to through the full environmental impacts proceed through screening environmental assessment - Pre-approved process including planning process consultation with affected parties



Schedule B EA Process





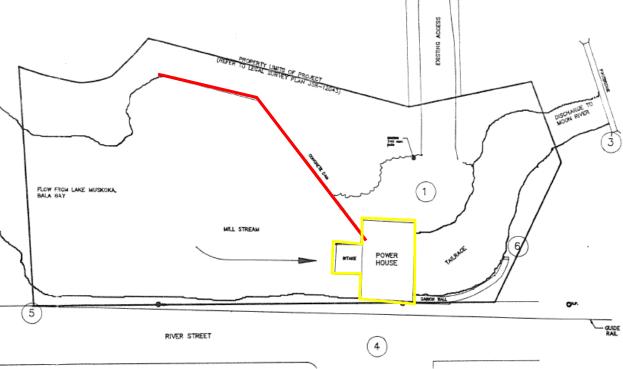
Burgess 1 Dam Facility Overview

- The dam runs approximately 59 m

 Dam terminates on natural ground to the south and River Street to the north

Dam consists of two sections:

- Non-Overflow
 - Concrete retaining structure
 - Approximately 3 m high
 - Founded on bedrock
- Powerhouse Section
 - 9 m X 14 m building constructed into the dam containing turbines





Burgess 1 Dam – Spring 2019 Event

- Flooding event of spring 2019 caused overtopping of the dam
- Emergency actions were taken and flooding event was mitigated
- This event triggered a Dam Safety Review for the Burgess Dam Facility





Burgess Dam – Dam Safety Review

Township retained TULLOCH Engineering to conduct a Dam Safety Review for Burgess 1 Dam

Deficiencies were noted and recommendations for improvement made for the facility

Major recommendations include:

- Improve facility to handle higher water levels
- Aging infrastructure requiring rehabilitation or replacement

The Township chose to complete a Municipal Class EA Study for the Burgess Dam to begin the process of public consultation and implementation of recommendations in a transparent manner

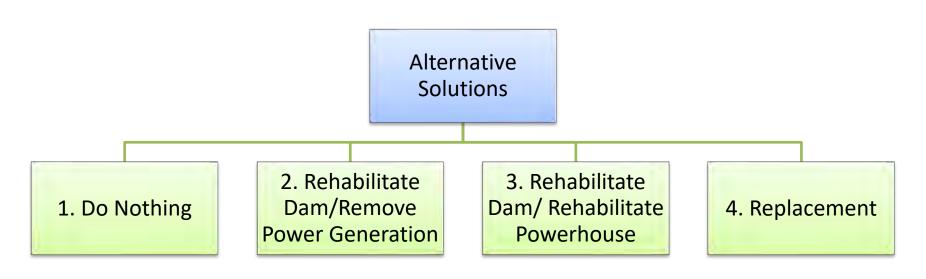


Phase 1– Problem Statement

In the spring of 2019, the Burgess 1 Dam experienced an overtopping event caused by flooding of the Muskoka watershed upstream of the facility that put the dam at risk. A Dam Safety Review conducted in the summer of 2019 determined safety concerns with respect to dam stability and capacity to withstand a similar event. Failure of the Burgess 1 Dam would result in significant loss of water control upstream affecting Lake Muskoka and its residents, furthermore, failure of the dam could result in property damage and risk to public safety downstream of the facility along the Moon River. The Township of Muskoka Lakes is considering replacement or rehabilitation of the Burgess 1 Dam.



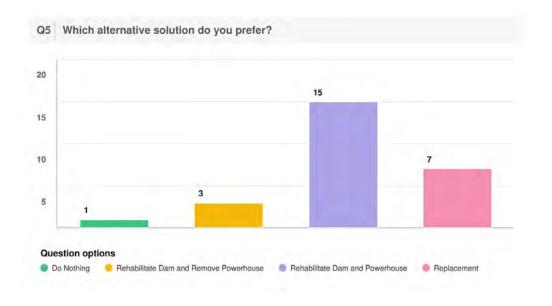
Phase 2 - Alternative Solutions





Public Feedback

- Virtual PIC held on Engage
 Muskoka lakes webpage
- Survey distributed most popular response was Option 3: Rehab Dam and Powerhouse
- General Comments included
 - Rehab and continue power generation if economically responsible
 - General support for green energy
 - Fix safety issues of the dam
 - Water should not be allowed to stagnate in tailrace





Cultural Heritage Evaluation Report

- Cultural Heritage Evaluation Report conducted by Horizon Archaeology Inc based in North Bay, Ontario
- Site visit conducted on May 6th, 2021
- CHER included historical document review of publicly available data as well as requested reports provided by TULLOCH
- Summary of findings:
 - Burgess Dam meets criteria for being included in Ontario Heritage Act Register
 - Façade and shell of building should be preserved if possible as there have only been minor modifications such as the head gate and new windows
 - The interior has been altered beyond any historic or cultural value
 - The original William Hamilton Turbine should be preserved if possible either in place or somewhere which may be able to use it for cultural or historical purposes such as a display or in a local museum.



Environmental Impact Assessment

EIA conducted to assess potential habitat and ecological impact of rehabilitation

Field visit conducted May 6, 2020

- Potential Habitat for Species at Risk exists – Barn Swallow
- Spawning habitat for Walleye and White Sucker observed downstream, White Sucker Spawning Observed 5-10 m downstream of dam

Final Summary

- Any vegetation removal/clearing should be outside of the General Nesting Periods
- In water work will required DFO approval, must be isolated with fish salvage and MRFO in-water timing guidelines should be followed.





Turbine/Mechanical and Electrical Assessment

- NORCAN Hydraulic Turbine Inc. was retained to conduct a condition assessment of the turbine and power generating equipment at Burgess. Site visit conducted March 2021
- Key findings:
 - Generally site in fair to poor safe condition
 - Head gate and trash rack in good condition upgraded by KRIS Power.
 - Original Francis turbine surpassed manufacturer's life expectancy, typically "run to fail"
 - Further detailed inspection recommended including review of internal parts/electronic control equipment
 - Replacement of new equipment ~ \$800,000 investment
 - Replacement might be replacing dual turbines with single Kaplan style turbine, replacement of turbine would be most cost effective during civil/structural upgrades.
 - New equipment if properly maintained could have a design life of up to 50 years.



Economic Analysis Part 1

- ROI on continued power generation is highly dependent upon rate paid per kwhr and the number of operable days per year
- Estimated Capital Costs
 - From DSR Conceptual Civil Costs \$775,000
 - From NORCAN Report Turbine Replacement \$800,000
 - Total Estimated Capital Cost = \$1,575,000
- Estimated Maintenance Costs
 - 20% of annual Revenue
 - Estimated \$15,000 annually in Dam Maintenance/property upkeep
 - \$15,000 every 10 years for turbine maintenance



Generation Capacity vs. Energy Production							
Scenario Inoperable Days Energy Production (kW – hrs)							
Conservative	170	680,000					
Average	69	1,040,000					
Optimistic	25	1,190,000					

Annual Generation Revenue							
Scenario	Typical Hydro Rate (¢ 8/kW -hr)	Solar Rate (¢ 10/kW-hr)	FIT Rate (¢ 24.1/kW-hr)				
Conservative	\$ 54,300	\$ 68,300	\$ 163,880				
Average	\$ 82,800	\$ 103,500	\$ 250,640				
Optimistic	\$ 95,300	\$ 68,300	\$ 286,790				

Return On Investment in Years							
Scopario	Typical Hydro Rate	Solar Rate	FIT Rate				
Scenario	(¢ 8/kW -hr)	(¢ 10/kW-hr)	(¢ 24.1/kW-hr)				
Conservative	40	30	13				
Average	25	20	8				
Optimistic	22	16	7				



Assessment of Alternatives: Weighted Evaluation Matrix

Evaluation Criteria	Weighting	Option 1: Do Nothing	Option 2: Rehab Dam Remove Power	Option 3: Rehab Dam/Rehab Powerhouse	Option 4: Replace Replacement
Public Input/Social Environment	15	1	2	4	3
Cultural Heritage	10	2	3	4	1
Natural Environment	15	4	2	3	1
Public Safety	30	1	3	2	4
Economic Impact	20	4	3	2	1
Physical Environment	10	1	3	4	2
TOTAL	100	215	270	285	230



Recommendations

- Public Input Option 3
- CHER Option 3 Plus maintain building façade and cultural value of original turbine
- EIA Maintain water flow, and rehabilitate, Option 2 or 3 feasible under conditions of EIA
- Condition Assessment Option 3 financial case for continued power generation given appropriate investment and care/maintenance
- Economic Analysis Option 3 Given the typical current hydro rate of 8¢/kw-hr and the conservative case of operating days the ROI would be 40 years, if design is for a 50 year lifespan there is an economic case that recouping the initial investment is feasible.
- Key item is to address Dam Safety Issues to prevent overtopping or possible failure, rehabilitation of dam can be done with either Option 2 or 3 however there may be an economic case given the possible return period for continued power generation either through a well managed lease agreement or possible sale after completion of upgrades.
- Overall, based on public and stakeholder feedback the general consensus would be to rehabilitate the dam and powerhouse while maintaining power generation – Option 3



	Burgess Class EA - Financial Overview										
No.		Item		Option 1 Do Nothing		Option 2 Rehab Dam/ Remove Generation		Option 3 Rehab Dam/ Rehab Generation		Option 4 Replacement	
	1	Engineering and Design									
	1.1	Detailed Design	\$	-	\$	120,000.00	\$	160,000.00	\$	480,000.00	
	1.2	Schedule C EA	\$	-	\$	-	\$	=	\$	100,000.00	
	1.3	SUBTOTAL	\$	-	\$	120,000.00	\$	160,000.00	\$	580,000.00	
	2.0	Capital Construction Costs									
	2.1	Estimated Civil Works	\$	-	\$	775,000.00	\$	775,000.00	\$ 4	4,000,000.00	
	2.2	Estimated Turbine Works	\$	-	\$	400,000.00	\$	800,000.00	\$	800,000.00	
	2.3	SUBTOTAL	\$	-	\$	1,175,000.00	\$	1,575,000.00	\$4	1,800,000.00	
	3.0	Construciton Admin and Inspection									
	3.1	Third Party CQA	\$	-	\$	120,000.00	\$	160,000.00	\$	480,000.00	
	3.2	SUBTOTAL	\$	-	\$	120,000.00	\$	160,000.00	\$	480,000.00	
	3.3	Contingency (25%)			\$	353,750.00	\$	473,750.00	\$1	1,465,000.00	
	3.3	TOTAL ESTIMATED CAPITAL COSTS (+/-25%)	\$	-	\$	1,768,750.00	\$	2,368,750.00	\$7	7,325,000.00	
	4.0	Annual Operating Maintenance and Revenue									
	4.1	Estimated Annual Civil Maintenance	\$15,00	00.00	\$	15,000.00	\$	15,000.00	\$	10,000.00	
		Estimated power generation cost (~20% of average									
	4.2	generating revenue)	\$	-	\$	-	\$	17,000.00	\$	17,000.00	
	4.3	Annual Turbine Maintenance	\$	-	\$	=	\$	3,000.00	\$	3,000.00	
	4.4	10 Year Turbine Maintenance	\$	-	\$	-	\$	15,000.00	\$	15,000.00	
	5.0	Estimated Annual Revenue									
	5.1	Annual Revenue (Average Case)	\$ 1,50	00.00	\$	-	\$	83,000.00	\$	83,000.00	

Exclusions:

- -Environmental Permitting Costs
 Land Acquisition
 Financing/IDG
 Owner's Costs

- Bonding and Insurance

	TULLOCH			Financial Overview of Alternative Solutions				
PROJECT:	20-1051	DATE:	Oct-21	Purgosa 1 Dam Environmental Assessment	Figure 1			
DESIGN:	EG	REV:	А	Burgess 1 Dam - Environmental Assessment Figure				

APPENDIX I

Preliminary Design Memo



80 Main St. W. Huntsville, ON P1H 1W9 T. 705 789.7851 F. 705 789.7891 TF. 877 535.0558 huntsville@tulloch.ca

www.TULLOCH.ca

20-1051 November 17, 2022

Township of Muskoka Lakes 1 Bailey Street Port Carling, ON P0B 1J0

Attention: Ken Becking, P.Eng. | Director of Public Works

CC: Tim Sopkowe C.E.T.

RE: Burgess 1 Dam Preliminary Design Brief Memo

Dear Mr. Becking,

This memorandum documents TULLOCH's design process for rehabilitation and improvement of the Burgess 1 Dam facility which comprises a small two (2) turbine generating station including a concrete powerhouse and concrete gravity dam which is located in Bala, Ontario adjacent to the North and South Bala Falls Dams. This memorandum will discuss the preliminary design intent, hydraulic and stability modelling for the dam and north slope wall, design upgrades, estimated quantities and costing.

1. BACKGROUND INFORMATION

In the Spring of 2019, the Burgess 1 Dam experienced an overtopping event caused by flooding of the Muskoka watershed upstream of the facility that put the safety of the dam at risk. A Dam Safety Review (DSR) in the Summer of 2019 was conducted by TULLOCH (TULLOCH Doc No. 19-1493-20-2050-0001) which determined safety concerns with respect to dam stability and capacity to withstand a similar or larger flood event in the future. Recommendations were made to replace or rehabilitate the existing facility to handle extreme flood events and improve the stability of the water retaining structure. A Municipal Class Environmental Assessment Schedule B Study (EA) was conducted starting in February of 2020 with the goal of evaluating and assessing the various proposed alternative solutions while encouraging public and agency feedback for the project. Four (4) alternative solutions were proposed to the Township and stakeholders for evaluation to address the recommendations made within the DSR. The project file report for the EA Project File Report was submitted in the Fall of 2022 (TULLOCH Doc No. 20-1051-2050-0003). The preferred solution chosen through the EA study was rehabilitation of the existing Dam and Powerhouse.

2. DESIGN INTENT

Major deficiencies identified for the Burgess 1 Dam during the 2019 DSR included an inadequate factor of safety against sliding and overturning for the gravity dam, absence of an emergency



spillway/inadequate capacity to pass flood flows, and the poor condition of the powerhouse. A visual assessment of the powerhouse was also conducted by TULLOCH's structural engineers who observed that the powerhouse was noted to have a longitudinal crack through the foundation, severe corrosion to the existing steel reinforcing frame, over spanned interior timber bearing line, and inadequate roof framing which was observed to be over spanned. The 2019 DSR also noted stability issues with the north slope directly downstream of the dam including the poor condition of the existing gabion baskets forming the toe of the north slope, and potential instability of the retaining wall adjacent to the powerhouse. An additional geotechnical investigation was conducted, and the findings are outlined in the report attached to this memorandum (TULLOCH Doc. No 20-1051-2050-0002).

The proposed rehabilitation measures of the Burgess 1 Dam are designed to address the safety concerns regarding stability and flow discharge capacity of the dam under a design flood event to prevent uncontrolled overtopping of the dam. The partial dam raise of 0.6 m meets the Inflow Design Flood (IDF) level of the structure with approximately 100 mm of additional freeboard. Raising the dam will allow for the IDF level to be retained without overtopping to allow time for the peak flood flows to be passed by the larger North and South Bala Falls Dams per the Muskoka River Dam Operation Manual.

In the event of water level rising above the IDF level, the existing non-overflow section of the gravity dam adjacent to the powerhouse will be upgraded to an overflow structure. This upgrade will allow flood flows to pass over the dam crest and then be diverted to the downstream main river channel. A designated spillway was initially discussed during the conceptual design phase in the 2019 DSR, however, due to limited space an overflow design was adopted. The downstream overflow path will be confined by the proposed south control berm and the left concrete wall of the powerhouse. The overflow will be designed and diverted to the main tailrace channel. Reinstatement of downstream fill material with rockfill erosion protection against the dam will improve the factor of safety against sliding and overturning, as well as to prevent downstream erosion under overflow flooding conditions.

Mitigation measures to the powerhouse structure should include foundation slab anchoring and grouting to reconnect the two broken halves, concrete infill for the undermining observed below the powerhouse, steel reinforcing frame replacement, interior bearing line replacement, removal and replacement of existing roof framing, and upgrades to the tailrace apron and walls.

The north slope improvements include an anchored concrete wall extending beyond the tailrace apron to act as both a retaining wall against the north slope as well as a training wall for the powerhouse to prevent future erosion of the toe from operational flows. The wall will be backfilled with free draining fill materials and should have drainage outlets which will improve factor of safety to meet the design criteria.

Preliminary design drawings are provided for the civil and structural rehabilitation of the Burgess 1 Dam attached to this memorandum. At this time mechanical and electrical drawings and



rehabilitation of the power generation equipment are considered out of TULLOCH's scope and should be considered in the Detailed Design Phase of the project, budgetary costing for replacement of the turbine has been included based on NORCAN's Turbine assessment which was included in the EA Project File Report.

3. HYDRAULIC AND STABILITY MODELLING

The Inflow Design Flood (IDF) for the Burgess 1 Dam is defined as 1/100-year return flood for Lake Muskoka of 226.49 m as defined in the Muskoka River Dam Operation Manual. This was used as a basis for hydraulic and stability modelling exercises. Riprap sizing calculations were completed for the downstream side of the overflow dam section which is designed to overtop and pass IDF flows. Based on the preliminary design, riprap gradation was determined, and is presented in Table 3-1 below.

Table 3-1: Downstream Riprap Sizing

Riprap Gradation	Riprap Diameter (m)
D100	1.43
D85	1.17
D50	0.84
D15	0.5

Stability modelling was completed for the preferred option, including the non-overflow dam section and north slope retaining wall. Table 3-2 and Table 3-3 show factors of safety associated with various case conditions for the dam non-overflow section and Table 3-4 shows factors of safety for the preliminary design of the north slope retaining wall. The factors of safety for the proposed dam and north slope upgrades all meet or surpass the design requirements.

Table 3-2: Slope Stability Summary for Non-Overflow Dam Section

Case	Water Level	Seismic Consideration	Failure Direction	Required FS	Calculated FS
1	Upper NOL ¹	No	US to DS	1.5	1.5
2	Lower NOL ¹	No	DS to US	1.5	12.2
3	Upper NOL ¹	Yes	US to DS	>1.0	1.4
4	Lower NOL ¹	Yes	DS to US	>1.0	11.8
5	IDF	No	US to DS	1.3	1.5

Note(s): 1 NOL = Normal Operating Level



Table 3-3: Block Stability for Non-Overflow Dam Section

Case	Phreatic Condition	Seismic Consideration	Failure Direction	Failure Condition	Required FS	Calculated FS
1	Upper NOL1	No	US to DS	Sliding	1.5	6.7
'	Upper NOL ¹	INO	03 10 03	Overturning	2.0	5.1
2	Lower NOL1	No	DC to LIC	Sliding	1.5	3.3
2	Lower NOL ¹	No	DS to US	Overturning	2.0	2.0
2	Linnar NOL 1	Vaa	LIC to DC	Sliding	1.3	6.7
3	Upper NOL ¹	Yes	US to DS	Overturning	1.3	5.1
4	Lower NOL ¹	Yes	DC to LIC	Sliding	1.3	2.5
4	Lower NOL	res	DS to US	Overturning	1.3	1.3
F	IDE	No	LIC to DC	Sliding	1.3	3.6
5	IDF	No	US to DS	Overturning	1.3	2.2

Note(s): ¹NOL = Normal Operating Level

Table 3-4: North Slope Retaining Wall Preliminary Design Block Stability

Failure Condition	Required FS	Calculated FS
Sliding	1.5	1.71
Overturning	2.0	2.04

4. QUANTITIES AND COSTING

Material quantities were estimated for the Burgess 1 Dam upgrade design with unit prices applied to each quantified item. The total construction cost for the Burgess 1 Dam Upgrades and Rehabilitation is estimated at \$2,599,680.00. The above cost estimate excludes, land acquisition, financing, owner costs, bonding and insurance.

5. CLOSURE

The findings of the Design Memorandum for improvement of the Burgess 1 Dam located in Bala, Ontario have been prepared by TULLOCH Engineering in consultation with the Township of Muskoka Lakes. This memorandum has been prepared for the exclusive use of the Township of Muskoka Lakes and their authorized agents.



We trust that the information in this report will be sufficient to allow the Township to proceed with the project. Should further elaboration be required for any portion of this project, we would be pleased to assist.

Sincerely,

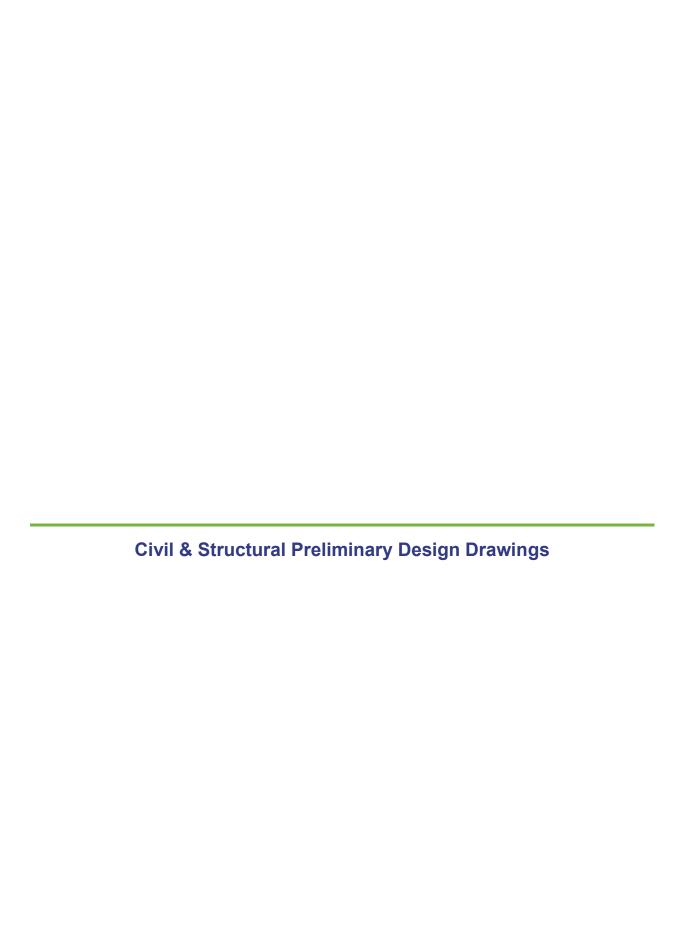
Kelvin Cheung, B.Sc., EIT. Engineer in Training

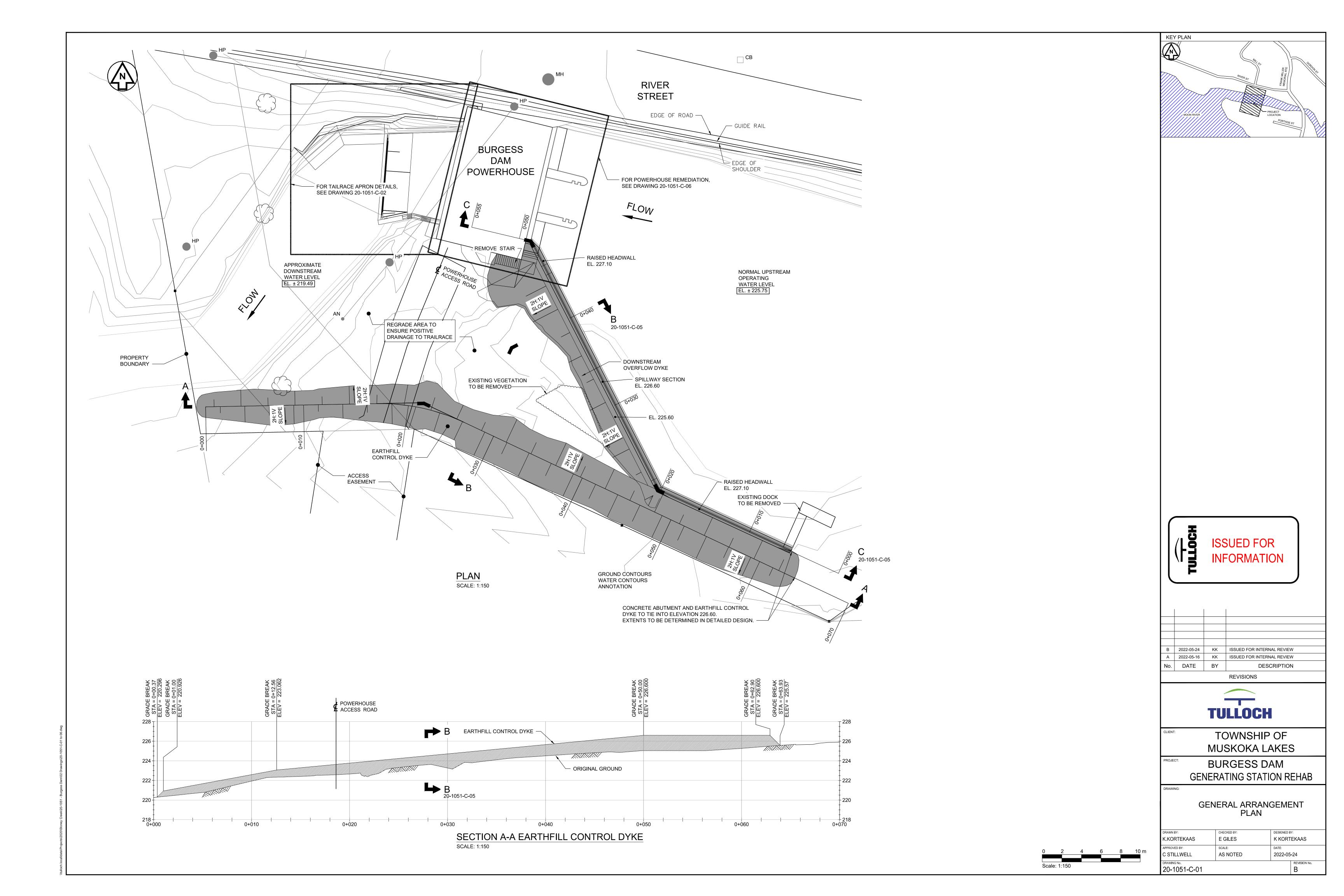
Erik Giles, P. Eng.

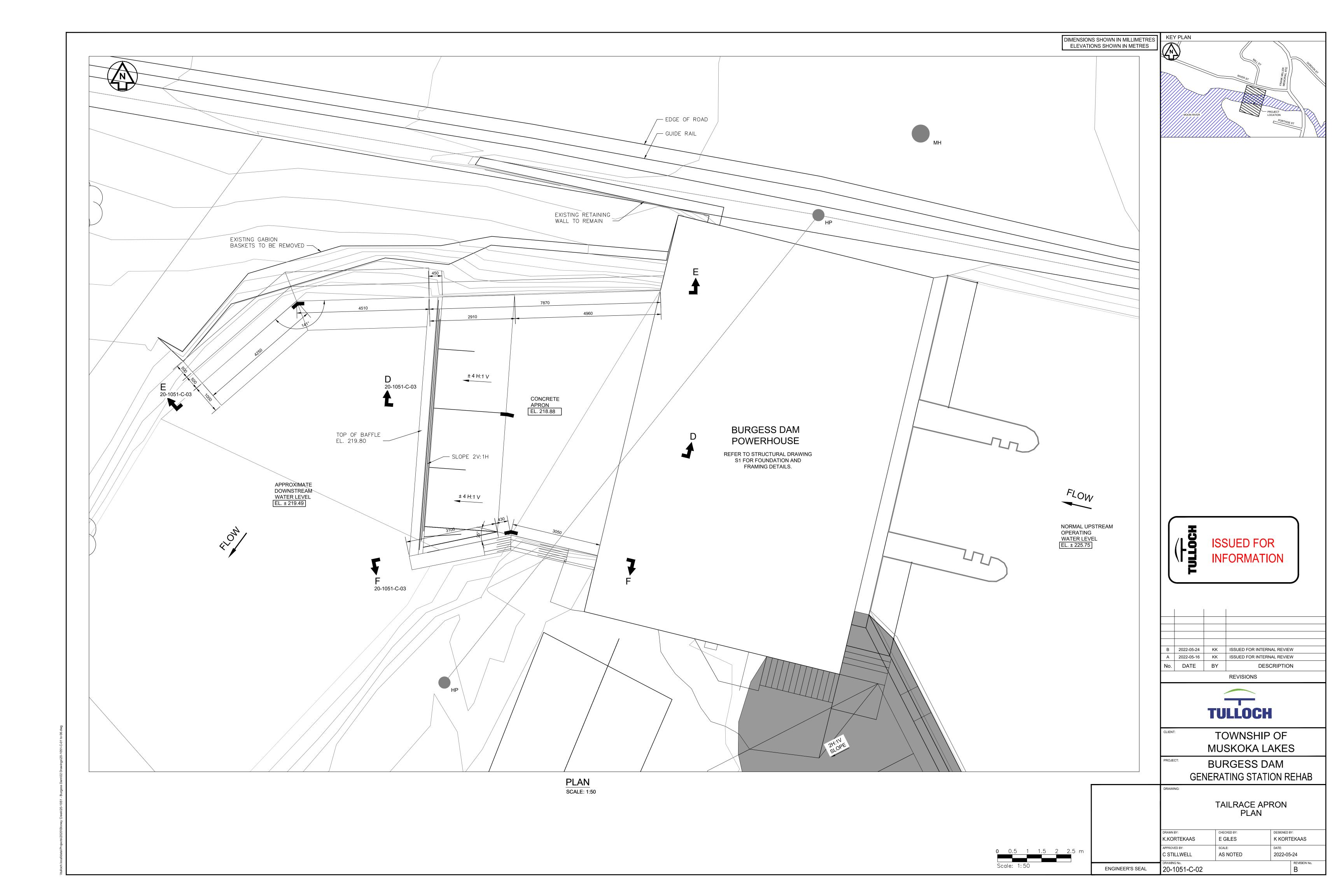
Erik Giles, P. Eng. Geotechnical Engineer

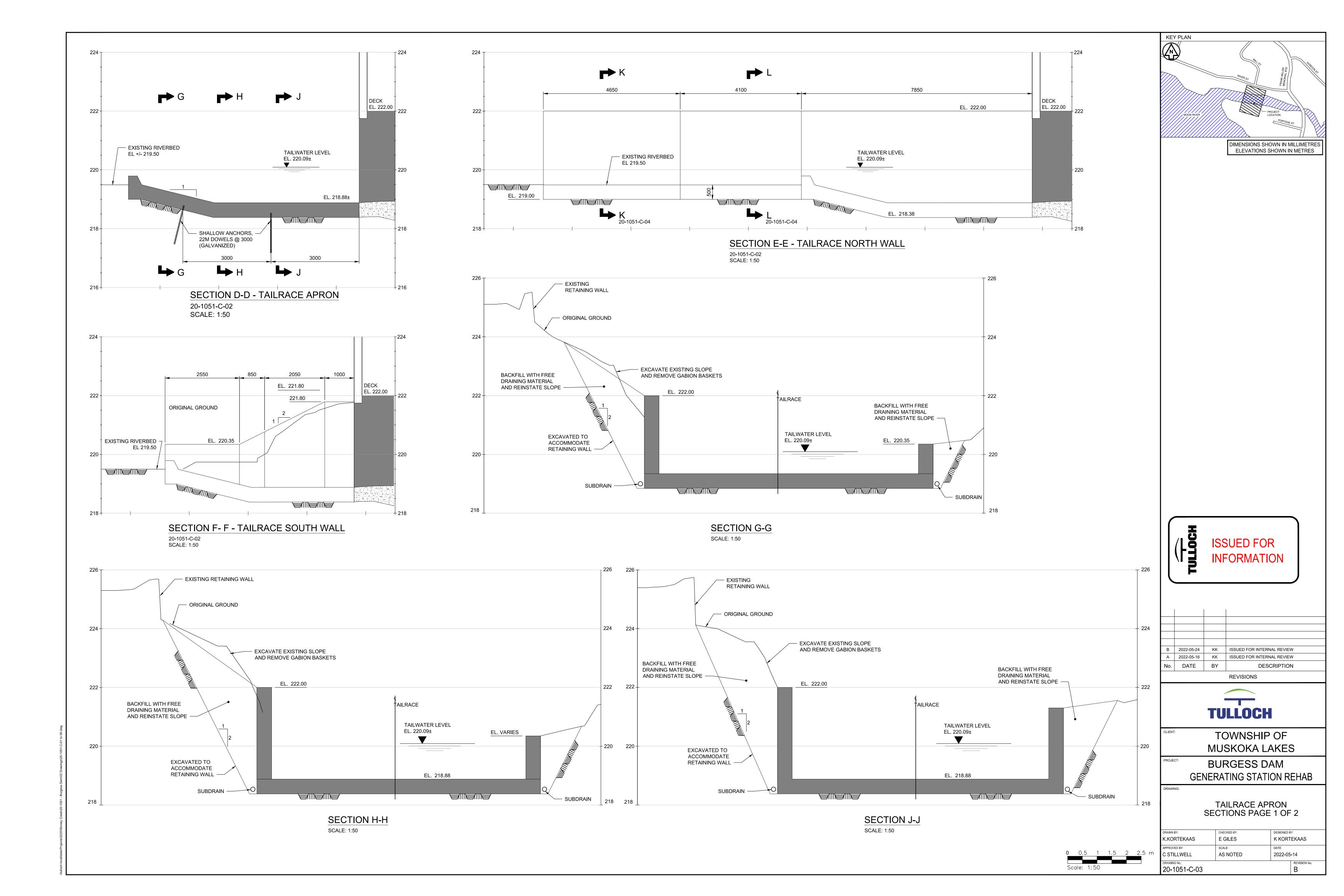
E. K. GILES 100206670 Reviewed By: George Liang, Ph.D., P. Eng. Senior Geotechnical Engineer

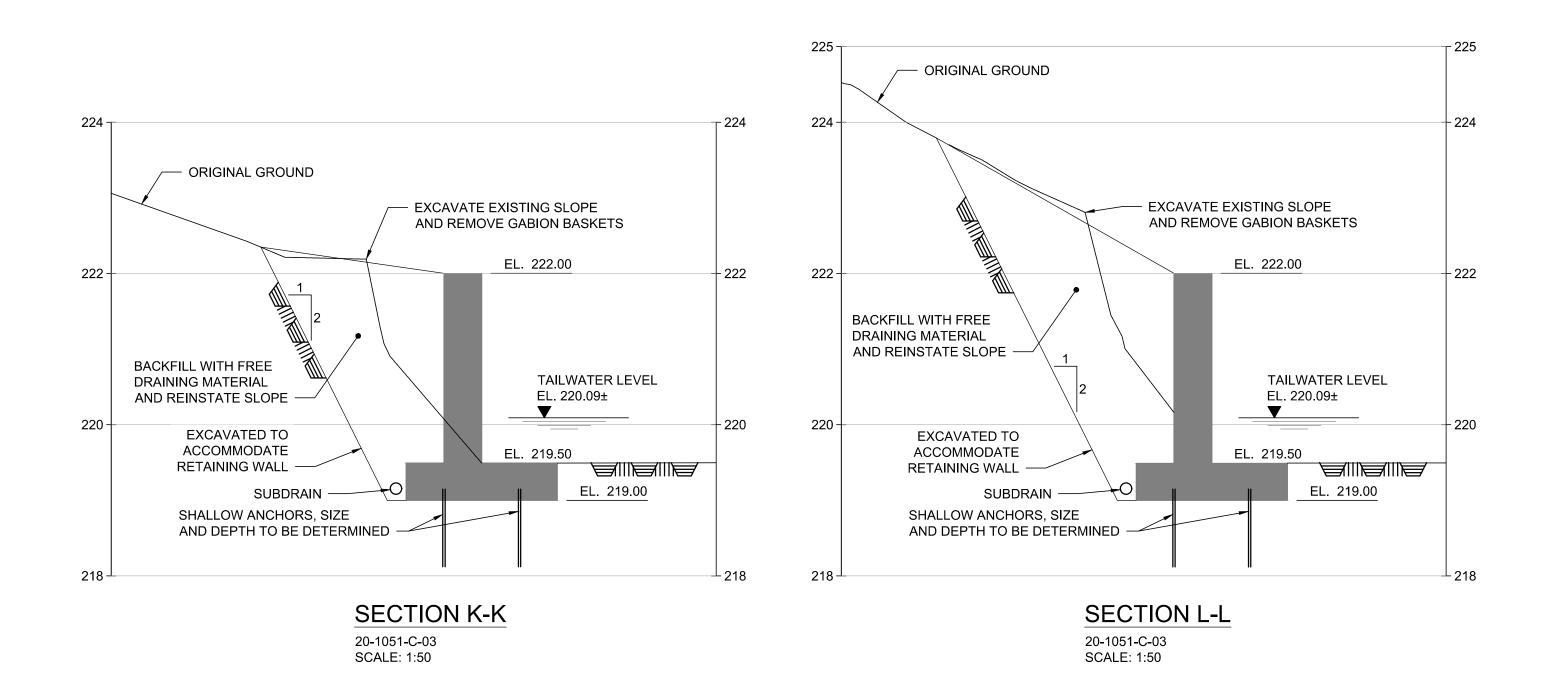
Attachment(s): Civil & Structural Preliminary Design Drawings, North Slope Investigation, Notice to Reader



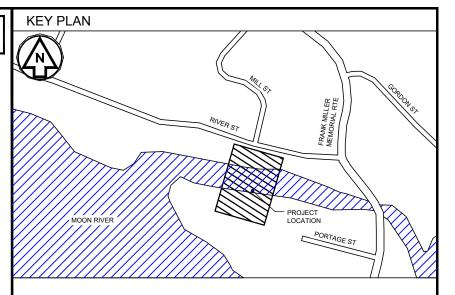


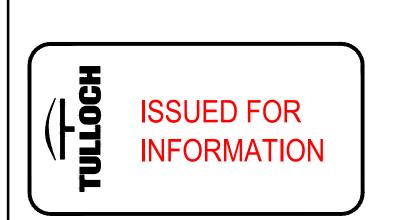






DIMENSIONS SHOWN IN MILLIMETRES ELEVATIONS SHOWN IN METRES





В	2022-05-24	KK	ISSUED FOR INTERNAL REVIEW
Α	2022-05-16	KK	ISSUED FOR INTERNAL REVIEW
No.	DATE	BY	DESCRIPTION

REVISIONS



TOWNSHIP OF MUSKOKA LAKES

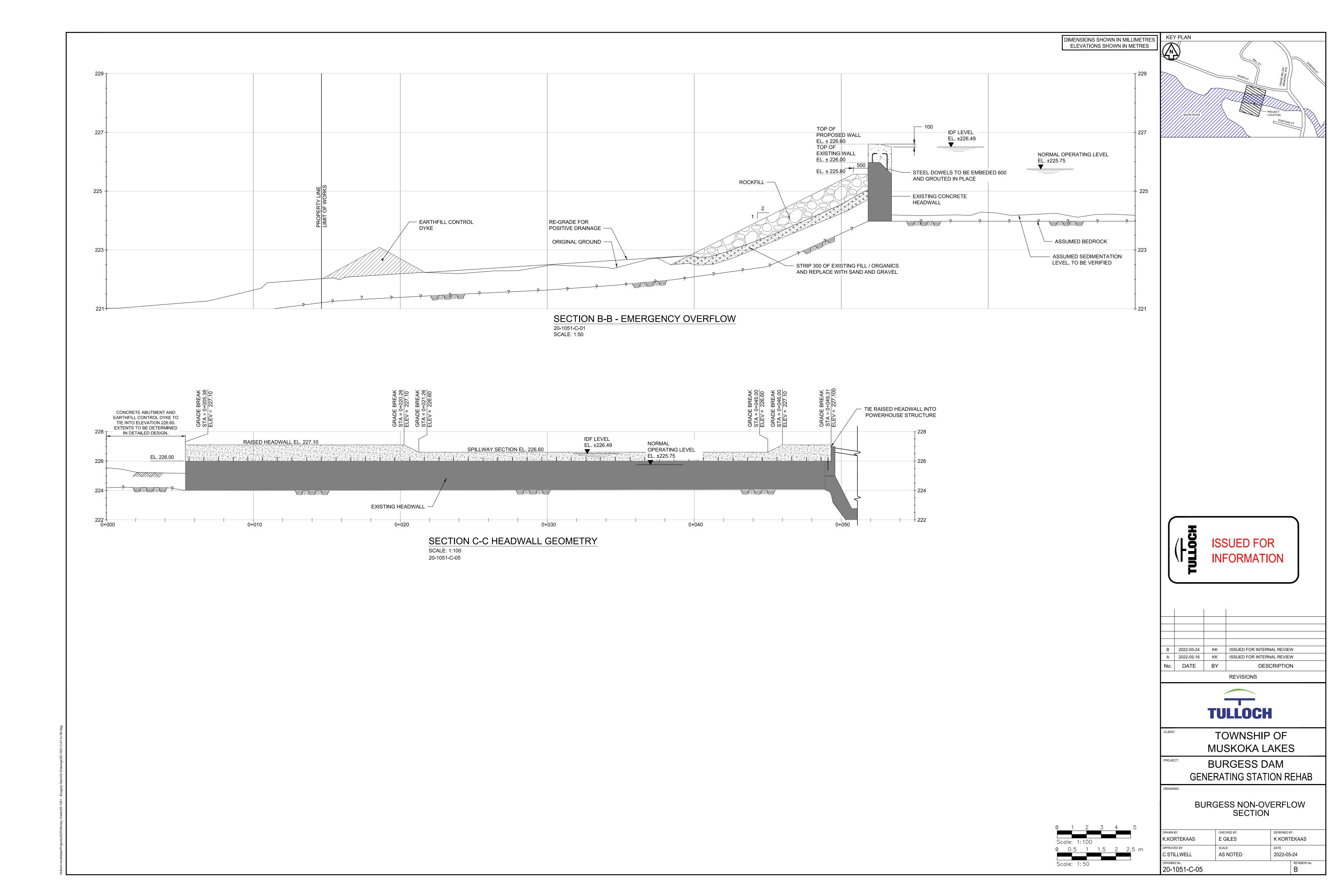
BURGESS DAM
GENERATING STATION REHAB

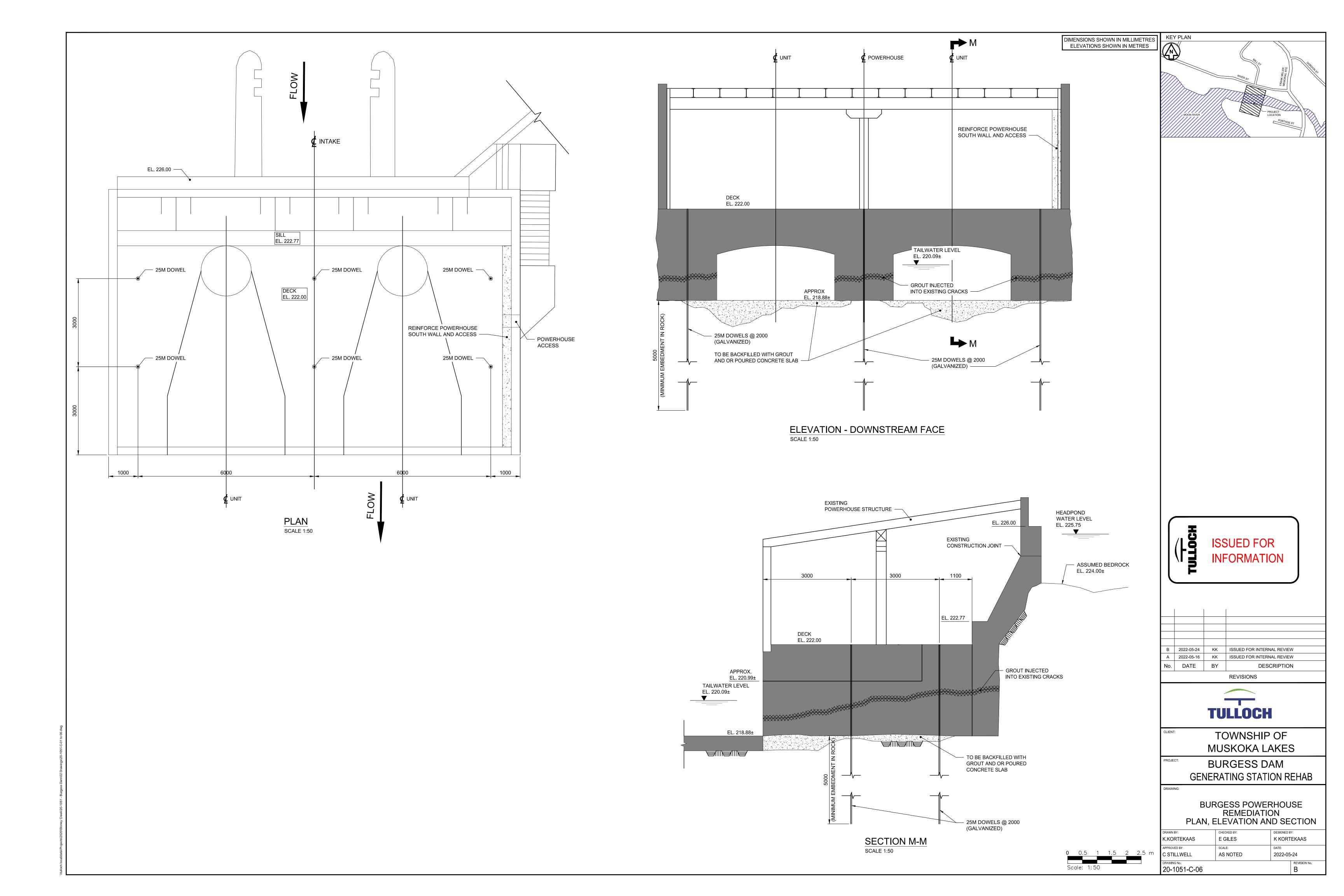
DRAWING:

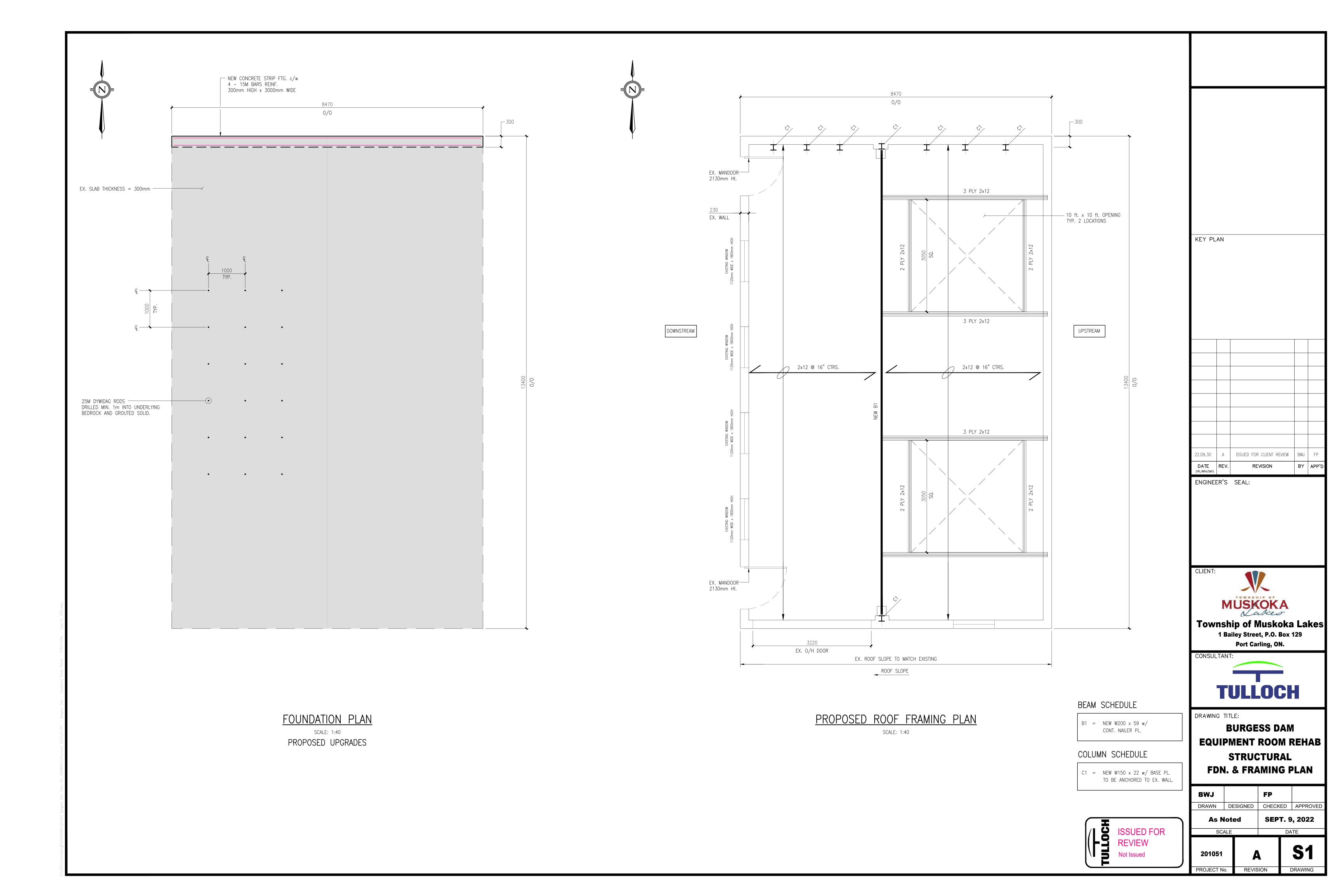
TAILRACE APRON SECTIONS PAGE 2 OF 2

DRAWN BY:	CHECKED BY:	DESIGNED BY:	
K.KORTEKAAS	E GILES	K KORTEKAAS	
APPROVED BY:	SCALE:	DATE:	
C STILLWELL	AS NOTED	2022-05-24	
DRAWING No.			REVISION No.
20-1051-C-04			В













MEMORANDUM

Date: Thursday, November 17, 2022

To: Ken Becking, P.Eng.
Director of Public Works
Township of Muskoka Lakes
1 Bailey St., P.O. Box 129
Port Carling, ON P0B 1J0

From: Erik Giles P.Eng., Kelvin Cheung E.I.T.

CC: George Liang P.Eng.

RE: Burgess Dam – North Slope Geotechnical Investigation and Slope Stability Analysis

Dear Mr. Becking,

TULLOCH was retained by The Township of Muskoka Lakes (The Client) to perform a site investigation adjacent to the North Slope downstream of the Burgess 1 Generating Station Powerhouse in Bala, Ontario. The scope of work included the advancement of three (3) sampled boreholes on River Street adjacent to the Burgess 1 Generating Station. The purpose of the investigation was to further understand the subsurface soil and shallow bedrock conditions of the area to aid in development of mitigation or rehabilitation options for the slope. Drawing 20-1051-G-01 attached to this memorandum presents a site plan detailing borehole location for the geotechnical investigation completed for this project.

The memorandum will discuss a brief overview of the regional local geology, summary of the investigation methodology and factual findings, followed by a description of the analysis undertaken, and presentation of rehabilitation options. Terminology as it pertains to the borehole logs and memorandum is attached. Detailed borehole logs including individual soil layers and descriptions are also attached to this document, as well as analysis results.

1. INTRODUCTION AND SCOPE

The slope directly north of the Burgess 1 Generating Station is located downstream of the dam and directly downstream of the powerhouse. An existing concrete retaining wall, approximately 7.25 m long, keys into the north side of the powerhouse. Gabion baskets provide support below the retaining wall and extend approximately 11 m beyond the retaining wall limits in the downstream direction. At the toe of the gabions, there appears to be historically placed or dumped rock fill that varies in height and size. Generally, the restricted slope areas near the powerhouse are overgrown, while the sloped area downstream is grass covered.



The scope of work for this memorandum as part of the larger Burgess Rehabilitation Project is outlined below, it includes:

- Geotechnical Site Investigation (including Borehole Drilling, Soil Sampling and Description, etc.)
- Detailed Description of factual subsurface conditions including laboratory testing and standard geotechnical testing
- Slope Stability Analysis including development of preliminary mitigation and rehabilitation options for the North Slope identified above
- Delivery of one (1) Engineering Geotechnical Memorandum for detailing the findings of the analysis and the preliminary options for remediation/rehabilitation of the North Slope based on the soil properties and in-situ groundwater measurements. The recommendations in this memo will be input into the overall preliminary design of the rehab of the Burgess 1 Dam facility.

It is noted that two (2) boreholes were originally proposed on the South side of River St., with one (1) proposed on the north side. Due to hazards associated with overhead powerlines on the South side of River St., all three (3) boreholes were advanced on the north side of River St.

2. REGIONAL GEOLOGY

Based on review of Bedrock Geology and Surficial Geology of Southern Ontario mapping as published by the Ontario Geological Society (OGS), the site surficial geology is comprised of Canadian Shield with formations of Precambrian Bedrock typical within the Muskoka region. The typical geologic formations for the Bala area including hard and smooth pink to grey migmatitic rocks as well as quartzofeldspathic gneisses (OGS 2019). The Burgess 1 Dam is located at the lower section of the Muskoka River watershed near the bottom of Lake Muskoka where regional topography is typically mapped as low local relief varying from plains to undulating hummocky conditions. Overburden in the Bala area is typically sandy and shallow in depth with thick organic deposits found in low lying wetland areas.

3. SITE INVESTIGATION AND METHODOLOGY

The geotechnical investigation program included the following scope of work:

1. Borehole investigations on September 9th, 2020, including three (3) sampled boreholes in total, labelled BH-20-01 to BH-20-03.

1.8



Bedrock coring was completed in BH-20-01. Core logging of all rock core samples retrieved during the investigation was completed during the execution of the borehole. Cores were logged immediately upon retrieval, and measurements for Rock Quality Designation (RQD) were obtained to determine bedrock quality.

Drawing 20-1051-G-01 attached presents a site plan detailing borehole locations for the geotechnical investigation.

3.1 **Geotechnical Borehole Summary**

A summary of the boreholes drilled on the site are shown below in Table 3-1.

Bedrock Borehole Elevation¹ Northing¹ Easting¹ Borehole No. Depth² Depth² (m) (m) (m) (mbgs) (mbgs) BH-20-01 609067 4985600 225.1 1.47 4.5 BH-20-02 224.7 609059 4985601 1.24^{3} 1.2 BH-20-03 224.4 509053 1.78^{3}

Table 3-1: Summary of Borehole Information

Note(s): 1 Elevation and Borehole Coordinates are shown in UTM 17T Datum. 2 Meters below ground surface (mbgs), rounded to nearest 0.1 m. ³ Inferred bedrock depth.

4985601

Boreholes were advanced using a CME55 truck-mounted drill rig owned and operated by Landcore Drilling from Chelmsford, Ontario. The boreholes were advanced using hollow stem augers. Bedrock cores were retrieved within the NW casing via diamond rotary with an NQ2 (76 mm OD) rock core barrel. The rig was equipped with standard soil sampling equipment including an automatic hammer.

During the geotechnical drilling, soil samples were obtained using standard split spoon equipment in conjunction with Standard Penetration Tests (SPT) conducted in accordance with ASTM D1586 procedures. SPT sampling generally occurred at semi continuous 0.76 m intervals. In the bedrock, core samples were generally retrieved in 1.5 m continuous runs with an NQ2 core barrel. The bedrock was logged in the field and Rock Quality Designation (RQD) was calculated on site as the core runs were retrieved.

The drilling and soil sampling programs were directed by a TULLOCH representative, who logged the drilling operations and identified the soil samples as they were retrieved. The recovered soil and rock cores were transported to TULLOCH's CCIL Certified Laboratory in Sault Ste. Marie, ON. Detailed borehole logs are attached to this memorandum.



4. LABORATORY TESTING PROGRAM

A geotechnical laboratory testing program was performed on representative soil and rock core samples in accordance with ASTM standards. Table 4-1 provides a list of the testing program. Detailed laboratory reports for the particle size analysis and unconfined compressive strength of rock tests, can be found attached to this memorandum.

Table 4-1: Summary of Rock Laboratory Testing Program

Test	Number of Tests	ASTM Standards
Particle Size Analysis	2	ASTM D422
Unconfined Compressive Strength (Rock)	2	ASTM D7012

5. SUMMARY OF SUBSURFACE CONDITIONS

5.1 General

The following section outlines the soil deposits/stratigraphy and corresponding depths encountered during the investigation. Further details can be found in the attached borehole logs.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. Further, in boreholes where bedrock coring was not undertaken, depths to bedrock are inferred based on auger refusal.

5.2 Stratigraphy Overview

A total of three (3) boreholes were advanced to assess the subsurface conditions on River St. and the adjacent North Slope. All boreholes were advanced to refusal, BH-20-01 was cored to confirm and assess the shallow bedrock conditions. Throughout the boreholes, 125 mm of asphalt was found to overly road base fills consisting of gravelly sand to sand some gravel. In BH-20-01 auger grinding occurred from below the asphalt to bedrock surface at 1.47 m, inferred to be caused by the presence of cobbles and boulders. Bedrock was confirmed at 1.47 m in BH-20-01 and was inferred at 1.2 and 1.8 mbgs in BH-20-02 and -03 respectively. In BH-20-01, bedrock was found to be granitic gneiss, fine to medium grained with angled foliation. The rock was slightly weathered to fresh, and strong with unconfined compression strengths ranging from 100.3 MPa in Run 1 to 130.3 MPa in Run 2.



A simplified stratigraphic profile, and bedrock depths for each borehole is summarized below in Table 5-1. Further details with individual soil layers and characteristics can be viewed in the detailed borehole logs attached to this memorandum.

Table 5-1: Summary of Soil and Bedrock Conditions

Borehole No.	Ground Surface Elevation ¹ (m)	Investigation Profile (mbgs)	Bedrock Depth (mbgs) ²	Bedrock RQD Range (%)
BH-20-01	225.1	0.00-0.13, Asphalt 0.13-1.47, (SW) Sand, some gravel	1.47	56-94
BH-20-02	224.7	0.00-0.13 Asphalt 0.13-1.24, (SW) Sand, some gravel	1.24 ³	-
BH-20-03	224.4	0.00-0.13 Asphalt 0.13-1.78, (SW) Sand, some gravel	1.78³	-

Note(s): ¹ Elevation and Borehole Coordinates are shown in UTM 17T Datum. ² Meters below ground surface (mbgs). ³ Inferred bedrock depth.

5.3 Groundwater Conditions

Groundwater was measured upon completion of each borehole location. A summary of groundwater measurements taken in the boreholes is presented in Table 5-2 below. Groundwater readings were taken down hole upon drilling completion, as such the ground water levels measured on site may not represent static conditions.

Table 5-2: Water Level Readings Summary

Borehole No.	Surface Elevation (m)	Groundwater Depth ¹ (mbgs)
BH-20-01	225.1	4.12
BH-20-02	224.7	Not encountered
BH-20-03	224.4	Not encountered

Note(s): 1 Meters below ground surface (mbgs)

Groundwater level is subject to seasonal fluctuations with high levels occurring during wet weather conditions in the spring and fall and lower levels during dry weather conditions.

6. NORTH SLOPE STABILITY ANALYSIS

The following sections will discuss the results of the stability modelling of the existing North Slope retaining wall, gabion basket wall and the overall global slope stability. The modelling was based on review of available drawings, topographic survey, and the encountered stratigraphy from the geotechnical investigation.



6.1 Retaining Wall and Gabion Stability Analysis

Concrete retaining wall global stability and gabion wall global and internal stability calculations were conducted for the North Slope area. Using the data collected from the geotechnical investigation, and topographic survey the initial Factor of Safety (FOS) calculations were completed to help frame the recommendations in the following sections. The FOS calculation for stability analysis of the gabion and retaining wall sections are based on the following Equations:

FOS against sliding failure:

$$FOS = \frac{\sum Resisting\ Froce}{\sum Driving\ Force}$$
[1-1]

FOS against overturning failure:

$$FOS = \frac{\sum Resisting\ Moment}{\sum Driving\ Moment}$$
[1-2]

Table 6-1 summarizes the geotechnical parameters used in the stability calculations. Geotechnical parameters were based on the results of the geotechnical investigation and TULLOCH's engineering experience for conservative design purposes.

Table 6-1: Summary of Geotechnical Parameters Stability Calculation¹

No.	Type of Material	Cohesion, c' (kPa)	Internal Friction Angle,φ' (Degree)	Unit Weight, γ' (kN/m³)
1	Silty Sand Fill	0	35	19
2	Rockfill	0	38	20
3	Gabion Basket	30	38	20
4	Retaining Wall Concrete	-	-	24
5	Concrete to Rock Interface	1	38	-

Note(s): 1-Geotechnical parameters are assumed based on TULLOCH's engineering experience.

6.1.1 Gabion Stability Results

Geometry used in stability analysis of the gabion retaining wall was based on the available historical information and observations during site inspection. For global stability, the external boundary of the gabion retaining wall structure was taken to be from the toe of the gabion basket (Gabion 1) retaining wall to the upstream edge of the upper most gabion basket (Gabion 4). The gabion wall is assumed to be founded on bedrock as no construction records or design drawings were available for the structure. Gabion basket widths are all taken to be 1m for the purposes of the stability calculation based on review of available historical drawings. Active and passive earth pressure coefficients have been modified to consider the sloping backfill geometry of the North



Slope above the gabion wall. Table 6-2 summarizes the required and calculated factors of safety for the stability of the gabion basket retaining wall.

Table 6-2: Calculated FOS for Stability of Gabion Basket Retaining Wall

Stability Case	Stability Case	FOS	Minimum Required FOS
Global	Sliding	1.69	1.5
Global	Overturning	7.64	2.0
Gabion 1	Sliding	1.05	1.5
Gabion 2	Sliding	1.40	1.5
Gabion 3	Sliding	2.15	1.5
Gabion 4	Sliding	5.08	1.5

It should be noted that based on the available survey data, traffic loading on top of the slope is within the active wedge zone and therefore is applied to the gabion wall calculations. This is a preliminary assessment with limited investigation data and the geometry of gabion wall inferred from the inspection.

Based on the above results, the stability of the gabion basket retaining wall is in a marginally unsafe condition. The internal stability of the wall does not meet the required safety factor with respect to sliding. The rockfill at the toe of the wall has been ignored in this analysis due to its discontinuous nature, however, in reality it may provide minor support to the lower two gabions. Continued deterioration and movement of the wall will likely cause further instability if left unchecked. Therefore, action is recommended to remediate or replace the Gabion Wall which will be discussed in Section 7.

6.1.2 Existing Concrete Retaining Wall Stability Results

Geometry used in stability analysis of the concrete retaining wall was based on the available historical information and provided drawings as well as observation during site inspection. Based on the historical drawings, the concrete retaining wall is assumed to be founded on bedrock. Table 6-3 summarizes the required and calculated factors of safety for the stability of the retaining wall. A sensitivity analysis was conducted based on the U/S water level of the retaining wall as a subdrain for the wall was not presented in the drawing nor established during the site inspection of the wall. As such in a flooding event similar to 2019 water could build up behind the wall causing additional force on the wall.



Table 6-3: Calculated FOS for Stability of Concrete Retaining Wall

Stability Case	Stability Case	FOS	Minimum Required FOS
U/S water level at	Sliding	2.5	1.5
surface of U/S fill	Overturning	1.7	2
U/S water level 0.5 m	Sliding	3.0	1.5
below surface of U/S fill	Overturning	2.2	2

It should be noted that based on the available survey data, the traffic loading is within the active wedge zone of the backfill and therefore is applied to the concrete retaining wall calculations. This is a preliminary assessment with limited investigation data and the geometry of concrete wall is inferred from the inspection and available historical information.

Based on the results, the existing concrete retaining wall is typically in a safe condition. However, when the U/S water level is high, i.e., at the surface of the fill, the factor of safety decreases to a marginally safe condition with the required Safety Factor for overturning not being met. This condition likely occurs during period of high precipitation, during the spring freshet and is also likely during an overtopping event. Buildup of water pressure on the upstream side of the wall is expected due to the lack of drains through the retaining wall. It is also noted that a large, open vertical crack exists in the retaining wall which indicates historic movement. Continued deterioration and movement of the wall may cause further reduction in overall stability if left unchecked.

6.2 North Slope Global Stability Analysis

Limit equilibrium global stability analysis was conducted for the North Slope area using Geostudio 2021 R2, version 11.1.3.22700 by GEOSLOPE International Ltd. Survey data collected as part of the 2019 DSR for the Burgess Dam, information from the geotechnical investigation, and limited available historical information, was used to generate analysis geometry and determine a critical section which is shown in Figure 6-1 Below. It should be noted that the bedrock profile in the model is assumed based on local site and regional geology characteristics. The phreatic surface was assumed based on typical powerhouse tailwater elevation and the groundwater conditions encountered during the geotechnical investigation. See Figure 6-1 below.



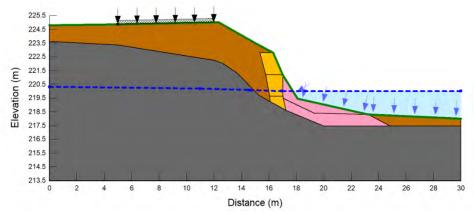


Figure 6-1: Slope Stability Geometry and Phreatic Surface

The slope stability model resulted in a global factor of safety of 1.24, the required factor of safety for the current site conditions is typically 1.5. A sensitivity study where the gabion basket netting has deteriorated was also run, this yielded a factor of safety of 0.61 showing that without a gabion wall in good condition, the slope is unsafe and would likely fail. The condition of the gabion wall below the rockfill at the downstream toe is unknown as it is covered in rock fill, however given its age and the fair condition of the existing gabion wall it is reasonable to assume that the gabions are nearing the end of their service life and it is recommended that they be rehabilitated or replaced.

7. ENGINEERING DISCUSSION

The following section will discuss engineering recommendations for the North Slope and associated structures to be incorporated into the preliminary design of the Burgess 1 Generating Station facility. The Gabion Basket Existing Retaining Wall and overall North Slope will be discussed.

The existing concrete retaining wall is noted to have extended vertical cracks from the crest to the soil contact on the downstream side. Further, typical features of modern retaining walls including subdrain system, and reinforcement in the form of anchor points or dowelling were not apparent on historical drawings or observed during the last DSR conducted in 2019. This indicates that the wall is in fair condition and should be rehabilitated or replaced. Given the planned rehabilitation of the overall facility replacement or remediation of this wall is recommended at this time.

The gabion wall is noted to be in marginally unsafe condition, with some unknowns as to the geometry and foundation. The North Slope is noted to be steep at approximately a 1.75 to 1 (H:V).



The various North Slope stability analyses indicate that the concrete retaining wall, gabion wall and north slope areas are all in a marginally safe condition. Given the above information, the following remediation options are presented for consideration.

7.1 Option 1 – Remediation of Existing Concrete Retaining and Gabion Basket Walls

With the various components of the North Slope area in fair to poor condition, remediation of the existing structure should be considered. This would include remediation of the existing concrete retaining wall and reinforcement and possible replacement of the existing Gabion Wall.

The following recommendations should be implemented for rehabilitation of the North Slope area:

- Subdrains should be installed in the concrete retaining wall to prevent pore pressure buildup on the upstream side, drains should be run into the tailrace area to prevent additional erosion. Surface run-off should be collected and diverted away from the retaining wall section.
- Cracks in the concrete retaining wall should be repaired and if required additional structural reinforcement should be added.
- Anchoring of the concrete retaining wall into the shallow bedrock should be considered to improve stability in overturning and sliding.
- The concrete retaining wall and repair locations should be regularly inspected for further movement over time. A monitoring system could be implemented on the wall to track movement in the future.
- Removal of rockfill at the toe of the gabion wall to inspect the lower Gabions and determine
 their condition, the Gabions could then be remediated or replaced as required. Adequately
 sized rip rap and/or larger gabion stone could be used to prevent erosion and help stabilize
 the North Slope.
- The North Slope should be monitored regularly for signs of instability or movement.

Rehabilitation may extend the service life of the walls and the North Slope; however, it would require regular monitoring and maintenance with potential for eventual replacement as the structures in question are aging and near the end of their service life.



7.2 Option 2 – Replacement of Concrete and Gabion Basket Retaining Walls

With future plans for upgrades to the current Burgess Dam structures including dam raising, powerhouse rehabilitation and improvements to the tailrace, this presents a good opportunity to replace the existing North Slope retaining structures and incorporate a more robust retention system for River Street. Though construction of properly engineered retaining structures requires larger initial investment, it will have reduced maintenance costs, increased safety of the walls and surrounding infrastructure, and minimized risk to power generation in the long term. Given the required rehabilitation of the Generating Station and Dam it may be difficult to replace these North Slope infrastructure at a later point which could increase cost when eventual replacement is required. The following recommendations should be implemented in North Slope area.

- Removal of existing concrete and gabion basket retaining walls.
- Removal of existing fill and native materials to competent bedrock.
- Construction of a concrete training wall dowelled into bedrock and tied into the Powerhouse, extending to the current downstream limit of the gabion wall. The concrete training wall should include subdrains.
- Construction of a replacement concrete retaining wall tied into the powerhouse and founded on bedrock, which should include subdrains.
- Backfilling behind and between all structures should be an approved free draining granular fill such as OPSS Granular B Type II or equivalent backfill compacted to 98% of the Standard Proctor Maximum Dry Density (SPMDD). Placed in compacted lifts of maximum loose lift thickness of 300 mm.
- Regrading of all slopes above the gabion wall to 2:1 (H:V) or less.

Extending a training wall from the powerhouse will prevent erosion of the North Slope and allow for significantly better control of water through the powerhouse particularly during high flow events. Furthermore, the heightened and improved training wall will act as a retaining wall for the North Slope and provide better structural resistance to the North Slope allowing the infrastructure to perform better and mitigate the risks associated with slope failure on the site.

A preliminary drawing will be issued for the training wall as part of the preliminary design memo for the Burgess 1 Generating Station. It should be noted that the recommendations in the memorandum are preliminary in nature. It is recommended that the calculations and remediation



options be re-evaluated in the detailed design phase to ensure that they meet the needs of the Township.

8. CLOSURE

This geotechnical memorandum has been prepared by TULLOCH for the exclusive use of the Client and their authorized agents. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering, for the above noted location. Classification and identification of soils, and geologic units have been based upon commonly accepted methods employed in professional geotechnical practice. No warranty or other conditions, expressed or implied, should be understood. Please refer to the Notice to Reader attached, which is an integral part of this report.

We trust that the information in this report will be sufficient to allow the Client to proceed with the project. Should further elaboration be required for any portion of this project, we would be pleased to assist.

Sincerely,

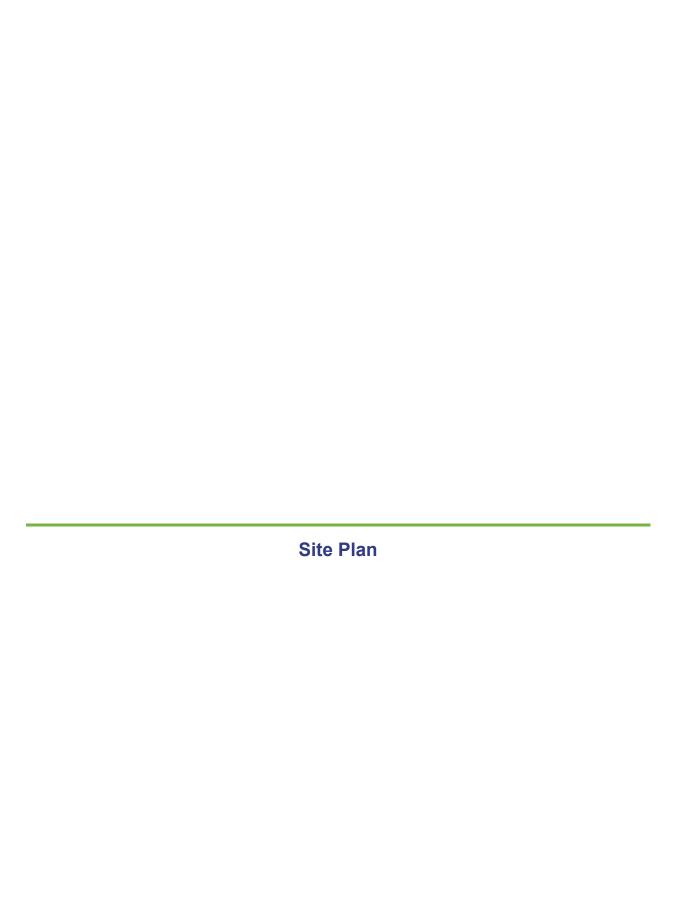
Kelvin Cheung B.Sc. E.I.T

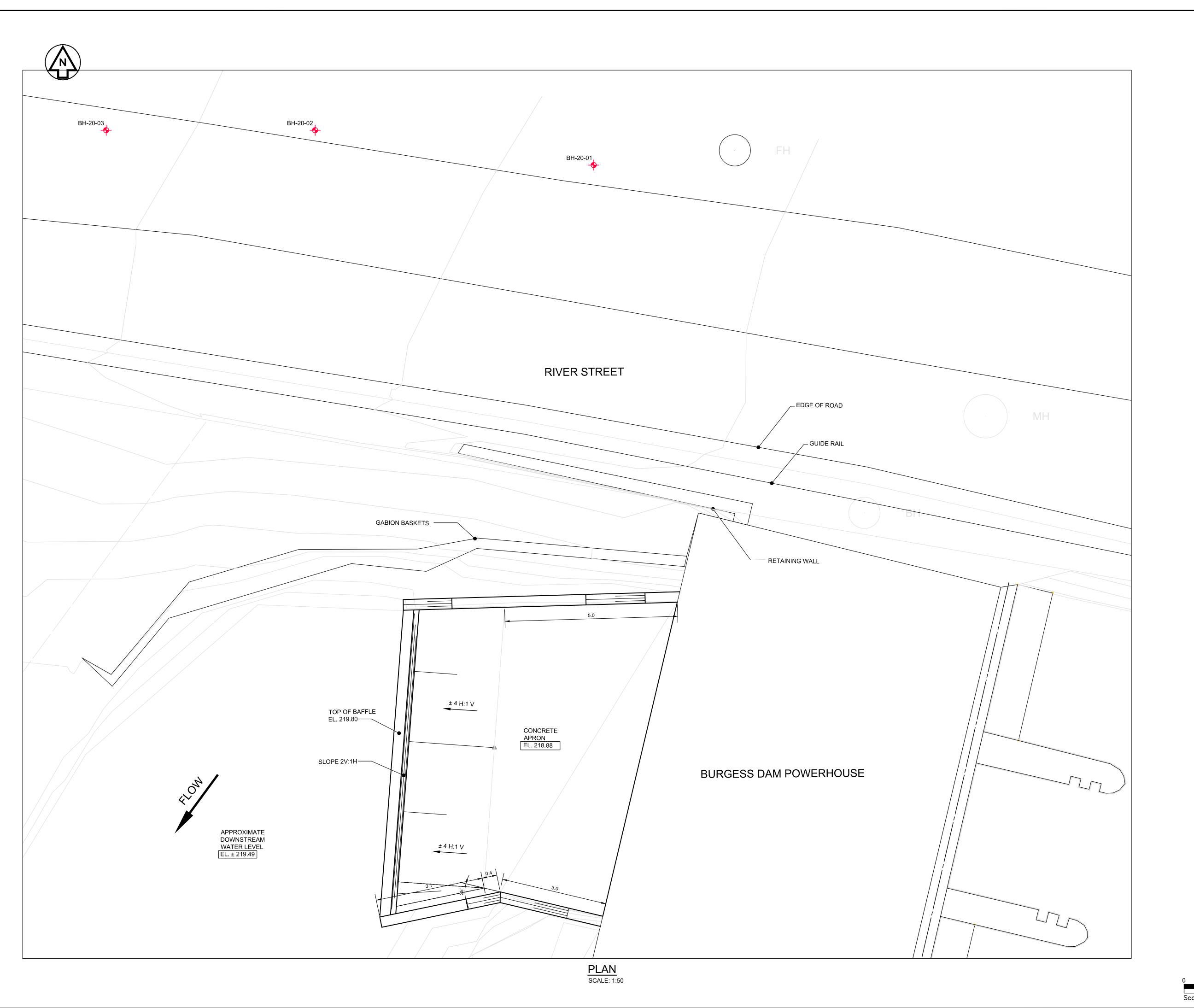
Engineer in Training

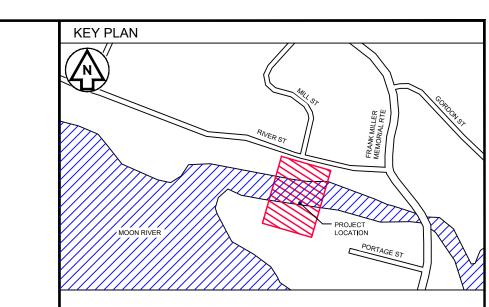
Reviewed By: Erik Giles P.Eng. Geotechnical Engineer



Attachment(s): Site Plan, Terminology, Site Photo Log, Borehole Logs, Rock Core Photos, Laboratory Data, Slope Stability Results, Notice to Reader







LEGEND:

BOREHOLE LOCATION

NOTES:

1. CO-ORDINATES ARE IN UTM ZONE 17 (NAD83 CSRS).

BOREHOLE LOCATIONS

EASTING	NORTHING	ELEVATION
609 067	4 985 600	225.1
609 059	4 985 601	224.7
609 053	4 985 601	224.4
	609 067 609 059	609 067

A 2022-02-23 KK ISSUED FOR INTERNAL REVIEW No. DATE BY REVISIONS



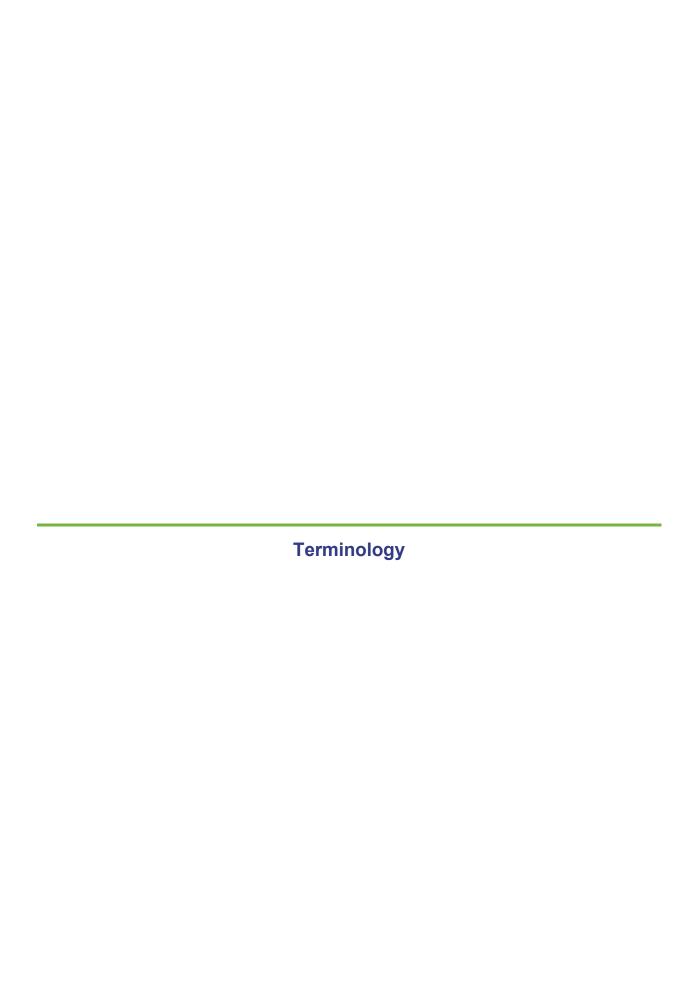
TOWNSHIP OF MUSKOKA LAKES

LITTLE BURGESS GENERATING STATION REHAB

NORTH EMBANKMENT GEOTECHNICAL INVESTIGATION PLAN

CHECKED BY: E GILES K KORTEKAAS AS NOTED 2022-02-23 DRAWING No. 20-1051-G-01





ABBREVIATIONS, TERMINOLOGY AND PRINCIPAL SYMBOLS USED IN REPORT AND BOREHOLE LOGS

BOREHOLES AND TEST PIT LOGS

Soils

AA	Auger Sample	w	Water Content
SS	Split Spoon	wP	Plastic Limit
TO	Tin-walled Tube	wL	Liquid Limit
TP	Thin-walled Piston	V(FV)	Field Vane
WS	Washed Sample	OR	Organic Content
SC	Soil Core	GR	Gravel
BS	Block Sample	SA	Sand
WH	Weight of rods &	SI	Silt
	hammer		
WR	Weight of rods	CL	Clay

Bedrock

TCR	Total Core Recover	VN	Vein
SCR	Solid Core Recovery	СО	Contact
FI	Fracture frequency index	KV	Karstic void
HQ	Rock Core (63.5 mm dia.)	MB	Mechanical Break
NQ	Rock Core (47.6 mm dia.)	PL	Planar
BQ	Rock Core (36.5 mm dia.)	CU	Curved
JN	Joint	UN	Undulating
FLT	Fault	IR	Irregular
SH	Shear	SM	Smooth
K	Slikensided	SR	Slightly Rough
BD	Bedding	R	Rough
FO	Foliation	VR	Very rough

IN SITU SOIL TESTING

Standard Penetration Test (SPT) "N" value. The number of blows required to drive a 51 mm OD split barrel sampler into the soil a distance of 300 mm with a 63.5kg weight free falling a distance of 760 mm after an initial penetration of 150 mm has been achieved.

Dynamic Cone Penetration Test (DCPT) is the number of blows required to drive a cone with a 60 degree apex attached to "A" size drill rods continuously into the soil for each 300 mm penetration with a 63.5 kg weight free falling a distance of 760 mm.

Cone Penetration Test (CPT) is an electronic cone point with a $10\,\mathrm{cm}$ base area with a $60\,\mathrm{degree}$ apex pushed through the soil at a penetration rate of $2\,\mathrm{cm/s}$.

Field Vane Test (FVT) consists of a vane blade, a set of rods and torque measuring apparatus used to determine the undrained shear strength of cohesive soils.

SOIL DESCRIPTIONS

The soil descriptions and classifications are based on an expanded Unified Soil Classification System (USCS). The USCS classifies soils on the basis of engineering properties. The system divides soils into three major categories; coarse grained, fine grained and highly organic soils. The soil is then subdivided based on either gradation or plasticity characteristics. The classification excludes particles larger than 75 mm. To aid in quantifying material amounts by weight within the respective grain size fractions the following terms have been included to expand the USCS:

Soil Classification		
Clay	<0.002 mm	
Silt	0.002 to 0.06 mm	
Sand	0.075 to 4.75 mm	
Gravel	4.751o 75 mm	
Cobbles	75 to 200 mm	
Boulders	>200 mm	

Terminology	Proportion
"trace", sand, etc.	1%to 10%
"some"	10% to 20%
Sandy, Gravelly, etc.	20% to 35%
"and"	>35%
Ex., SAND, SILT, etc.	>35%

Notes:

- Soil properties, such as strength, gradation, plasticity, structure, etc., dictate the soils engineering behaviour over the grain size fractions;
- With the exception of soil samples tested for grain size distribution or plasticity, all soil samples have been classified based on visual and tactile observations and is therefore an approximate description.

The following table outlines the qualitative terms used to describe the relative density condition of cohesionless soil:

Cohesionless Soils

Compactness	SPT "N" Value (blows/30cm)
Very Loose	0 to 4
Loose	5 to 10
Compact	11 to 30
Dense	31 to 50
Very Dense	>50

The following table outlines the qualitative terms used to describe the consistency of cohesive soils related to undrained shear strength and SPT, N-Index:

Cohesive Soils

Consistency	Undrained Shear Strength (kPa)	SPT "N" Value (blows/30 cm)
Very Soft	<12.5	< 2
Soft	12.5 to 25	2 to 4
Firm	25 to 50	5 to 8
Stiff	50 to 100	9 to 15
Very Stiff	100 to 200	16 to 30
Hard	> 200	>30

Note: Utilizing the SPT, "N" value to correlate the consistency and undrained shear strength of cohesive soils is very approximate and needs to be used with caution.

Particle Sizes

Constituent	Description	Size (mm)	Size (in)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse	19 to 75	0.75 to 3
	Fine	4.75 to 19	(4) to 0.75
SAND	Coarse	2.00 to 4.75	(10) to (4)
	Medium	0.425 to 2.00	(40) to (10)
	Fine	0.075 to0.425	(200) to (40)
SILT/CLAY	Classified by plasticity	< 0.075	< (200)

ROCK CORING

Rock Quality Designation (RQD) is an indirect measure of the number of fractures within a rock mass, Deere et al. (1967). It is the sum of sound pieces of rock core equal to or greater than 100 mm recovered from the core run, divided by the total length of the core run, expressed as a percentage. If the core section is broken due to mechanical or handling, the pieces are fitted together and if 100 mm or greater included in the total sum.

Intact Rock Strength

Intact Strength (Mpa)	Description
< 1	Extremely low strength
1-5	Very low strength
5-25	Low strength
25-50	Medium strength
50-100	High strength
100-250	Very high strength
>250	Extremely high strength

Rock Mass Quality

RQD Classification	RQD Value (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Qualty	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

Rock Mass Weathering

ROCK Mass Weathering		
Term	Description	
Unweathered (Fresh)	No visible sign of material weathering to discoloration on major discontinuity surfaces.	
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity of surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than its fresh condition.	
Moderatly Weathered	Less than half the rock material is decomposed and/or disintegrates to soil. Fresh or discolored rock is present either as a continuous frame work of as core stones.	
Highly Weathered	More than half the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a discontinuous frame work or as core stones.	
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is largely intact.	
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	

Joint and Foliation Spacing

Description	Spacing	
Very Wide	Greater than 3 m	
Wide	1 m to 3 m	
Moderately Close	0.3 m to 1 m	
Close	50 mm to 300 mm	
Very Close	Less than 50 mm	

Bedding Thickness

Description	Spacing
Very thick	Greater than 2 m
Thick	0.6 m to 2 m
Medium	0.2 m to 0.6 m
Thin	60 mm to 0.2 m
Very thin	20 mm to 60 mm
Laminated	6 to 20 mm
Thinly Laminated	Less than 6 mm

SYMBOLS

Genera

w_N Natural water content within the soil sample

γ Unit weight

 γ' Effective unit weight

 γ_D Dry unit weight

 γ_{SAT} Saturated unit weight

ρ Density

 ρ_s Density of solid particles

 ho_w Density of water

 $ho_{\scriptscriptstyle D}$ Dry density

 ho_{SAT} Saturated density

e Void ratio

n Porosity

S Degree of saturation

 E_{50} Fifty percent secant modulus

Consistency

 w_L Liquid Limit

w_P Plastric Limit

I_P Plasticity Index

w_s Shrinkage limit

 I_L Liquidity index

Ic Consistency index

e_{max} Void ratio in loosest state

 $e_{\text{min}}\ \ \text{Void}$ ratio in densest state

Density index (formerly relative density)

Shear Strength

Su Undrained shear strength parameter (total stress)

 c^\prime Effective cohesion intercept

 ϕ' Effective friction angle

 $au_{\it R}$ Peak shear strength

 $au_{\it R}$ Residual shear strength

 δ Angle of interface friction

 μ Coefficient of friction = tan ϕ'

Consolidation

C_c Compression index (normally consolidated range)

C_r Recompression index (over consolidated range)

m_v Coefficient of volume change

c_v Coefficient of consolidation

T_v Time factor (vertical direction)

U Degree of consolidation

 σ_v' Effictive overburden pressure

OCR Overconsolidation ratio

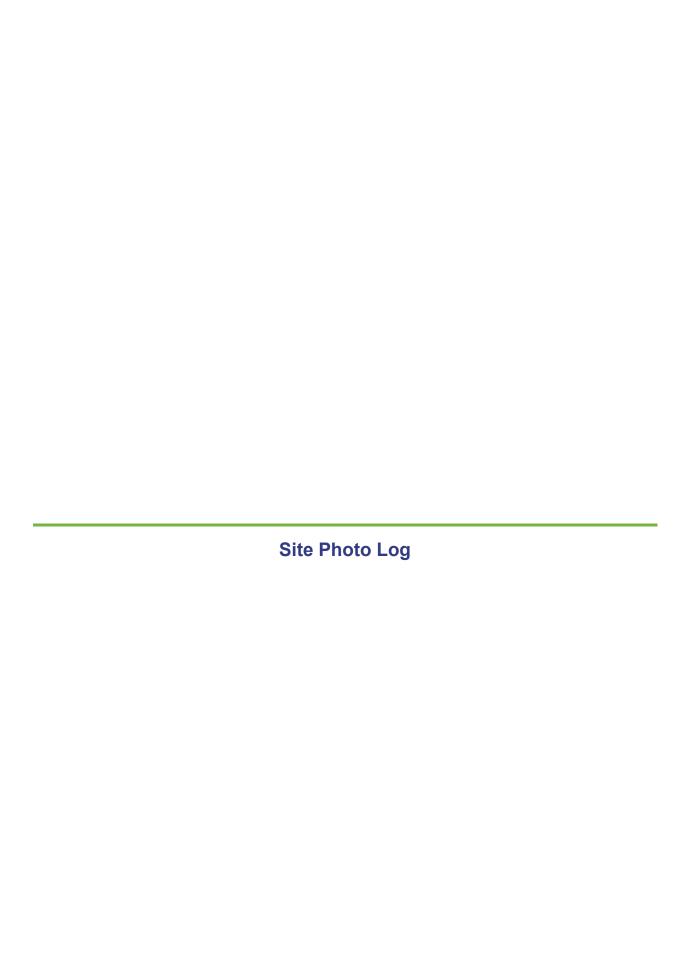




Photo 1: General investigation area, note low powerlines on left side of photo which prevented drilling closer to the North Slope. Powerhouse on left.



Photo 2: Retaining wall near road surface, gabion basket wall at slope toe. Powerhouse on right. Image looking from downstream of powerhouse to upstream.

Township of Muskoka Lakes

Burgess Dam – North Slope Investigation

CONSULTANT



YYYY-MM-DD	2022-03-08
PREPARED	K. Cheung
DESIGNED	K. Cheung
REVIEWED	E.Giles
APPROVED	

Geotechnical Investigation - Site Photos

Phase/Task 20-1051

Rev 0

C1



Photo 3: View of retaining wall behind the fence from road surface.



Photo 4: North Slope with powerhouse and tailrace in background on right. Note abrupt slope change where gabion basket wall exists at break in slope.

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Township of Muskoka Lakes

Burgess Dam – North Slope Investigation

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YYYY-MM-DD	2022-03-08
PREPARED	K. Cheung
DESIGNED	K. Cheung
REVIEWED	E.Giles
APPROVED	

Geotechnical Investigation – Site Photos

PROJECT NO. **20-1051**

Phase/Task

C2

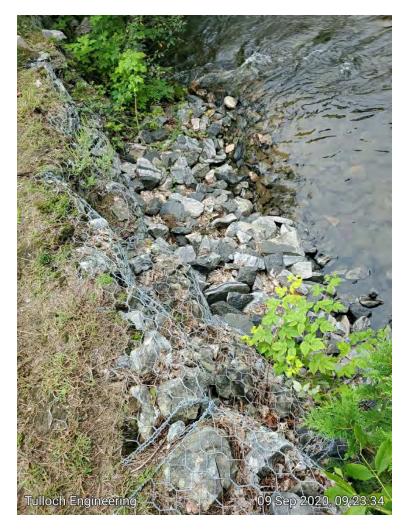


Photo 5: Gabion wall at toe of North Slope. Note rockfill located at toe of gabion wall above tailrace water level.

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PROJECT
Burgess Dam – North Slope Investigation

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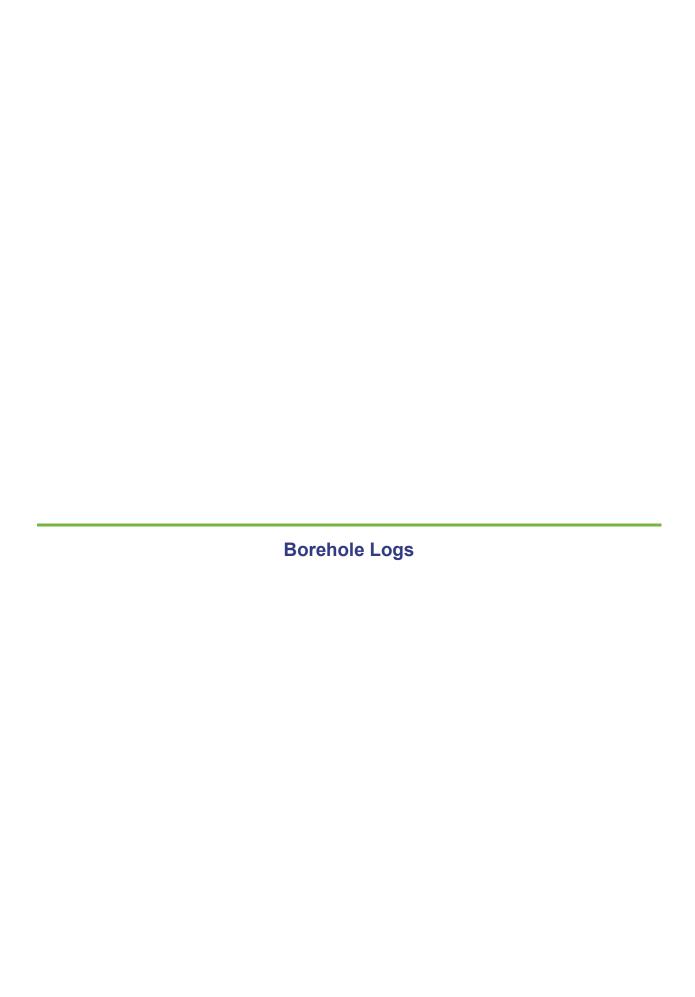


YYYY-MM-DD	2022-03-08
PREPARED	K. Cheung
DESIGNED	K. Cheung
REVIEWED	E.Giles
APPROVED	

Geotechnical Investigation – Site Photos

PROJECT NO. **20-1051** Phase/Task

FIGURE C3 Rev 0



TULL	OCH	RECORD OF BOREHOLE No 20-01 1 OF 1 LOCATION _River Street, Bala, Ontario															METRIC			
	NUMBER 20-1051							ORIGINATED BY JM												
	NT Township of Muston AT Landes Ground Sufa	-			_				_									PILED BY		
							- NOI	DRTHING 4985600 EASTING DYNAMIC CONE PENETRATION RESISTANCE PLOT					_	609067	<u>′</u>	CHEC	CKED BY	EG		
ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	NUMBER	14PE	N" VALUES S	GROUND WATER CONDITIONS	DЕРТН (M)	SHEA O PO		0 6 RENG PEN	0 8 TH kP +	a FIELD		W _P	٧	TENT V	LIQUID LIMIT W _L	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
	Ground Surface 125 mm ASPHALT	0)			-			2	20 4	0 6	0 8	0 1	00	2	0 4	0 6	0	kN/m ³	GR SA SI CL Grinding augers	
-8:93 0.13	FILL - (SW) SAND, fine to coarse grained, gravelly to some fine to coarse gravel, sub-angular, trace non-plastic fines, brown (PAVEMENT STRUCTURE, Base, Subbase); non-cohesive, moist, dense to compact		1	SS	31		- - -	-											from 0.125 m to 1.47 m. Inferred cobbles to boulders.	
	Note: - Auger refusal encountered at 1.47 m. - Landcore Drilling switched to NW		2	SS	20		1-	-											30 58 (12)	
-1.47	casing and core barrel. BEDROCK - Granitic Gneiss, fine to medium grained, angled foliation, medium to coarse grained feldspar intrusion, natural vertical and angular jointing with muscovite and calcite deposits within discontinuities, angular and horizontal fractures throughout, slightly weathered, strong rock Note: - SILT infiltration in discontinuity near 2.59 m Run 1: RQD: 83/147 = 56% TCR: 138/147 = 94% SCR: 105/147 = 71%		Run 1	NQ			2- - -												Rock Core Compressive Strength at 2.3 mbgs = 100.3 MPa	
-2.95 2.95	BEDROCK - Granitic gneiss, fine to medium grained, angled foliation, medium to coarse grained feldspar intrusion, angular and horizontal fractures throughout, unweathered, strong rock Run 2: ROD: 145/155 = 94% TCR: 155/155 = 100% SCR: 155/155 = 100%		Run 2	NQ		<u>\</u>	3												Rock Core Compressive Strength at 3.9 mbgs = 130.3 MPa	
-4.50 4.50	END OF BOREHOLE Note: - Groundwater was measured at 4.12 m upon completion of investigation. It should be noted that groundwater may not be stabilized upon completion of borehole A reduced section sub broke during the attempted removal of a 1.54 m long section of streel casing which became ceased within the borehole. Landcore Drilling was unable to remove this ceased section of casing, therefore it was hammered to 0.2 m below top of asphalt surface, backfilled and abandoned in the borehole.																			

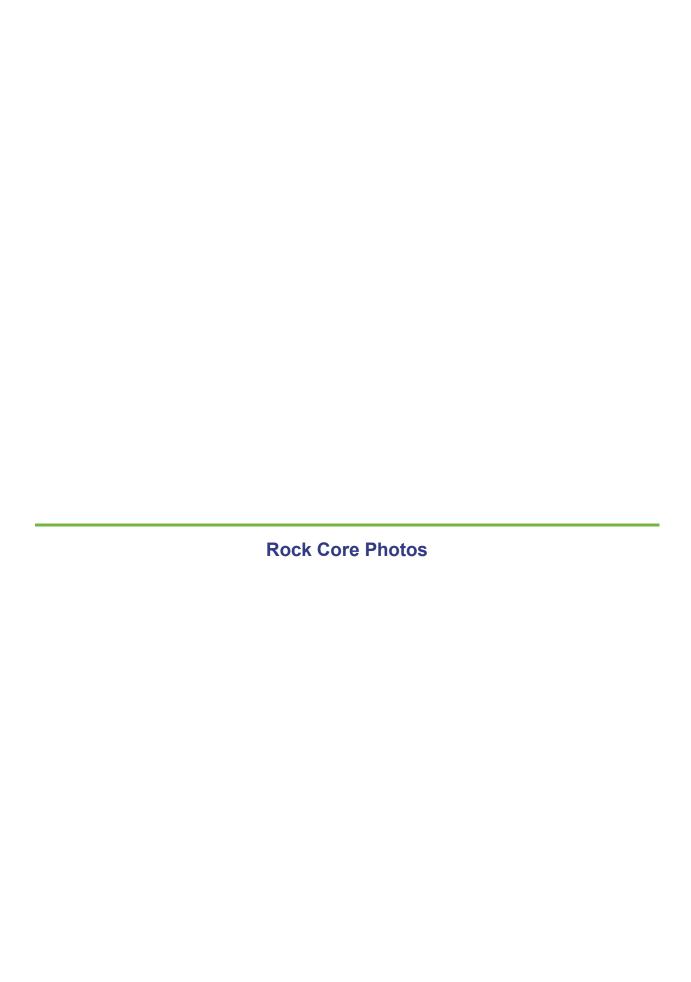
1. SOIL REPORT (DEPTH) (DEFAULT) PROJECT FILE (20-1051 - BURGESS DAM NORTH SLOPE).GPJ ONTARIO MTO.GDT 22-3-1

TULLOCH		RECORD OF BOREHOLE No 20-02 1 OF 1														METRIC				
JOB NUMBER 20-1051			LOCATION River Street, Bala, Ontario														ORIGINATED BY JM			
CLIE	NT_Township of Mus DAT Lames Ground Sufa	ceBOR	EHC	DLE TY	PE _	HSA											COM	PILED BY	′JM	
DRILI	LER Landcore Drilling	DATE _2020.09.09					NORTHING 4985600 EASTING								609067			KED BY	EG	
SOIL PROFILE			SAMPL		.ES	œ		DYNA! RESIS	MIC CO TANCE	NE PEN PLOT	NETRA	ΓΙΟΝ		PLASTIC NATURAL		JRAL		_	REMARKS	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER TYPE "N" VALUES		GROUND WATER CONDITIONS	DEPTH (M)	SHEA O PO	OCKET JICK TF	LENG RENG PEN RIAXIAL	TH kP + . ×	a FIELD V LAB VA	VANE	W _P WA1	CONT V TER CO	TENT v > DNTENT	` '	UNIT WEIGHT	& GRAIN SIZE DISTRIBUTION (%)		
0.00	Ground Surface 125 mm ASPHALT							2	0 4	0 6	0 8	0 10	00	2	0 4	0 6	0	kN/m³	GR SA SI CL	
-0.13 0.13	FILL - (SW) SAND, fine to coarse grained, gravelly to some fine to coarse gravel, sub-angular, trace non-plastic fines, brown (PAVEMENT STRUCTURE, Base, Subbase); non-cohesive, moist, dense to compact		1	SS	29		-													
-1.24 1.24	END OF BOREHOLE		2	ss	>50/ 2"		1													
	Note: - Spoon and auger refusal encountered at 1.24 m. Inferred bedrock surface - Groundwater was not encountered upon completion of investigation. It should be noted that groundwater may not be stabilized upon completion of borehole.																			

1. SOIL REPORT (DEPTH) (DEFAULT) PROJECT FILE (20-1051 - BURGESS DAM NORTH SLOPE).GPJ ONTARIO MTO.GDT 22-3-1

ENGINE		RECORD OF BOREHOLE No 20-03 1 OF 1 LOCATION River Street, Bala, Ontario										METRIC ORIGINATED BY JM							
	NUMBER 20-1051 NT Township of Mus DAaTLaM esGround Sufac																	INATED PILED BY	
	LER Landcore Drilling							RTHING		85600		FAST	ING		609067			CKED BY	
	SOIL PROFILE		_	AMPL				DYNAM RESIST											
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	DEPTH (M)	SHEAI O POO	R STF	0 6 RENG PEN RIAXIAL	0 8 TH kP: + ×	0 10 a FIELD V LAB VA	/ANE NE		CONT V ER CO	TENT V > NTENT		WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
0.00	Ground Surface 125 mm ASPHALT							20) 4	0 6	0 8	0 10	10	2	0 4	0 6	0	kN/m³	GR SA SI CL
-0.13	FILL - (SW) SAND, fine to coarse																		
0.13	grained, gravelly to some fine to coarse gravel, sub-angular, trace non-plastic fines, brown (PAVEMENT STRUCTURE, Base, Subbase); non-cohesive, moist, dense to compact		1	SS	33		-												Grinding experienced throughout auger advancement from 0.125 m to 1.78 m. Inferred cobbles to boulders.
			2	SS	30		1—												
							-												
-1.78			3	SS	>50/ 2"		_												
1.78	END OF BOREHOLE Note: - Spoon and auger refusal encountered at 1.78 m. Inferred bedrock surface - Groundwater was not encountered upon completion of investigation. It should be noted that groundwater may not be stabilized upon completion of borehole.																		

1. SOIL REPORT (DEPTH) (DEFAULT) PROJECT FILE (20-1051 - BURGESS DAM NORTH SLOPE).GPJ ONTARIO MTO.GDT 22-3-1



Retrieved Rock Core at Borehole Location

BH-20-01: Run 1 and Run 2 – 1.47 m to 4.50 m

Top of Bedrock



Bottom of Core

Township of Muskoka Lakes

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Burgess Dam – North Slope Investigation

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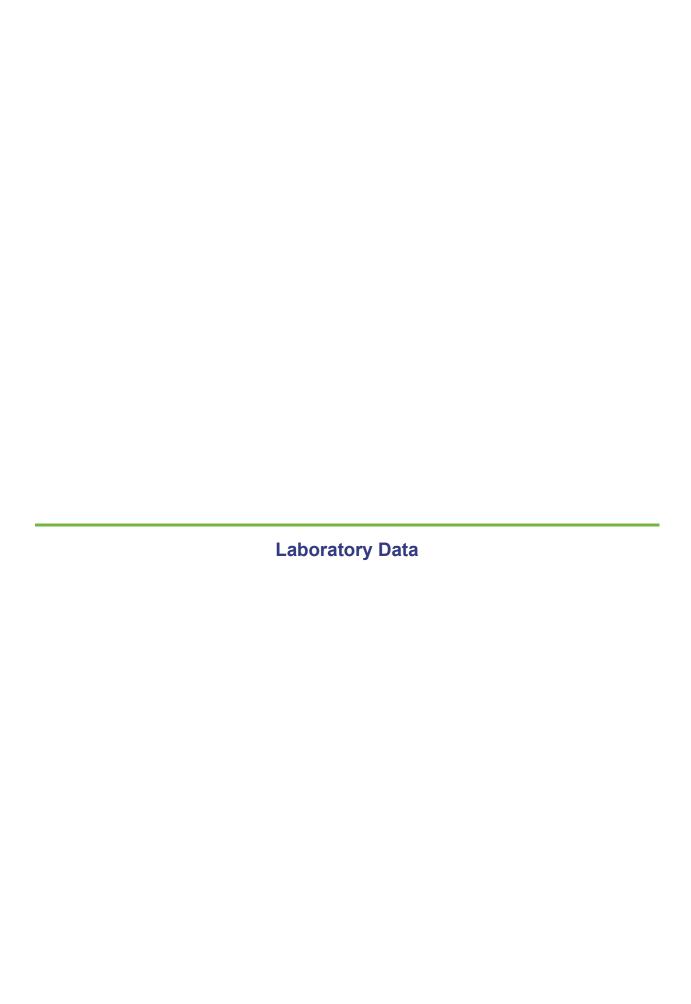


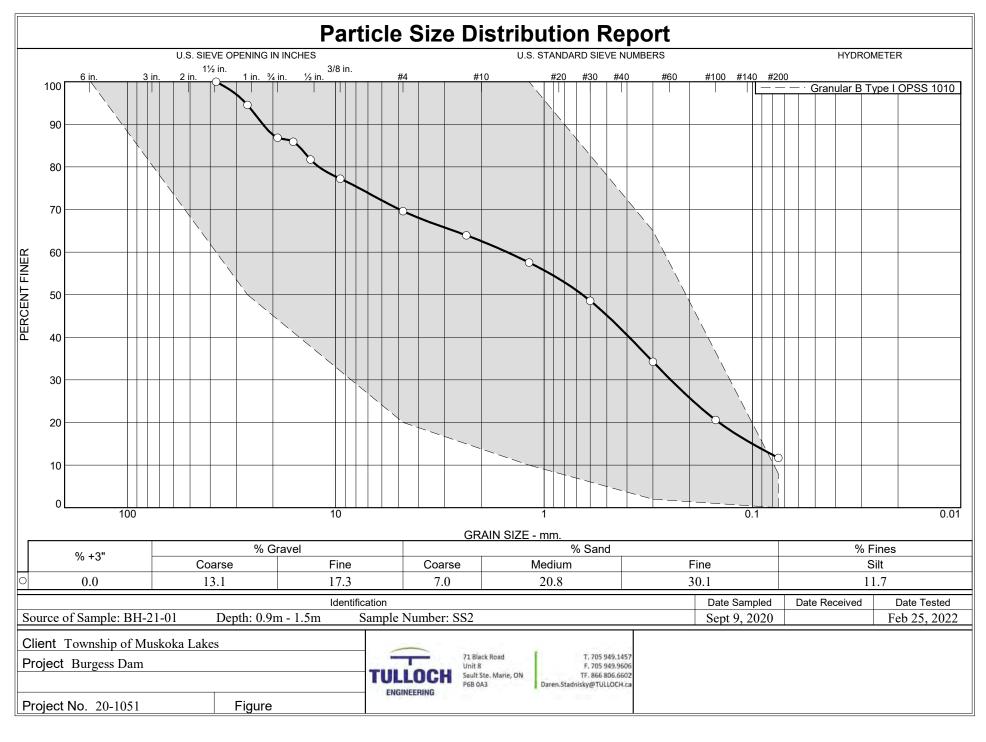
YYYY-MM-DD	2022-03-08
PREPARED	KC
DESIGN	KC
REVIEW	EG
APPROVED	FG

...-

Rock Core Photos - BH-20-01

PROJECT No.	Phase / Task	
20-1051		





2022-03-01

GRAIN SIZE DISTRIBUTION TEST DATA

Client: Township of Muskoka Lakes

Project: Burgess Dam
Project Number: 20-1051
Location: BH-21-01

Depth: 0.9m - 1.5m **Sample Number:** SS2

Tested by: T. Linley

Material specification: Granular B Type I OPSS 1010

Sieve Test Data

Post #200 Wash Test Weights (grams): Dry Sample and Tare = 778.00

Tare Wt. = 163.30

Minus #200 from wash = 8.2%

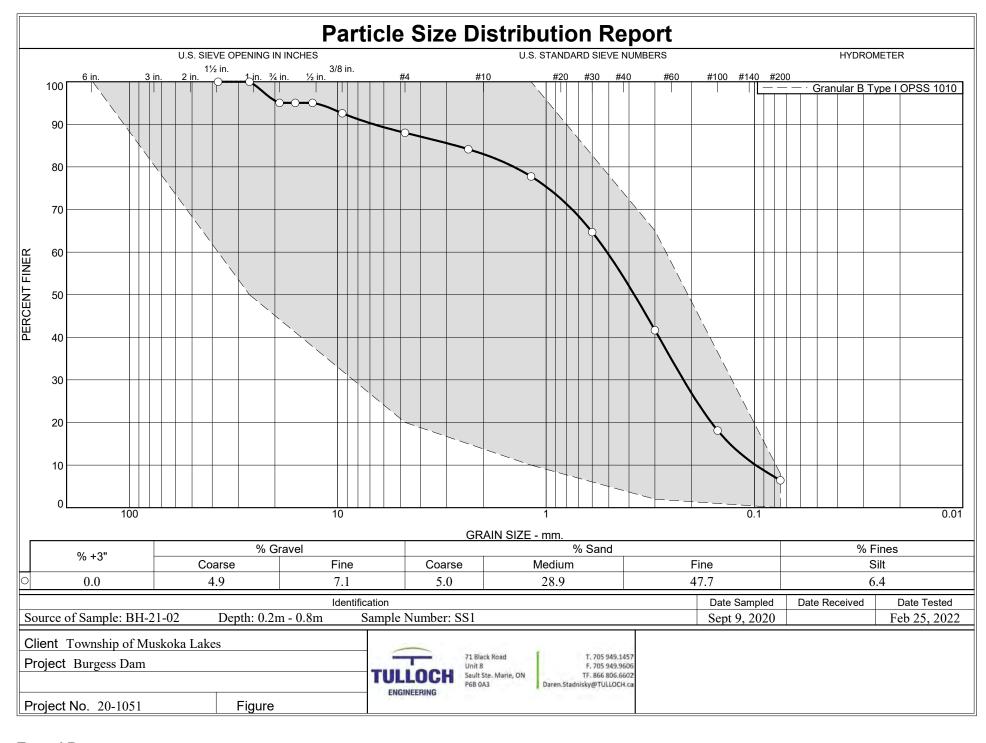
Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Lower Spec. Limit, %	Upper Spec. Limit, %	Deviation From Spec., %
832.80	163.30	37.5mm	0.00	0.00	100.0			
		26.5mm	36.60	0.00	94.5	50.0	100.0	
		19mm	51.40	0.00	86.9			
		16mm	6.30	0.00	85.9			
		13.2mm	28.00	0.00	81.7			
		9.5mm	30.10	0.00	77.2			
		#4	51.10	0.00	69.6	20.0	100.0	
		#8	38.00	0.00	63.9			
		#16	42.80	0.00	57.5	10.0	100.0	
		#30	60.10	0.00	48.6			
		#50	95.80	0.00	34.2	2.0	65.0	
		#100	91.50	0.00	20.6			
		#200	59.60	0.00	11.7	0.0	8.0	+3.7

Fractional Components

Cobbles Gravel				Sa	nd	Fines				
Copples	Coarse Fine Total		Coarse	Medium	Fine	Total	Silt	Clay	Total	
0.0	13.1	17.3	30.4	7.0	20.8	30.1	57.9			11.7

D ₅	D ₁₀	D ₁₅	D ₂₀	D ₃₀	D ₄₀	D ₅₀	D ₆₀	D ₈₀	D ₈₅	D ₉₀	D ₉₅
		0.1001	0.1446	0.2464	0.3900	0.6544	1.5061	12.0512	15.1429	22.3752	27.0349

Fineness Modulus 3.41



GRAIN SIZE DISTRIBUTION TEST DATA

Client: Township of Muskoka Lakes

Project: Burgess Dam
Project Number: 20-1051
Location: BH-21-02

Depth: 0.2m - 0.8m Sample Number: SS1

Tested by: T. Linley

Material specification: Granular B Type I OPSS 1010

Sieve Test Data

Post #200 Wash Test Weights (grams): Dry Sample and Tare = 879.00

Tare Wt. = 151.50

Minus #200 from wash = 4.1%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer	Lower Spec. Limit, %	Upper Spec. Limit, %	Deviation From Spec., %
910.20	151.50	37.5mm	0.00	0.00	100.0			
		26.5mm	0.00	0.00	100.0	50.0	100.0	
		19mm	37.60	0.00	95.0			
		16mm	0.00	0.00	95.0			
		13.2mm	0.00	0.00	95.0			
		9.5mm	18.50	0.00	92.6			
		#4	34.90	0.00	88.0	20.0	100.0	
		#8	29.30	0.00	84.1			
		#16	48.50	0.00	77.8	10.0	100.0	
		#30	99.30	0.00	64.7			
		#50	174.50	0.00	41.7	2.0	65.0	
		#100	178.70	0.00	18.1			
		#200	88.80	0.00	6.4	0.0	8.0	

Fractional Components

Cobbles				Sa	nd	Fines				
Copples	Coarse Fine Total		Coarse	Medium	Fine	Total	Silt	Clay	Total	
0.0	4.9	7.1	12.0	5.0	28.9	47.7	81.6			6.4

D ₅	D ₁₀	D ₁₅	D ₂₀	D ₃₀	D ₄₀	D ₅₀	D ₆₀	D ₈₀	D ₈₅	D ₉₀	D ₉₅
	0.0986	0.1313	0.1609	0.2189	0.2869	0.3771	0.5100	1.4264	2.7128	6.7118	13.0360

Fineness Modulus	c _u	C _C
2.38	5.17	0.95



CSA A283 Certified Laboratory for Concrete Testing CCIL Certified Laboratory for Aggregates and Asphalt Testing CSA/CCIL Certified Technicians

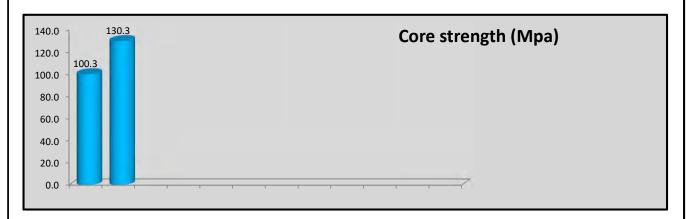




Rock Core Compressive Strength Report

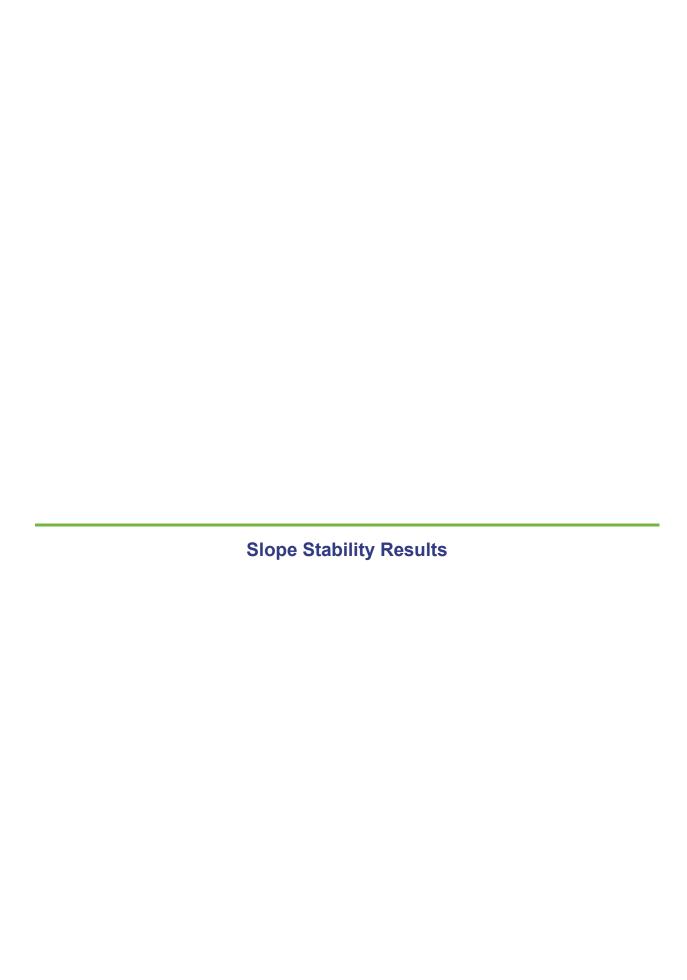
PROJECT:Burgess DamCONTRACT:20-1051DATE SAMPLED:September 9, 2020RUN BY:J. DraperDATE TESTED:February 25, 2022SOURCE:Boreholes

Sample Location	Run #	Distance from top of run (cm)	Height (mm)	Diameter (mm)	L/D Ratio	Correction Factor	Peak Load (lbs)	Compressive Stength (Mpa)
BH-01	1	81	94.62	47.35	2.0	1.0	39700	100.3
BH-01	2	97	94.68	47.41	2.0	1.0	51700	130.3

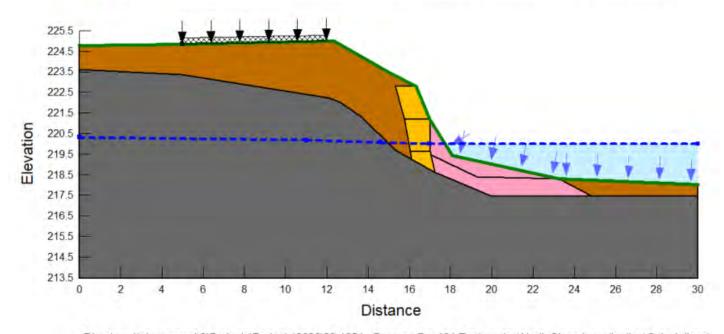


REMARKS:

CLIENT: Township of Muskoka Lakes



Color	Name	Material Model	Unit Weight (kN/m°)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Line
	Bedrock	Bedrock (Impenetrable)					1
	Gabion Baskets	Mohr-Coulomb	20	30	38	0	1
	Rockfill	Mohr-Coulomb	20	0	38	0	1
	Sandy Soil	Mohr-Coulomb	19	0	35	0	1



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PROJEC^{*}

Burgess Dam - North Slope Investigation

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PREPARED	KC
DESIGN	KC
REVIEW	EG
APPROVED	GL

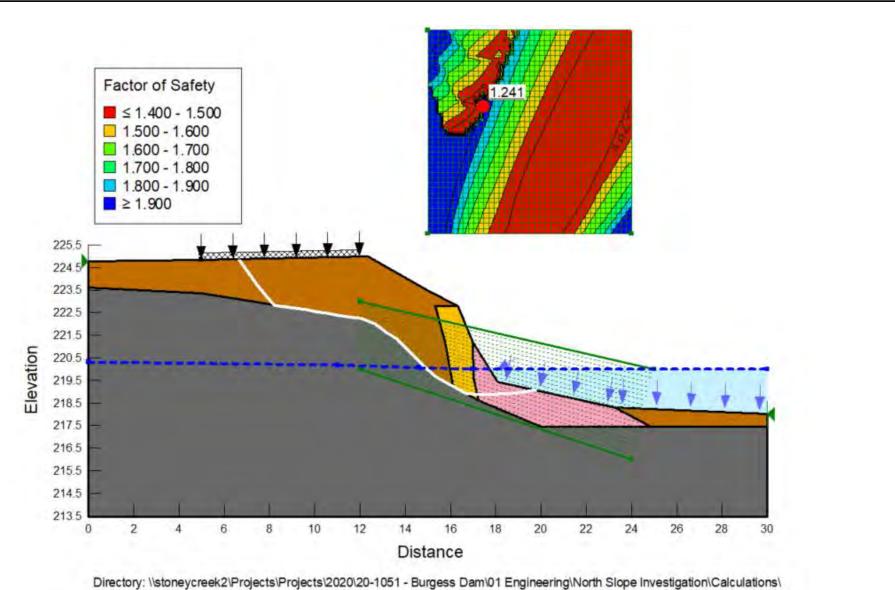
TITLE

North Slope

Geostudio LE Model Geometry and Parameters

 PROJECT No.
 Phase / Task
 Rev.
 Figure

 20-1051
 A
 G-1



CONSULTANT

TITLE

Burgess Dam – North Slope Investigation

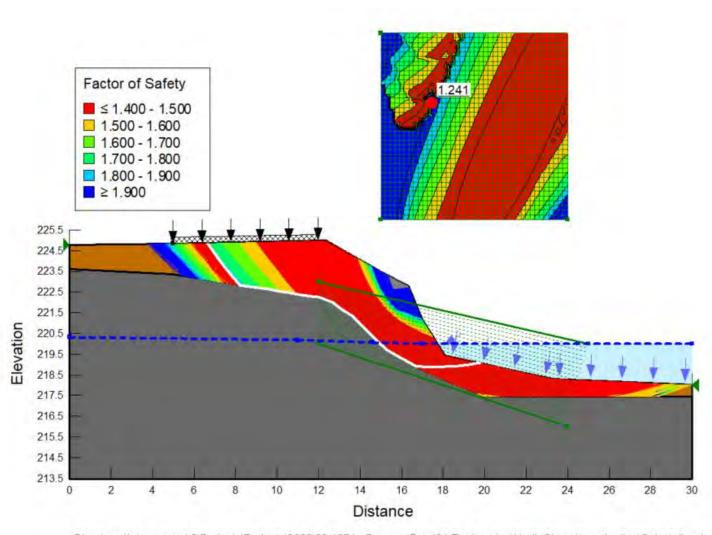
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North Slope Geostudio LE Model Results PRO

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Figure

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TITLE

Burgess Dam – North Slope Investigation

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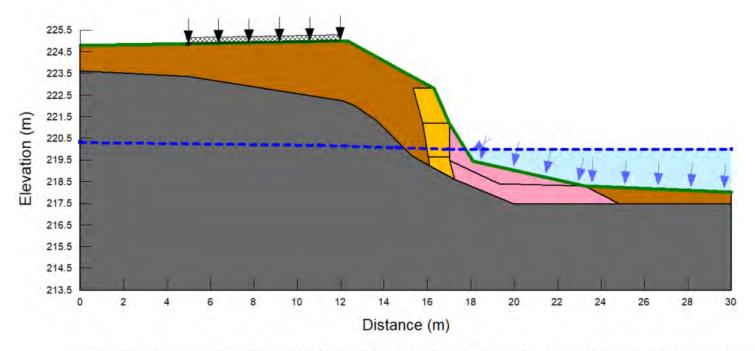
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PREPARED	KC
DESIGN	KC
REVIEW	EG
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North Slope Geostudio LE Model Results

PROJECT No. Rev. Phase / Task 20-1051 Α

Figure Ğ-3

Color	Name	Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Line
	Bedrock	Bedrock (Impenetrable)					1
	Gabion Baskets	Mohr-Coulomb	20	0	38	0	1
	Rockfill	Mohr-Coulomb	20	0	38	0	1
	Sandy Soil	Mohr-Coulomb	19	0	35	0	1



Directory: \\stoneycreek2\\Projects\\2020\20-1051 - Burgess Dam\\01 Engineering\\North Slope Investigation\\Calculations\

KC

KC

EG

GL

CLIENT
Township of Muskoka Lakes

CONSULTANT

YYYY-MM-DD

2022-03-08

PREPARED

APPROVED

DESIGN

REVIEW

TITLE

North Slope – Failed Gabion Meshing Geostudio LE Model Geometry and Parameters

Burgess Dam – North Slope Investigation

PROJECT No. 20-1051

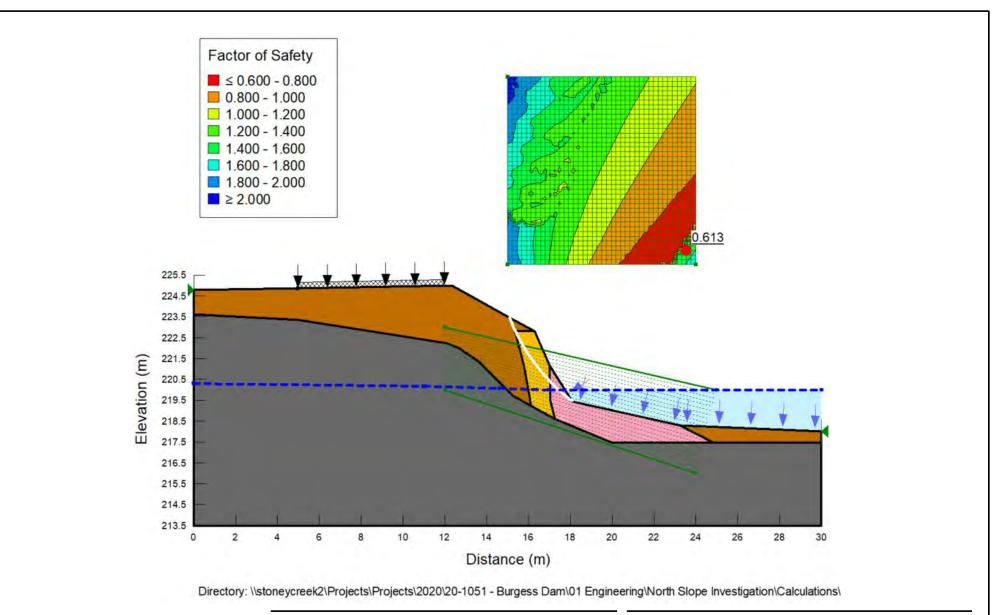
ECT No. Phase / Task -

Figure **G-4**

Rev.

Α





PROJEC1

Burgess Dam - North Slope Investigation

CONSULTANT

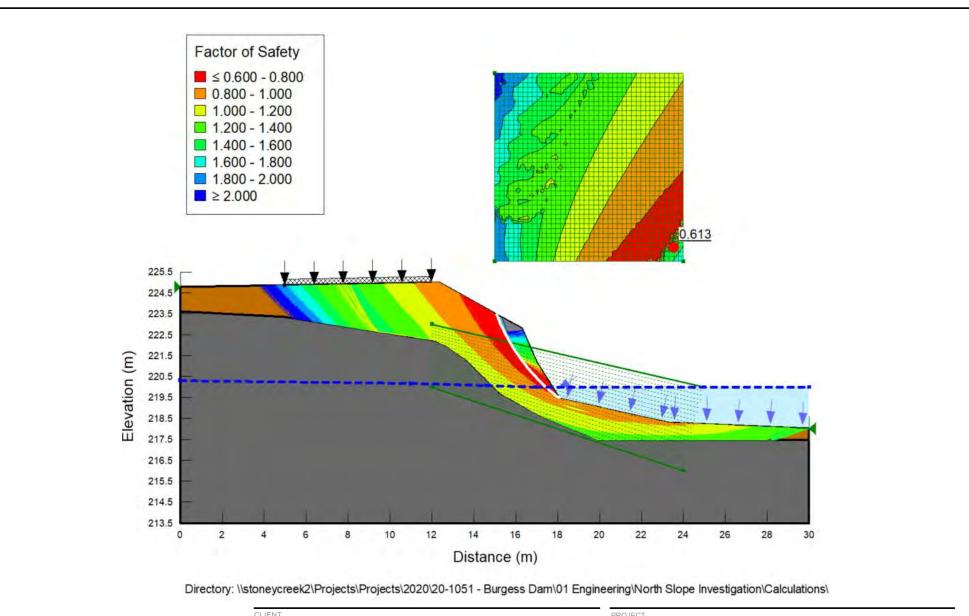


YYYY-MM-DD	2022-03-08
PREPARED	KC
DESIGN	KC
REVIEW	EG
APPROVED	GL

North Slope – Failed Gabion Meshing Geostudio LE Model Results

PROJECT No. Phase / Task Rev. **20-1051 - A**

Figure **G-5**



Burgess Dam – North Slope Investigation

TULLOCH

CONSULTANT

YYYY-MM-DD	2022-03-08
PREPARED	KC
DESIGN	KC
REVIEW	EG
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North Slope – Failed Gabion Meshing Geostudio LE Model Results

20-1051	-	Α
PROJECT No.	Phase / Task	Rev.

Ğ-6

Givens and Assumptions

Geometry Input Parameters

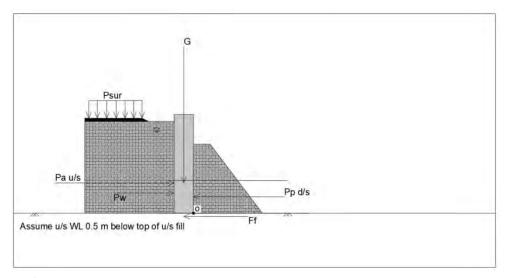
Max. Wall Height	Н	3.66 m
Dam Base width	t	0.30 m
Height of the u/s fill	hfus	3.35 m
Height of the d/s fill	hfds	2.44 m
Height of u/s water	hw	3.35 m
Traffic Surcharge Loading	Psur	20 kPa

Soil/Rock Input Parameters

Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-u/s and d/s Fill	γf	19 kN/m³
Unit weight of water	γ w	9.8 kN/m ³
Friction angle- u/s and d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	38 degree
Active Earth Pressure Coeff.	ka	0.27 -
Passive Earth Pressure Coeff.	kp	3.69 -



WL 0.5m below Top of U/S Fill - U/S to D/S Slide Direction



*N.T.S

Calculation

Force (kN)	FBD ID	Force (kN)	Moment Arm to "O" (m)	Moment (kN.m)
Traffic Surcharge Load	Pt	5.42	1.68	9.09
u/s Water Pressure	Pw	39.88	0.95	37.92
u/s Active Earth Pressure	Pa u/s	28.94	1.12	32.34
d/s Passive Earth Pressure	Pp d/s	208.44	0.81	-169.42
Gravity Force of Concrete dam	G	26.29	0.15	-4.01
Uplift Force	n/a	0.00	0.00	0.00
Friction Force-Concrete-to-Rock	Ff	14.27	0.00	0.00

Result

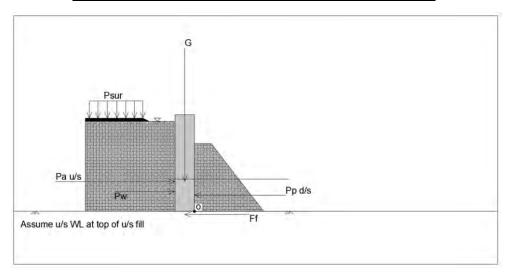
Sliding	Σ Applied Force (kN)	Σ Resistive Force (kN)	FOS	ОК	Required FOS
	74.2	222.7	3.0		1.5

	Σ OT Moment	∑ Anti–OT	Anti–OT FOS		Required
Overturning	(kN*m)	Moment (kN*m)	FU3	OK	FOS
	79.4	-173.4	2.2		2.0

Calculated By: KC Checked By: EG



WL at Top of U/S Fill - U/S to D/S Slide Direction



*N.T.S

Calculation

Force (kN)	FBD ID	Force (kN)	Moment Arm to "O" (m)	Moment (kN.m)
Traffic Surcharge Load	Pt	5.42	1.68	9.09
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Friction Force-Concrete-to-Rock	Ff	14.27	0.00	0.00

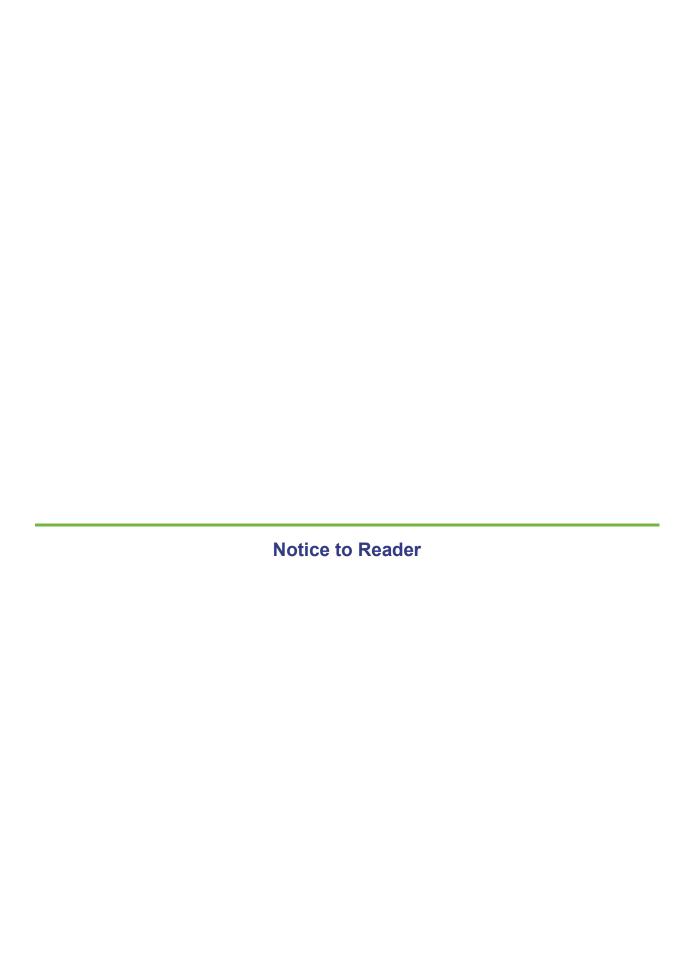
Result

Sliding	Σ Applied Force (kN)	Σ Resistive Force (kN)	FOS	ОК	Required FOS
	89.4	222.7	2.5		1.5

Overturning	Σ OT Moment	∑ Anti–OT	FOS		Required
	(kN*m)	Moment (kN*m)	FU3	Not OK	FOS
	103.0	-173.4	1.7		2.0

Calculated By: KC Checked By: EG





NOTICE TO READER

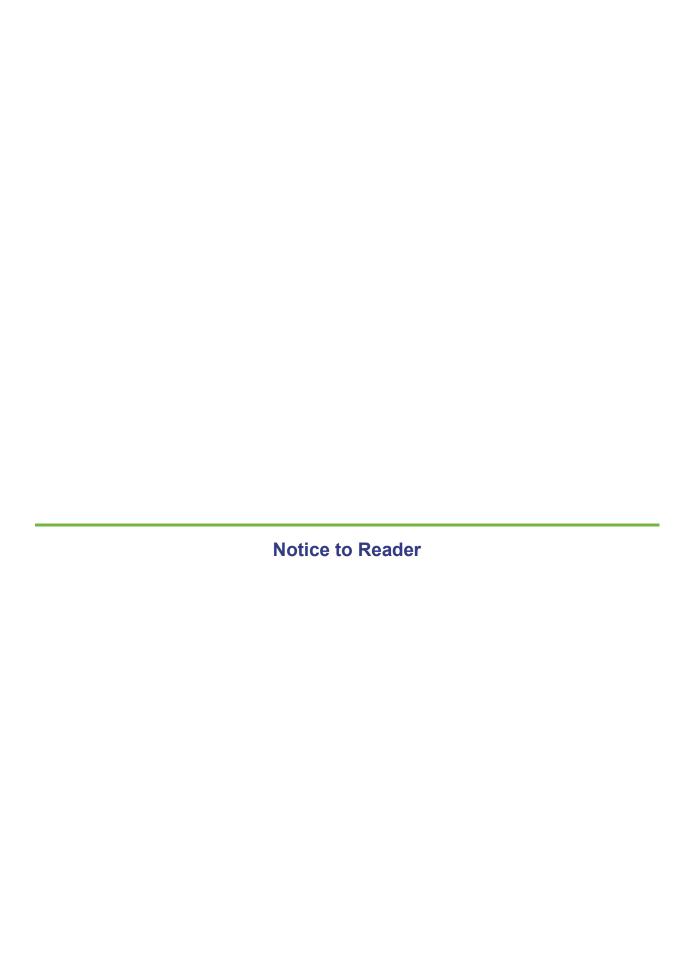
This factual Report has been prepared by TULLOCH Engineering Inc. ('TULLOCH') for the sole and exclusive use of the Township of Muskoka Lakes. (the 'Client') to support the rehabilitation of the north slope located downstream of the Burgess 1 Dam facility along River Street (the 'Development') in Bala, Ontario (the 'Site'). The Report shall not be used for any other purpose, or provided to, relied upon or used by any third party without the express written consent of TULLOCH.

A limited number of boreholes were advanced at the Site; and as such, the information collected and presented herein applies to the borehole locations only. The subsurface conditions between boreholes can change and accordingly any use of the data contained in this Report should take into consideration the nature of the materials and potential variation between boreholes.

This Report contains opinions, conclusions and recommendations made by TULLOCH using professional judgment and reasonable care for the purpose preliminary assessment for the Development. Use of or reliance on this report by the Client is subject to the following conditions:

- a) the report being read in the context of and subject to the terms of the Engineering Services Agreement for the Work, including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions specified or agreed therein;
- b) the report being read in its entirety. TULLOCH is not responsible for the use of portions of the report without reference to the entire report;
- the conditions of the site may change over time or may have already changed due to natural forces or human intervention, and TULLOCH takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report;
- d) the classification of soils and rocks in this report is based on commonly accepted methods. However, the classification of geologic materials and the boundaries between subsurface layers involves judgement. Boundaries between different soils layers may also be transitional rather than abrupt. TULLOCH does not warrant or guarantee the exactness of these descriptions and boundaries.
- e) the subsurface conditions must be verified by a qualified geotechnical engineer during construction to ensure that the borehole data presented herein is representative of the actual site conditions so that the design recommendations contained herein remain valid; and
- f) the report is based on information made available to TULLOCH by the Client or by certain third parties; and unless stated otherwise in the Agreement, TULLOCH has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

This report has been prepared with the degree of care, skill and diligence normally provided by engineers in the performance of comparable services for projects of similar nature.



NOTICE TO READER

This Memorandum has been prepared by TULLOCH Engineering Ltd. ('TULLOCH') for the sole and exclusive use of The Township of Muskoka Lakes (the 'Client') to support the preliminary design for the rehabilitation of the Burgess 1 Dam (the 'Development') in Bala, Ontario (the 'Site'). The Report shall not be used for any other purpose, or provided to, relied upon or used by any third party without the express written consent of TULLOCH.

The Memorandum is based up on interviews with stakeholders and publicly available information, limited borehole data, and commonly accepted engineering practices; and as such, the information collected and presented herein applies for preliminary design purposes.

This Report contains opinions, conclusions and recommendations made by TULLOCH using professional judgment and reasonable care for the purpose of aiding the preliminary design for the rehabilitation for the Development. Use of or reliance on this report by the Client is subject to the following conditions:

- a) the report being read in the context of and subject to the terms of the Engineering Services Agreement for the Work, including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions specified or agreed therein;
- b) the report being read in its entirety. TULLOCH is not responsible for the use of portions of the report without reference to the entire report;
- the conditions of the site may change over time or may have already changed due to natural forces or human intervention, and TULLOCH takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report;
- d) the assumed flow conditions should be verified by a qualified hydrotechnical engineer or study to confirm assumptions made in the memorandum and advance design past the preliminary phase; and
- e) the report is based on information made available to TULLOCH by the Client or by certain third parties; and unless stated otherwise in the Agreement, TULLOCH has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.

This report has been prepared with the degree of care, skill and diligence normally provided by engineers in the performance of comparable services for projects of similar nature. The scope of this report includes foundation engineering design only and it specifically excludes investigation, detection, prevention and assessment of the presence of subsurface contaminants. No conclusions or inferences should be drawn regarding contamination at the site including but not limited to molds, fungi, spores, bacteria, viruses, soil gases such as Radon, PCBs, petroleum hydrocarbons, inorganic and volatile organic compounds, polycyclic aromatic hydrocarbons and or any by products thereof.

APPENDIX J

Quantities & Preliminary Cost Estimate

Burgess 1 Dam Rehabilitation

Cost Estimate - Dam Upgrades and Rehabilitation

	Item	Description	Estimated	Unit	Unit Price	Total
		-	Quantity		(\$/Unit)	(\$)
Α		abilitation Items				
_		Dam Rehabilitation			^	***
	1.1	Stripping	135		\$50.00	\$6,750
	1.2	Sand and Gravel	40		\$150.00	\$6,000
-	1.3	Riprap/rockfill	40		\$250.00	\$10,000
-	1.4	Geotextile	135		\$10.00	\$1,350
-	1.5	Concrete (partial raise 0.5m)	35	m3 LS	\$3,000.00 \$95,000.00	\$105,000 \$95,000
-	1.6 1.7	Grouting existing dam cracks Anchor Φ25, 1m @ spacing 2m for dam raise	1	LS	\$35,000.00	\$35,000
-	1.7	Anchor Φ25, 1m @ spacing 2m for dam raise Subtotal	- 1	LO	\$35,000.00	\$35,000 \$ 259,100
	2	Downstream Regrading				\$259,100
	2.1	Regrading (Fill produced)	15	m3	\$50.00	\$750
-	2.1	Fill used on site	25	m3	\$50.00	\$1,250
		Balance - Imported Fill	10		\$100.00	\$1,000
		Subtotal	10	1110	ψ100.00	\$3,000
	3	South Control Berm				Ψ0,000
H	3.1	Stripping	260	m2	\$50.00	\$13,000
	3.2	Berm Fill (sand and gravel)	150	m3	\$100.00	\$15,000
	3.3	Sod or Seed with Topsoil (slope stabilization)	300	m2	\$30.00	\$9,000
		Subtotal				\$37,000
	4	Powerhouse Retrofit				, ,
	4.1	Concrete Fill for undermined area of the powerhouse foundation	30	m3	\$3,000.00	\$90,000
	4.2	Foundation Grouting	1	LS	\$125,000.00	\$125,000
	4.3	Anchorage the existing concrete slab to bedrock,Φ36mm, 8m long with 6m in rock	1	LS	\$100,000.00	\$100,000
	4.4	New powerhouse roof	1	LS	\$100,000.00	\$100,000
	4.5	Additional frame and column for powerhouse structure	1	LS	\$50,000.00	\$50,000
	4.6	Downstream cofferdam	15	m3	\$150.00	\$2,250
		Subtotal				\$467,250
	5	Tailrace, excluding North Slope Rehabilitation				
	5.1	Concrete for apron and South wall	30	m3	\$3,000.00	\$90,000
	5.2	Anchors - shallow	1	LS	\$15,000.00	\$15,000
	5.3	Stripping	70	m3	\$50.00	\$3,500
_	5.4	Sand and Gravel	15	m3	\$100.00	\$1,500
	_	Subtotal				\$110,000
	6	North Slope Rehabilitation		_		
_	6.1	Stripping	65	m2	\$50.00	\$3,250
	6.2	Slope Excavation and Gabion basket removal	105	m3	\$100.00	\$10,500
_	6.3	Sand and Gravel	95	m3	\$150.00	\$14,250
\vdash	6.4 6.5	Geotextile	45 30	m2 m3	\$10.00 \$4,000.00	\$450 \$120.000
-	0.0	Concrete Wall on North Slope	30	1113	φ4,000.00	, ,,,,,,
\vdash		Subtotal Subtotal Civil Behabilitation Items				\$148,450 \$1,024,800
H		Subtotal Civil Rehabilitation Items				\$1,024,800
P	Power Go	eneration Equipment Upgrades				
۴	1	Turbine Replacement and Upgrades	1	LS	\$800,000.00	\$800,000
\vdash		Subtotal Power Generation Upgrades	I	LO	φουσ,σου.σο	\$800,000
H		Subtotal Fower Generation Opyrades				ψ000,000
c	Continge	ncies				
Ĕ		on Contingency	10%			\$102,480
H		Design Allowance	10%			\$182,480
H		ng Allowance (CQA)	10%			\$182,480
H	Preliminar	y Design Estimating Contingency	30%			\$307,440
H		Subtotal Civil Contingencies	5570			\$774,880
H		Sastan San San San San San San San San San S				, ,
H		Total Estimated Construction Cost				\$2,599,680
L	Evolusion					, - , -, -, -, -, -, -, -, -, -, -, -, -, -,

- Exclusions:
 Land acquisition
 Financing / IDC
 Owner's costs
 Bonding and Insurance

APPENDIX D HPC MEMORANDUM



Planners | Surveyors | Biologists | Engineers

MEMORANDUM

Date: Wednesday, April 9, 2025

To: Ms. Laurel Gordon

IRM Technical Specialist Ministry of Natural Resources

Bracebridge Minden Parry Sound District

R.R. 2, HWY 11 North Bracebridge, Ontario

P1L 1W9

From: Erik Giles, P.Eng. George Liang, Ph.D., P. Eng., Kelvin Cheung, P.Eng.

CC: Emelia Myles-Gonzalez, M.Sc., E.P.

RE: MNR Comment and Clarification Response for Burgess Dam Rehabilitation LRIA Permitting Application – HPC Selection Criteria

Dear Ms. Gordon,

This memorandum documents elaboration on the selection of the HPC for the Burgess Dam rehabilitation project. As requested by the MNR, further elaboration on the selected criteria based on the LRIA Technical Bulletin has been requested. As a basis for this discussion, the HPC table originally published in the Dam Safety Review conducted by TULLOCH in 2019 is shown below in Table 1.

Table 1: Burgess Dam Hazard Classification Summary

Cotogony	Burgess	1 Dam
Category	Flood	Non-Flood
Incremental Loca of Life (LOL)	0	0
Incremental Loss of Life (LOL)	Low	Low
Faceparia Demagas	<\$300,000	<\$300,000
Economic Damages	Low	Low
Environmental	Low	Low
Cultural / Heritage	Low	Low
Governing Criteria	Economic / LOL	Economic / LOL
Overall Classification (HPC)	LOW	LOW



The HPC selection was based on a desktop review inclusive of the scope and budget at the time of completing the DSR based on TULLOCH's proposed scope of work to the Township of Muskoka Lakes. A comprehensive Dam Break analysis was not completed largely due to budgetary constraints as well as the small size/head levels of the dam and typically low flow conditions. A desktop assessment of the surrounding area was completed to help guide the decision for HPC selection, as well as an inspection of the facility which was completed during the DSR. The assigned HPC was carried forward in the design work presented in the LRIA Application.

Each main category from the MNR LRIA Technical Bulletin will be discussed to provide further elaboration on TULLOCH's rationale for the HPC criteria selection of LOW.

Incremental Loss of Life

The Burgess 1 Dam is a small dam with a relatively low head level, under normal operating levels generally less than 1.5 m at the non-powerhouse station of the dam is associated with a maximum flow rate of 4 m³/s for power generation. A flood comparable to the IDF event, which occurred in 2019, showed a potential simulation subject of what an overtopping event at the structure would look like and the incremental consequences that may occur during failure. With respect to loss of life, there are private property owners adjacent to the dam; however, the dam is generally well-secured, and the presence of members of the public is minimal. The channel valley of the downstream tailrace is relatively well defined and water flows into the larger lower reach of the Muskoka River which converts into the Moon River further downstream.

In the event of sudden failure, it is unlikely that Loss of Life would be experienced, and the incremental damage caused by overtopping/flooding during 2019 did not place members of the public in harm's way. As such, it is unlikely that under flooding and non-flooding conditions, Loss of Life is likely to occur.

Economic Damages

Outside of economic damages to the station itself, incremental damages would largely be confined to property damage of the surrounding upstream and downstream areas. There are several docks along the upstream reach and near the outlet of the downstream tailrace area as the water flows into the lower reach of Lake Muskoka/Moon River. As such, it is likely that these structures would be damaged or potentially lost under sudden dam failure. During flooding conditions, most of these structures have been put at risk historically as a result of the increased water levels of Lake Muskoka. As such, given there is no significant infrastructure that would likely be affected incrementally, the economic losses would likely be less than \$300,000 (the dollar value is indexed to Statistics Canada values Year 2000), which would largely be associated with the above-mentioned shoreline infrastructure.

Environmental Losses

Incremental environmental losses would largely be associated with the sudden failure of the dam. Generally, there is existing habitat at the station, particularly, a small area for walleye spawning was identified in the eddy directly downstream of the generating station during TULLOCH's





Environmental Impact Assessment conducted in 2020. In the event of sudden failure of the structure, this small habitat area would likely be impacted. The remainder of the lower tail race reach is exposed bedrock with relatively swift-moving water. As such, flooding would likely not impact this area significantly, and this area was not identified as a suitable habitat for spawning. Sediment loading would also be experienced in the event of failure with the movement of fill and soil material downstream into Lake Muskoka. However, given the relatively small property size and impact in comparison to the overall Lake Muskoka habitat area, the overall loss of environmental habitat is relatively small in comparison. Similarly, incremental losses under flooding conditions would also be relatively small. Sediment transport and washouts were noted during the flooding of 2019; however, the EIA conducted the following year still identified habitat areas adjacent to the dam, as mentioned above, indicating that recovery of habitat was possible even after a large flow/overtopping event. As such the hazard potential associated with incremental environmental losses was assigned as Low at the time of the DSR for both Flood and Non-flood conditions.

Cultural – Built Heritage Losses

Incremental losses due to Cultural/Built Heritage features are considered to be negligible, with the exception of the Francis Turbine located within the powerhouse of the dam itself. Generally, directly upstream and downstream, there are no heritage features; while some heritage structures and cultural areas do exist near the dam, such as the Bala United Church and the Kee to Bala, a review of satellite imagery indicates that these structures would not be impacted by sudden dam failure or impacted incrementally during a failure under flooding conditions as they are not adjacent to the dam headpond or tailrace. With respect to heritage loss, the main item that would be impacted would be the loss of the original Francis turbine itself, which, to TULLOCH's knowledge while identified during the CHER report in the Environmental Assessment, does not have any special designation from the Township of Muskoka Lakes. Further, there are no municipally designated heritage sites that would be impacted by dam failure. Therefore, the incremental loss associated with Cultural/Built Heritage would be very small and overall fit into the definition of Low.

Given the study of the above criteria under the LRIA Technical Bulletin guidelines, generally, the Economic damage, specifically with respect to property damage associated with shoreline infrastructure (e.g., docks), is most at risk; however, it is likely this would fall under a \$300,000 (the dollar value is indexed to Statistics Canada values Year 2000) threshold. Therefore, the HPC assigned to the structure was designated to be LOW.

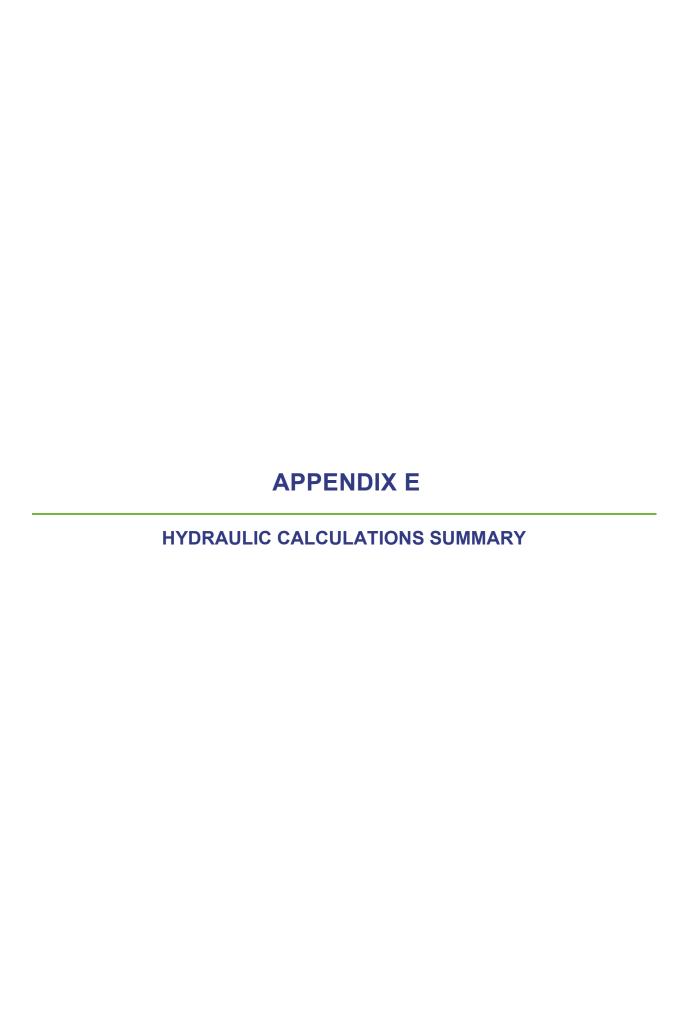
Should the MNR wish to seek further clarifications, please do not hesitate to contact the undersigned.

Sincerely,



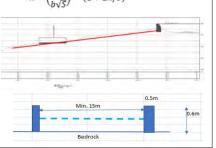






Project No.: 23-1236			Burge	ss Spillway Hydrauli	Calculation	TILLOCH
Project No.: 23-1236	Date	2024-01-1	4 Cal. By:	Kelvin C.	Checked By: G. Liang	ENGINEERING
Spillway Rating Curve		•				
Spillway Rating Curve	IDF	226.49	masl	Notes	Sketch/Figure/Equatio	n
Crest	Elevation	226.5	masl	Crest to spillway=0.57		
Spillway Crest		225.93	masl	(OG crest elev.)		
Spillway Botton		224.5	masl	*from C5 cross section	25m	/
Tailwater	Elevation	219.5	masl		150/	_
				*this is depth of water	1	
				based on IDF vs spillway	Jen J	
				crest. Using this as Yc	1	
				over the dam gives us Q		
				which we can use to	EST 1	
IDF-Spillway 0	Crest yn _{us}	0.56	m	solve for YC	Maril 1	
Maximum Design Flow, Q-desi						
	Qdesign=	19.28	m3/s		Compound, Cipolletti, Trapezoidal and Re	ctangular Broad-crested weirs.
	bo 7	25 0	m m		C 10	
Ang	led width	0	m	*total	$Q = C_W L H^{1d}$	
Ang	lea wiath g	9.81	m/s2	totai	Where:	
	5	5.01	111/32		Q = discharge over well, cfs (cms)	
Sharp crested rect	angular weir	computing O			L = length of the weir crest, ft (m)	
	Cw		1.84 -		H = distance between water surface and	
	L	25	m		Ow = weir coefficient, typically 3.33 (1.84)	for sharp-crested; 3:367 (1.83) for
Q trapezo	oidal weir		19.28 m3/s	*See research tab	Cipolietti; 3.09 (1.7) for Broad-crested	
	ge Curve	El. (m) 225.93 226.13 226.33 226.49	Q (m3/s) C 4.11 11.64 19.28		226.5 226.4 (E) 226.3 3 226.2 3 226.2 3 226.2 4 225.9 5 10 Q	15 20 25 (m3/s)
	Shape with S Design Q b bo/rockfill)	19.28 15 0.045 0.125	m3/s m m-1/3s slope	min width m Manning n 1/8-site condition	$h = \left(\frac{nQ}{h\sqrt{\varsigma}}\right)^{a/5} (1 + 2)$	h/b) ^{2/5}
normal wa	ter depth	0.125 h	siope	1/0-site condition	WY3	
						2 200
Ca	lculation					
	hn	0.37	iteration			
	h	0.34	m			
	a	0.33749				
	h	0.344	Check	Ok	****	
Flow Veloc	ity Check					0.5m
	Area	5.16	m2		Min. 15m	*
	V	3.74	m/s	d/s of Rip-Rap Area		0.6m

0.37	iteration	
0.34	m	
0.33749		
0.344	Check	Ok
5.16	m2	
3.74	m/s	d/s of Rip-Rap Area
0.25	m	
0.59	m	Calculated
0.60	m	Final (rounded up)
	0.34 0.33749 0.344 5.16 3.74 0.25 0.59	0.34 m 0.33749 0.344 Check 5.16 m2 3.74 m/s 0.25 m 0.59 m



Final Height Wall	0.60	m	Final (rounded up)	
Hydraulic Slope Check for Riprap Size D50 and Slop	oe			45
d/s slope design			_	4.0 P Abt & Johnson (1991) q.= 30 cts/ft
Max. Q	19.28	m3/s	flow	A Robinson (1999)
b	15	m	min. width	q_=20 cl/ft
				3.0 Comman Process, occupy reproductively
convert				D ₅₀ (ft) 15 q ₄ =10 ds/ft
Convert	680.867416	ft3/s	flow	20 A A A
	49.2	ft	width	15 000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
qa, unit rate	13.8	ft^3/s/ft	width	14 A A A A A A & A A A A A A A A A A A A
Design D50	1.2	ft		as a second
Slope	25%	4H:1V		900
Зюре	23/0	411.20		on son son
				Figure 8-4.—Example calculation of required stone size as a function of slope, assuming a fixed allowable unit discharge (Reclamation).
Spillway End Riprap Chute Calculation				54 - 242 31/199
Input:				$D_{50} = \left[\frac{(qS^{\bullet,58})}{(qS^{\bullet,58})}\right]^{1/1.89}$ (9)
Energy slope (S) = Bed slope (So)	0.125			8.07E - 6
Channel bottom width (B)	0.125	m		
Channel side slopes (Z)	0	m Vertical		$n = 0.0292 \text{ (D}_{50} \text{ S}_{\odot})^{0.147}$ (7)
Total discharge (Q)	19.28	m3/s		11 010212 (030 00) (1)
Total discharge (Q) The unit discharge (qt)	1.29	m3/s/m		
The unit discharge (qt)	1.29	m3/s/m		
Riprap D50	299			depths, and the Stephenson (1979) empirical equation for velocity through rock material:
Manning roughness coefficient,n	0.050	mm		V' - V + 800
ivianning roughness coefficient, n	0.050			$V_{m} = n_p \left(\frac{S_m g D}{K} \right)^{1/2}$ (4)
				where
The velocity through the rock mantle (Vm)				V _m = velocity through took (in/s) K = 4 for crushed rock n ₀ = posisity R = Reynolds number (dV/n ₀ v)
np	0.46			g + gravitational acceleration (9.5.1 m/s ²).
SO SO	0.125		Bed slope 1/8	K' = a dimensionless friction factor D = representative rock diameter in m (use D ₁₀ in m)
g	9.81	m/s2		Abs et al. (1987) presented values for no of 0.44 to 0.46 for
D50	0.360	m		angular tiprap. The factor K' is defined by Stephenson (1979) as:
К'	4			
K	4			
800/Re	0.01			
Vm	0.15	m/s		

The unit discharge through the mantle ,qm

The surface flow unit discharge, qs
The flow depth above the effective
top-of-riprap (d) 0.11 1.18 m3/s/m Vm*(2*D50) m3/s/m qs=qt-qm 0.34 m

$$d = \left(\frac{n \ q_s}{S_o^{0.5}}\right)^{3/5}$$



Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	2.07 m
Water Level (NOL Upper Bound)	hw1	1.32 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m

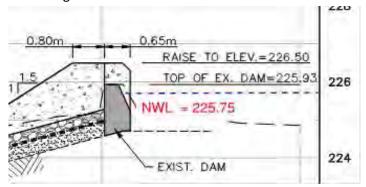
Basis Elevations for Calculation

Dam Crest	226.5	masl
NOL	225.75	masl

Soil/Rock Input Parameters

Son/ Nock input Parameters		
Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m ³
Unit weight of water	γw	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	3.69 -

Burgess Dam Non-Overflow Section Sketch





NOL Case - Upstream to Downstream Slide Direction

Calculation

Force (kN)	FBD ID	Force (IAN)	Moment Arm	Moment
Force (kN)	רוט וט	Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure NOL U/B	Pw	8.54	0.44	3.76
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	31.26	0.33	-10.16
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	4.20	0.43	1.82
Friction Force-Concrete-to-Rock	Ff	204.12	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	269.10	1.04	-278.52
Side Friction Force of the Concrete Dam Section (two sides)	Fs	94.25	0.33	-30.63

Result

Sliding	Σ Applied Force	Σ Resistive Force	FOS		Required
	(kN)	(kN)		OK	FOS
	8.5	476.4	55.80		2.0
Overturning	Σ OT Moment	∑ Anti–OT	FOS		Required
	(kN*m)	Moment (kN*m)	FU3	OK	FOS
	5.6	-319.6	57.30		2.0

Calculated By: KC Checked By: GL



Stability Factor of Safety Calculation for Burgess 1 Dam Non-Overflow Section - IDF Case

Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	2.07 m
Water Level (IDF Level)	hw1	2.06 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m

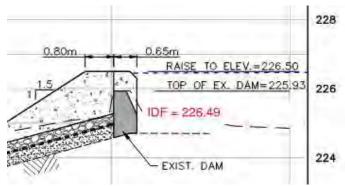
Basis Elevations for Calculation

Dam Crest	226.5	masl
IDF	226.49	masl

Soil/Rock Input Parameters

Son, Rock input i arameters		
Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m ³
Unit weight of water	γw	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	3.69 -

Burgess Dam Non-Overflow Section Sketch





IDF - Upstream to Downstream Slide Direction

Calculation

Force (IM)	FBD ID	Forse (kNI)	Moment Arm	Moment
Force (kN)	רוו טוא	Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure IDF Level	Pw	20.79	0.69	14.28
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	31.26	0.33	-10.16
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	6.56	0.43	2.84
Friction Force-Concrete-to-Rock	Ff	202.76	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	269.10	1.04	-278.52
Side Friction Force of the Concrete Dam Section (two sides)	Fs	94.25	0.33	-30.63

Result

resure					
Sliding	Σ Applied Force	\sum Resistive Force	FOS		Required
	(kN)	(kN)		OK	FOS
	20.8	475.0	22.84		1.3
Overturning	Σ OT Moment	∑ Anti–OT	FOS		Required
	(kN*m)	Moment (kN*m)	FU3	OK	FOS
	17.1	-319.6	18.67		1.3

Calculated By: KC Checked By: GL



Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	2.07 m
Water Level (NOL Upper Bound)	hw1	1.32 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m

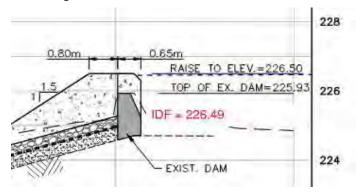
Basis Elevations for Calculation

Dam Crest	226.5	masl
NOL	225.75	masl

Soil/Rock Input Parameters

Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m ³
Unit weight of water	γw	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	4 -
PGA (NBCC - 500 yr)	PGA	0.028 g

Burgess Dam Non-Overflow Section Sketch





Seismic (500 yr) - Upstream to Downstream Slide Direction

Calculation

Force (kN)	FBD ID	Force (kN)	Moment Arm	Moment
Force (KIV)	רו טו	Force (kiv)	to "O" (m)	(kN.m)
u/s Water Pressure NOL U/B	Pw	8.54	0.44	3.76
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	31.26	0.33	-10.16
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	4.20	0.43	1.82
Friction Force-Concrete-to-Rock	Ff	204.12	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	269.10	1.04	-278.52
Side Friction Force of the Concrete	Fs	94.25	0.33	-30.63
Dam Section (two sides)	гъ	94.25	0.55	-50.05
Seimic Loading	F_seis	0.04	1.24	0.06

D	
RACIII	1

Sliding	Σ Applied Force (kN) 8.6	\sum Resistive Force (kN) 476.4	FOS 55.50	ОК	Required FOS 1.0
	Σ OT Moment	∑ Anti–OT	FOS		Required
Overturning	(kN*m)	Moment (kN*m)	103	OK	FOS
	5.6	-319.6	56.73		1.0



Stability Factor of Safety Calculation for Burgess 1 Dam Non-Overflow Section

Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	2.07 m
Water Level U/B (Winter NOL Upper Bound)	hw1	1.17 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m
Ice Loading Location	h_{ice}	0.87 m

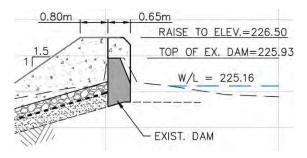
Basis Elevations for Calculation

Dam Crest	226.5	masl
NOL Winter Target on Jan 31	225.3	masl
NOL Winter (Upper Bound)	225.6	masl
NOL Winter (Lower)	224.6	masl

Soil/Rock Input Parameters

Soll/ Rock illput Parameters		
Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m^3
Unit weight of water	γ w	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	3.69 -

Burgess Dam Non-Overflow Section Sketch





Winter NOL (Upper Bound) - Upstream to Downstream Slide Direction

Calculation

Force (kN)	FBD ID	Force (I/NI)	Moment Arm	Moment
Force (KN)	רו עו	Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure Winter NOL U/B	Pw	6.71	0.39	2.62
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	31.26	0.33	-10.16
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	3.73	0.43	1.61
Friction Force-Concrete-to-Rock	Ff	204.39	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	269.10	1.04	-278.52
Side Friction Force of the Concrete	Fs	94.25	0.33	-30.63
Dam Section (two sides)	1.5	54.23	0.55	-30.03
Ice Loading	Fice	75.00	0.87	65.25

Result

	Σ Applied Force	Σ Resistive Force	FOS		Required
Sliding (kN) 81.7	(kN)	FUS	OK	FOS	
	81.7	476.6	5.83		2.0

	Σ OT Moment	\sum Anti $-$ OT	FOS		Required
Overturning	(kN*m)	Moment (kN*m)		OK	FOS
	69.5	-319.6	4.60		2.0



Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	1.5 m
Water Level (NOL Upper Bound)	hw1	1.32 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m

Basis Elevations for Calculation

Dam Crest	225.93	masl
NOL	225.75	masl

Soil/Rock Input Parameters

John Nock input Parameters		
Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m ³
Unit weight of water	γ w	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	3.69 -

Burgess Dam Overflow Section Sketch





NOL - Upstream to Downstream Slide Direction

Calculation

Fores (IAN)	EDD ID	Force (IAN)	Moment Arm	Moment
Force (kN)	FBD ID	Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure NOL U/B	Pw	8.54	0.44	3.76
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	22.52	0.33	-7.32
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	4.20	0.43	1.82
Friction Force-Concrete-to-Rock	Ff	199.07	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	195.00	0.75	-146.25
Side Friction Force of the Concrete	Fs	94.25	0.33	-30.63
Dam Section (two sides)	. 3	3 1.23	0.00	

Result

Sliding	Σ Applied Force (kN)	\sum Resistive Force (kN)	FOS	ОК	Required FOS
	8.5	397.2	46.53		2.0
	Σ OT Moment	Σ Anti $-$ OT	FOS		Required
Overturning	(kN*m)	Moment (kN*m)	103	OK	FOS
	5.6	-184.5	33.08		2.0



Stability Factor of Safety Calculation for Burgess 1 Dam Overflow Section - IDF Case

Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	1.5 m
Water Level (IDF Level)	hw1	2.06 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m

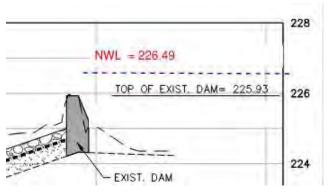
Basis Elevations for Calculation

Dam Crest	225.93	masl
IDF	226.49	masl

Soil/Rock Input Parameters

John Nock input Parameters		
Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m ³
Unit weight of water	γ w	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	3.69 -

Burgess Dam Overflow Section Sketch





IDF - Upstream to Downstream Slide Direction

Calculation

Force (IAN)	FBD ID	Force (I/NI)	Moment Arm	Moment
Force (kN)	רוו טו	Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure IDF Level	Pw	20.79	0.69	14.28
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	22.52	0.33	-7.32
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	6.56	0.43	2.84
Friction Force-Concrete-to-Rock	Ff	0.00	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	195.00	0.75	-146.25
Side Friction Force of the Concrete	Fs	94.25	0.33	-30.63
Dam Section (two sides)	. 3	3 1.23	2.33	

Result

Sliding	Σ Applied Force (kN)	\sum Resistive Force (kN)	FOS	ОК	Required FOS
	20.8	198.2	9.53		1.3
	Σ OT Moment	Σ Anti $-$ OT	FOS		Required
Overturning	(kN*m)	Moment (kN*m)	103	OK	FOS
	17.1	-184.5	10.78		1.3



Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	1.5 m
Water Level (NOL Upper Bound)	hw1	1.32 m
Dam Base width	t	0.65 m
Crest Width	t1	0.45 m
Crest Width Change height	h1	0.2 m
Height of the d/s rockfill	hf1	0.3 m

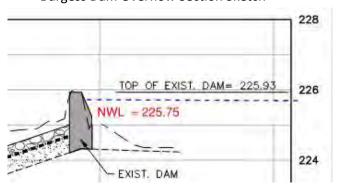
Basis Elevations for Calculation

Dam Crest	225.93	masl
NOL	225.75	masl

Soil/Rock Input Parameters

Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill Unit weight of water	$\gamma f \ \gamma w$	19 kN/m³ 9.8 kN/m³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface Cohesion- Concrete-to-rock interface	φ'c-R C'c-R	40 degree 290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	4 -
PGA (NBCC - 500 yr)	PGA	0.028 g

Burgess Dam Overflow Section Sketch





Seismic (500 yr) - Upstream to Downstream Slide Direction

Calculation

Force (kN)	FBD ID	Force (IAN)	Moment Arm	Moment
rce (kin) Folice (kin		Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure NOL U/B	Pw	8.54	0.44	3.76
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	22.52	0.33	-7.32
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	4.20	0.43	1.82
Friction Force-Concrete-to-Rock	Ff	0.00	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	195.00	0.75	-146.25
Side Friction Force of the Concrete	Fs	94.25	0.33	-30.63
Dam Section (two sides)	F5	94.25	0.33	-30.03
Seismic Loading	F_seis	0.02	0.90	-0.02

Result

Sliding			FOS 23.16	ОК	Required FOS 1.0
Overturning	\sum OT Moment (kN*m)	\sum Anti–OT Moment (kN*m)	FOS	OK	Required FOS
Overtaining	5.6	-184.5	33.17	J.K	1.0



Stability Factor of Safety Calculation for Burgess 1 Dam Overflow Section

Givens and Assumptions

Geometry Input Parameters

Max. Dam Height	Н	1.5 m	
Water Level U/B (Winter NOL Upper Bound)	hw1	0.88 m	
Dam Base width	t	0.65 m	
Crest Width	t1	0.45 m	
Crest Width Change height	h1	0.2 m	
Height of the d/s rockfill	hf1	0.3 m	
Ice Loading Location	h_{ice}	0.58 m	

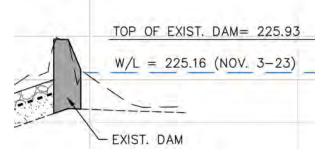
Basis Elevations for Calculation

Dam Crest	225.93	masl
NOL Winter Target on Jan 31	225.31	masl
NOL Winter (Upper Bound)	225.6	masl
NOL Winter (Lower)	224.6	masl

Soil/Rock Input Parameters

con, need input i didineters		
Unit weight-Unreinforced Concrete	γс	23.58 kN/m ³
Unit weight-d/s Fill	γf	19 kN/m^3
Unit weight of water	$\gamma \mathbf{w}$	9.8 kN/m ³
Friction angle- d/s fill	φ'f	35 degree
Friction angle- Concrete-to-rock interface	φ'c-R	40 degree
Cohesion- Concrete-to-rock interface	C'c-R	290 kPa
Tensile Strength Concrete-to-Rock interface	Ft	145 kPa
Cohesion Concto-Conc. Conctruction Joints	C-j	100 kPa
Passive Earth Pressure Coeff.	kp	3.69 -

Burgess Dam Overflow Section Sketch





Winter NOL (Upper Bound) - Upstream to Downstream Slide Direction

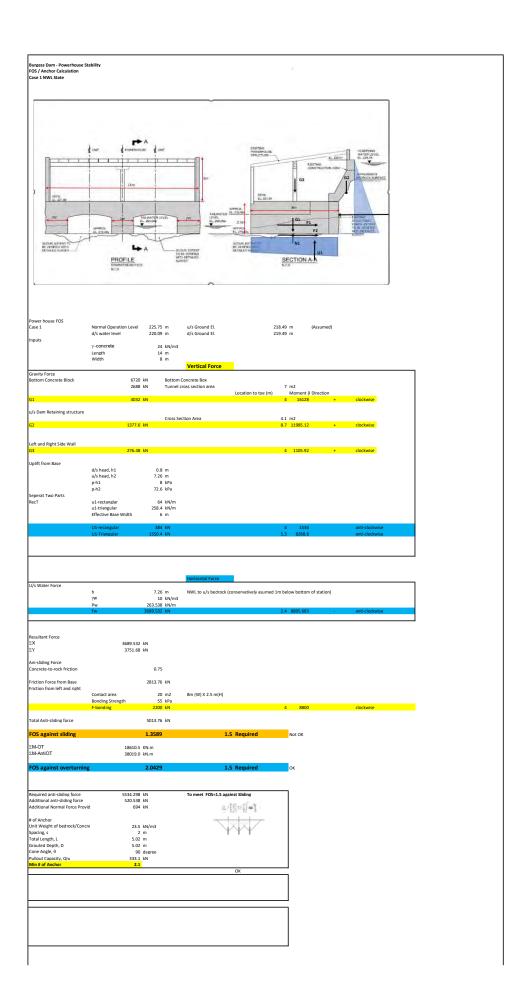
Calculation

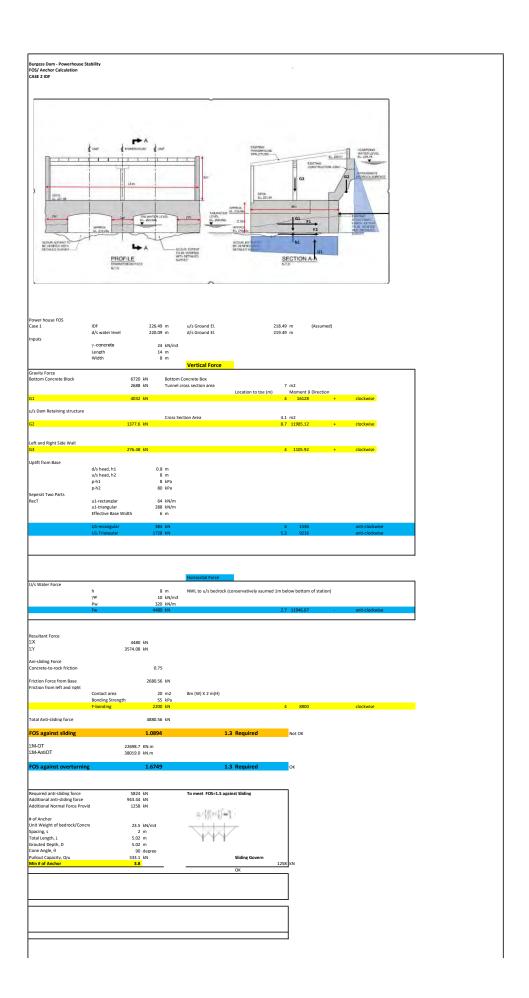
Force (IAN)	FBD ID	Force (kNI)	Moment Arm	Moment
Force (kN) FBD ID Force		Force (kN)	to "O" (m)	(kN.m)
u/s Water Pressure Winter NOL U/B	Pw	6.71	0.39	2.62
d/s Earth Pressure	Pe	3.16	0.10	-0.32
Gravity Force of Concrete dam	G	22.52	0.33	-7.32
Cohesion of Concrete-to-Rock	С	188.50	0.00	0.00
Uplift Force	Fup	3.73	0.43	1.61
Friction Force-Concrete-to-Rock	Ff	199.35	0.00	0.00
Tensile Force Concrete-to-Rock	Ft	195.00	0.75	-146.25
Side Friction Force of the Concrete	Fs	94.25	0.33	-30.63
Dam Section (two sides)	гъ	34.23	0.55	-30.03
Ice Loading	Fice	75.00	0.87	65.25

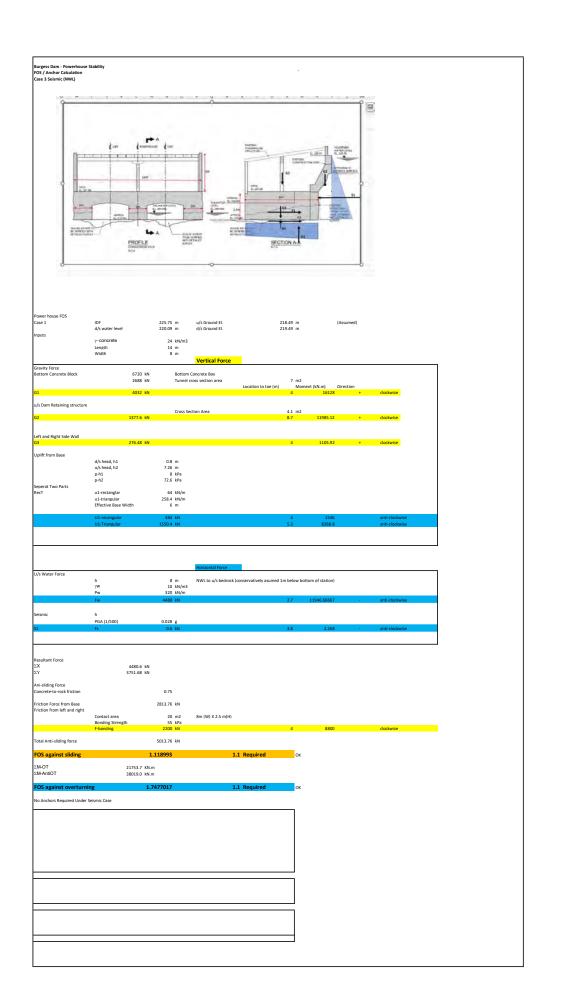
Result

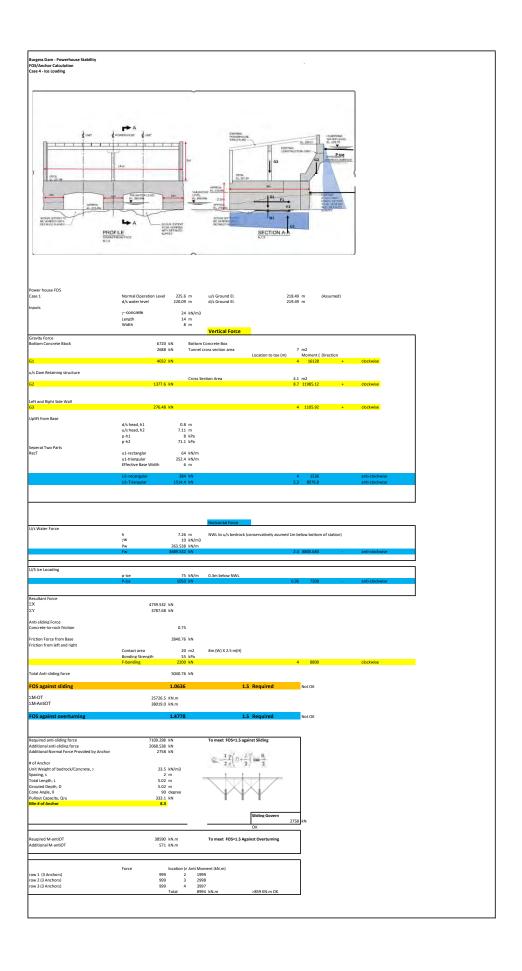
Sliding	Σ Applied Force Σ Resistive Force (kN) (kN) 81.7 397.5		FOS 4.86	ОК	Required FOS 2.0
Overturning	∑OT Moment (kN*m)	\sum Anti–OT Moment (kN*m)	FOS	OK	Required FOS
Overtaining	69.5	-184.5	2.66	311	2.0

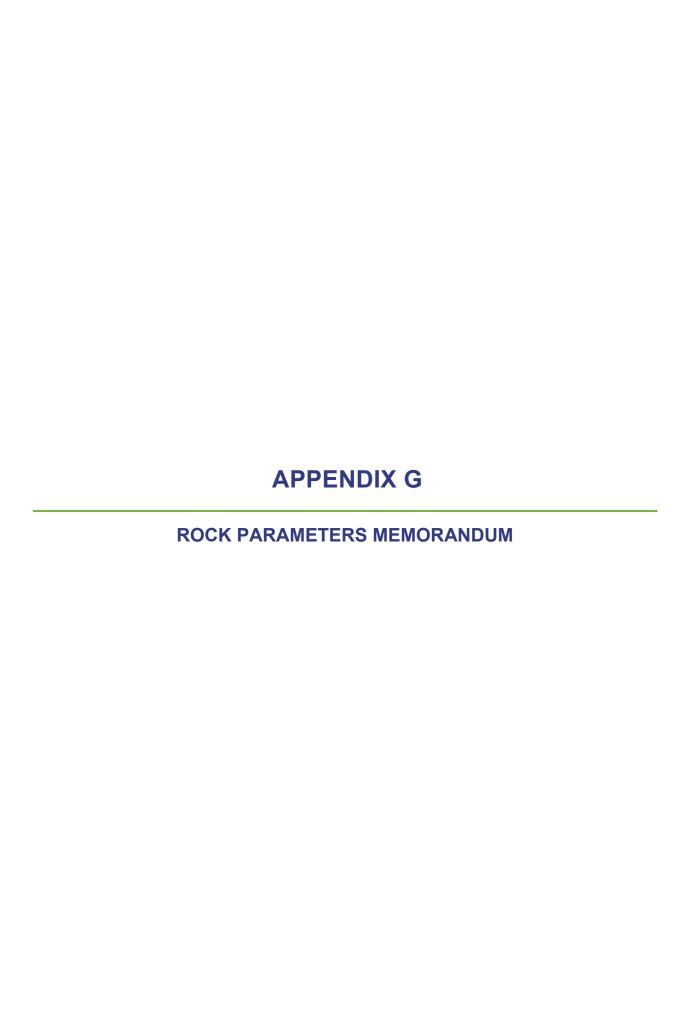














STRENGTH PARAMETERS

FOR CONCRETE DAM STRUCTURE ON BEDROCK

This memorandum summarised the recommended concrete/rock interface strength parameters for the Burgess Concrete Dam Structure (the Site) located in Bala, ON. Including:

- i) concrete/rock interface strength parameters reported in the literature, and
- ii) Recommended concrete/rock interface parameters for the Burgess concrete structure stability assessment.

Table 1 below summarizes the interface parameters recommended for the Burgess Dam sitting on the Granitic Gneiss bedrock.

Table 11: Recommended Concrete/Rock Contact Properties

Site	Rock Type	Built	Tensile Strength (kPa)	Cohesion (kPa)	Base Friction Angle (փ) ¹	Roughness <i>i</i>	Friction Angle (degree)
Burgess Dam	Granitic Gneiss	1917	145	290	35°	5°	40°

LITERATURE REVIEW FOR CONCRETE/ROCK INTERFACE PARAMETERS

In 1986, Ontario Hydro (now Ontario Power Generation) initiated a Dam Safety Program. During the early stages of the program, core samples were retrieved of the concrete/rock contacts at 47 dams owned by Ontario Power Generation. The concrete/rock specimens were tested by Lo et al. (1991) to measure tensile strength, cohesion and the internal frictional angle fo the Concrete-to-Bedrock interface for the dams.

Table 1 summarize the strength parameters for concrete dams sitting on Gneiss/Granitic Gneiss bedrock constructed before 1942 (Lo et al,1991 a & b), which have a similar bedrock type to the Burgess site. Figure 1 shows the mean tensile strength measured from 47 dams versus the year of construction developed by Lo et al. (2002). To be conservative, the average of the tensile strength, cohension and fricition angle of concrete-to-bedrock interface (Lo. et. al. 2002) are recommended for the Burgess Dam site founded on the bedrock.



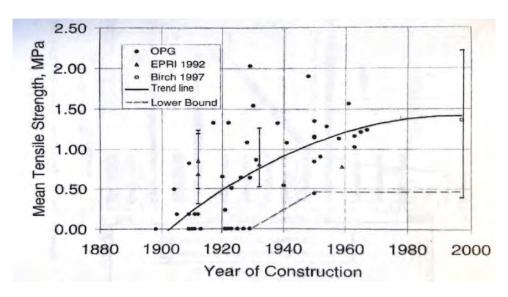


Figure 1: Mean Tensile Strength Measured from 47 Dams (Lo et al. 2002)

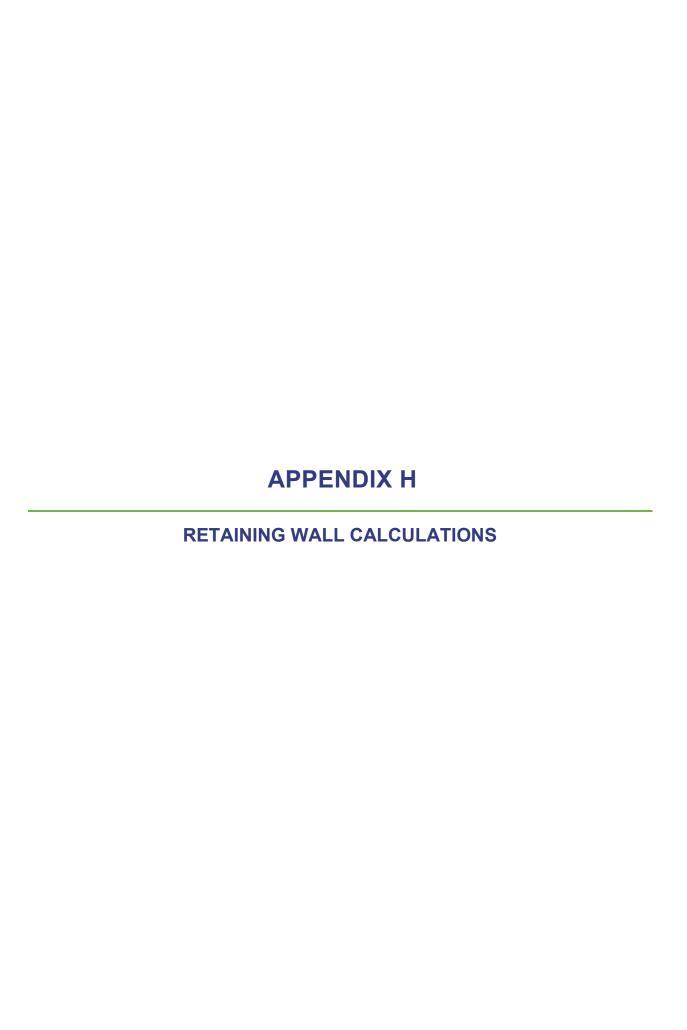
Table 1: Summary of Concrete/rock Interface Parameters for the Concrete Dam on Gneiss Bedrock Conctructed before 1942 (Lo et al. 1991)

River System	Location	Date of Construction	Cohesion , c (kPa)	Tensile Strength, σ _t (kPa)	Angle of Friction, \$\phi\$ (degree)	Bedrock Type	
	Calabogie	1916 &1917	138	69	35	Horonblende biotite Gneiss	
Madawaska	Barrett Chute	1938-1942	482	241	45	Horonblende biotite Gneiss	
	Bark Lake	1942	620	310	35	Granitic Gneiss	
Mananitai	McVittie	1936	138	69	35	Granitic Gneiss	
Wanapitei	Consiston	1938	68	34	32	Granitic Gneiss	
Sturgeon	Crystall Falls	1921	0	0	35	Granitic Gneiss	
	South Falls	1907	0	0	40	Gneiss	
	Hanna	1925	206	103	40	Gneiss	
Muskoka	Hanna Chute		552	276	40	Gneiss	
	Chale	Cridle		0	0	40	Gneiss
	Trethewey	1925	344	172	40	Gneiss	
Nipigon	Cameron Fals	1921	690	345	44	Granitic Gneiss	
Ottawa	Chats Falls	1931	620	310	42	Granitic Gneiss	
South	Nipissing	1923	414	207	44	Granitic Gneiss	
South	Elliot Chute	1929	68	34	36	Granitic Gneiss	
	Dog Lake 1	1909 rebuilt 1940	68	34	43	Gneiss	
Kaministikwia	Dog Lake 2	1910	276	138	43	Gneiss	
	Fedrick House	1937	690	345	42	Gneiss	
_	Average		299	149	40		



REFERENCES

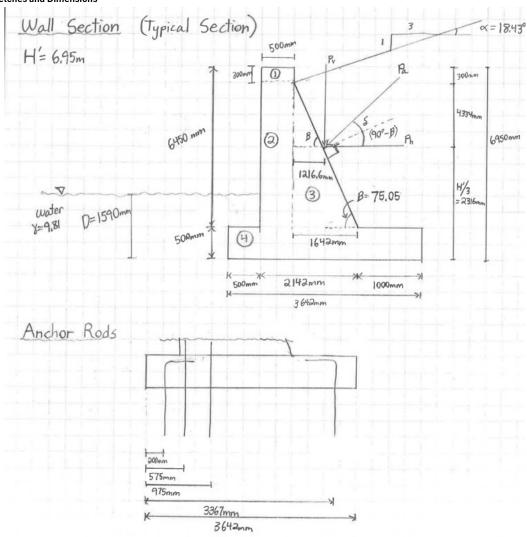
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Burgess Dam Stability Check

Soil Properties	
Concrete Unit Weight (γ _c)(kN/m³)	24
Water Unit Weight (γ _w)(kN/m³)	9.81
Active Pressure Soils - Granular A (γ ₁)(kN/m3)	
Soil Unit Weight (Y1)(kN/m³)	22
Soil Friction Angle (ϕ_1)(Degrees)	38
Cohesion (c ₁ ')	0
Passive Pressure - (y2)(kN/m3)	
Soil Unit Weight (γ ₂)(kN/m³)	20
Passive Pressure - (ф2)(kN/m3)	
Soil Friction Angle (φ ₂)(Degrees)	35
Soil Dimensions	
Angle (β)(Degrees)	75.05118849
α	18.43
$\delta = 2/3\phi_1$ (Degrees)	25.33333333
k1	2/3
Wall Dimensions	
H' (Full Height) (m)	6.95
Base Width (B) (m)	3.643
Footing Height(m)	0.5
Toe Length (m)	0.5
Heel Length (m)	1.0
Stem Width (m)	0.5
Wall Height (m)	6.45
Depth at Toe (D)(m)	1.59
Surcharge Loading	
Surcharge Load (kPa)	12
Lateral Point Load (kN)	23
Distance from Base (m)	3
Surcharge Moment (kNm)	69

Sketches and Dimensions



Areas

Section	Shape	Base	Height	Area
1	Rectangle	0.500	0.300	0.150
2	Rectangle	0.500	6.150	3.075
3	Triangle	1.642	6.150	5.049
4	Rectangle	3.643	0.500	1.822

Determine Coulomb's Active Earth Pressure Coefficient $K_a = \text{Coulomb's active earth pressure coefficient} \\ = \frac{\sin^2(\beta + \phi')}{\sin^2\beta\sin(\beta - \delta)\left[1 + \sqrt{\frac{\sin(\phi' + \delta)\sin(\phi' - \alpha)}{\sin(\beta - \delta)\sin(\alpha + \beta)}}\right]^2}$ $K_A = 0.4491741$

P_a =
$$\frac{1}{2}$$
K_a γ_1 H'²

Determine Components of Active Force		
	$P_h = P_a \cos \delta$	
P _h (kN/m)	182.07	
$P_V = P_a \sin \delta$		
P _V (kN/m)	154.31	

20M Anchor Bolts (Failure of the Steel Governed) Resisting Overturning				
Row	# of Bolts/ meter	Tensile Resistance (kN)	Moment Arm (m)	Moment (kN*m/m)
1	2	95.9	0.2	38.36
2	2	95.9	0.575	110.285
3	2	95.9	0.925	177.415
4	2	95.9	3.367	645.7906
Total Moment Resistance			971.8506	

Determine the Factor of Safety Against Overturning				
Section	Area (m²)	Weight/Unit Length (kN/m)	Moment Arm From Point A (m)	Moment (kN·m/m)
1	0.150	3.60	0.75	2.70
2	3.075	73.80	0.75	55.35
3	5.049	121.18	1.33	161.57
4	1.822	43.72	1.50	65.57
Anchors				971.85
P _V		154.31	1.71	263.09
Total Vertical Forces		396.60	Total Resisting Moments	1520.13

Overturning Moment		
$\sum M_o = P_h \left(\frac{H'}{3}\right)$		
M₀ (kN·m/m)	421.78	

Surcharge Moment	
M _{surcharge} (kN⋅m/m)	69.00

	$FS_{(overturning)} = \frac{\sum M_R}{\sum M_o}$
FS _{overturning}	3.1

Sliding Resistance

Determine Coulomb's Passive Earth Pressure Coefficient $K_{\mu} = \frac{\sin^2(\beta - \phi')}{\sin^2\beta\sin(\beta + \delta)\left[1 - \sqrt{\frac{\sin(\phi' + \delta)\sin(\phi' + \alpha)}{\sin(\beta + \delta)\sin(\beta + \alpha)}}\right]^2}$ $K_{\mu} = \frac{\sin^2\beta\sin(\beta + \delta)\left[1 - \sqrt{\frac{\sin(\phi' + \delta)\sin(\phi' + \alpha)}{\sin(\beta + \delta)\sin(\beta + \alpha)}}\right]^2}{0.1129675}$

Determine Coulomb's Passive Earth Force		
	$P_p = \frac{1}{2} K_p \gamma_2 D^2$	
P _P (kN/m)	1.40	

20M Anchor Bolts (Shear Resistance)	
Total Shear Resistance from 8 anchors per 1 meter (CSA-S16:19)	
Vr (kN/m)	520

	Lateral Surcharge Load Adding to Ph	
P (Surcharge) (kN/m)	23	

Determine the Factor of Safety Against Sliding
$$FS_{sliding} = \frac{\sum F_{R'}}{\sum F_d} = \frac{(\sum V) \tan(k_1 \varphi) + Bk_2 c_2' + P_P}{P_h}$$
 FS_{sliding}

Bearing Capacity

Bearing capacity was not considered as the retaining wall is supported by bedrock.

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		CALCULATION SHEET
Project:	Job. No.:	
Description: Surcharge	Date:	of
Surchage a'= 6.5m	$\theta_1 = \tan^{-1} \left(\frac{b'}{H} \right) =$ $\theta_2 = \tan^{-1} \left(\frac{a' + b'}{H} \right) =$	= 32.69°
b' = 4.46m H= 6.95m q= 12kPa	$R = (a+b')^{2} \cdot (90-\theta_{2}) = 3$ $Q = b'^{2}(90-\theta_{1}) = 1139.9$	3889.54
	-0,) + (R-Q) - 57.3 a H 2H (02-01) 7.62-32.69) + (3889.54-113 2.695. (57.62-32.	34.99) - 57,3(6.5)(6.95) (69)
$\overline{Z} = 3.01 \text{m}$		
$P = \frac{q}{90} \left(H \left(\theta_2 - \theta_1 \right) \right)$ $P = \frac{12}{90} \left(6.95 \left(57.62 - 3 \right) \right)$	2.(9))	
90 (0.15(5).00. 5 P= 23.10kN/per Im)		



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CALCULATION SHEET

Project: Burges Dam Job. No.: 231236
Description: Anchor Bolt Strengths Date: Of
rebar 20M each row spaced at 610mm 1
Fu=540MPa Aar=300mm An=0.85Aar v · · ·
Tensile Tr= Par An Fu
Tr = 0.67(0.85.300)(540)
$T_r = 92259N \Rightarrow 92.26kN$
Shear
Vr = 0.60 Par Aar Fu
Vr = 0.60 (0.67) (300) (540)
Vr= 65124N => 65.12KN
There are 8 vertical rod per Im of the retaining wall
$T_r = 738.08 \text{kN/m}$
Vr = 520.96 KN/m
Adhesive Strength (assuming Granite has a similar bond to concrete)
Tensile Strength = 6.1 MPa Table 54 Pullout = 227950N Strength
Area of adhesive = $\pi \times (19.5)(610)$ = 37369mm ² = 228kN
steel Suilure governs





Little Burgess Dam Rehabilitation Existing Conditions and Environmental Impact Assessment

Township of Muskoka Lakes, Bala, ON. Project # 23-1236

16 May 2025

Version 1.0













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APPENDICES

Appendix A – Project Plans

Appendix B – Natural Heritage Review and Communication with Regulators



16 May 2025

The Township of Muskoka Lakes 1 Bailey Street P.O. Box 129 Port Carling, ON P0B 1J0

Re: Existing Conditions and Environmental Impact Assessment (EC/EIA) for the Little Burgess Generating Station Rehabilitation, Township of Muskoka Lakes, Ontario; Tulloch Project # 230236

1. BACKGROUND

1.1 General

Tulloch Environmental, a division of Tulloch Engineering Inc. (Tulloch), was retained by the Township of Muskoka Lakes to complete an Existing Conditions and Environmental Impact Assessment (ECEIA) in support of the Little Burgess Generating Station Rehabilitation in Bala, ON (henceforth the Site). This report outlines the results of a Natural Heritage Desktop Review and field studies performed at the Site. It also provides assessment of impacts anticipated by the Project outlined in the Municipal Class EA. Avoidance and mitigations strategies to alleviate the anticipated impacts for each solution are provided.

1.2 Study Area and Project Description

The existing structure (henceforth referred to as Burgess Dam) is an approximately 59 m long and 3 m high concrete dam (Figure 1). The powerhouse is approximately 9m x 14m including the turbine, generator and associated equipment. A retaining wall 16m in length connects the north wall of the powerhouse and supports River St. immediately North of the powerhouse. The Burgess Dam runs across the north channel of the outlet from Lake Muskoka to the Moon River in Bala, Ontario; UTM (NAD83) coordinates are 17T 609163 4985226.

The Township has identified the need to complete the rehabilitation / replacement of Burgess Dam. A Municipal Class EA was initiated and assesses the impacts of alternative solutions for the rehabilitation / replacement. The below sections are taken from the justification section of the Class EA document.

"The powerhouse section of the dam is in poor overall condition from both a structural and dam safety perspective and will require remediation due to the presence of failed or failing structural members and a large transverse crack through the floor slab of the dam. Furthermore, significant washout of the downstream fill from another future flooding event has the potential to cause the structure to fail."



"The facility has no spill capacity as upstream water level control is provided by the Bala North and Bala South dams. It can be determined that the Burgess Dam does not have sufficient freeboard nor was the existing facility designed to handle inflow design flood in its current state"

"Repair or mitigation measures must be developed for both the non-overflow dam section and powerhouse dam section to improve the FOS to meet the minimum acceptable criteria."

"The Embankment along River Street downstream of the Site is very steep and appears to be eroding at the toe where there are newer gabion baskets placed on a historic boulder/stone wall. There is a concern for slope failure of the embankment due to the erosion / scour caused by water flows during power generation activity."

The results of the Class EA identified repair of the dam and construction of a spillway as the preferred solution.

1.3 Scope

The Ministry of Natural Resources (MNR) has identified a need to complete an ECEIA to support the permitting and approvals process for the proposed Burgess Dam repair project. To assess the existing conditions and potential impacts of the proposed alternative solutions (Appendix A), TULLOCH performed a Natural Heritage Desktop Review of the site and surrounding area as well as an on-site field assessment. The Natural Heritage Desktop Review included areas within 1000 m of the proposed solution footprint. The Study Area for on-site assessments was defined as areas within 120 m of the proposed solution footprints. The information presented in this submission have been taken from the 2020 Class EA document and updated to reflect the current plans and consultation to date.



Burgess Dam Rehabilitation/Replacement **Environmental Impact Assessment**

Site Investigations

Legend

Site (Approx.)

Study Area (120m)

Figure 1

PROJECT: 191493

DATE: 23/06/2020 SCALE: 1:1,500







2. NATURAL HERITAGE DESKTOP REVIEW

2.1 Sources Reviewed

The Natural Heritage Desktop Review was conducted to determine which natural heritage features exist, or have the potential to exist, within 1000 m of the Site. Records and resources searched as part of the background review are listed in Table 1. Communications with regulatory authorities are provided in Appendix B. Project staff qualifications are provided in Appendix C.

2.2 Land Use

The existing structure is currently located on private land and is surrounded by privately owned land.

2.3 Ecodistrict and Ecoregion

This Site is located in Ecodistrict 5E-7 of Ecoregion 5E (the Georgian Bay Ecoregion). The Georgian Bay Ecoregion is characterized by a cool-temperate and humid climate with a mean annual temperature range of 2.8 to 6.2°C (MNR 2009). This Ecoregion is situated on the southern edge of the Precambrian shield. It is typically underlain with gneissic bedrock as well as deposits of ground moraine till and glaciofluvial materials. This Ecoregion is part of the Great Lakes Watershed. Land cover is predominantly mixed forest, deciduous forest, and coniferous forest of the Great Lakes – St. Lawrence Forest Region (MNR 2009).

2.4 Protected Areas

Protected areas included federal, provincial, and municipal parks as well as Conservation Reserves, Enhanced Management Areas (EMAs), Provincially Significant Wetlands (PSWs) and Areas of Natural and Scientific Interest (ANSI). A review of data provided by Land Information Ontario (LIO) in conjunction with communications with the Ministry of Natural Resources and Forestry (MNRF) have identified no protected areas within 1000 m of the project site.



Table 1 - Records and resources searched during the Natural Heritage Desktop Review.

Record Source		Records Requested and/or Reviewed
Ministry of Natural Resources and Forestry (MNRF)	Date of Request: 03 February 2020 Date of Data Receipt:	Jeremy Rouse Management Biologist
Parry Sound District	12 February 2020	Existing environmental values information, including any sensitivities and environmental constraints.
Natural Heritage Information Centre (NHIC)	Accessed: 28 January 2020	Natural Heritage Mapping Tool queried for records of provincially tracked species (e.g. SAR and rare species), ANSI and other protected areas in vicinity to the Site.
MNRF Species at Risk in Ontario (SARO) List	Accessed: 28 January 2020	Determine SAR within range and their status.
MNRF Fish ON-line	Accessed: 28 January 2020	Reviewed known fish species present in Lake Muskoka and Moon River.
Atlas of the Breeding Birds of Ontario (Ontario Nature; ABBO)	Accessed: 28 January 2020	Determine migratory birds, including SAR within block #s: 17PK08
Bat Conservation International	Accessed: 28 January 2020	Reviewed SAR bat ranges associate with the Site and surrounding area.
eBird.org Cornell Lab of Ornithology	Accessed: 28 January 2020	Query for records of selected SAR bird species in vicinity to the Site.
iNaturalist – Herps of Ontario Project	Accessed: 28 January 2020	Reviewed recorded reptile and amphibian sightings in the area.
Ontario Butterfly Atlas Online (Toronto Entomologists' Association; OBAO)	Accessed: 28 January 2020	Query for records of SAR butterflies in vicinity to the Site.
Land Information Ontario (LIO)	Accessed: 30 January 2020	Accessed GIS spatial data regarding known significant habitats including:



2.5 Species at Risk

Species at Risk (SAR) include species identified federally under the *Committee on the Status of Endangered Wildlife in Canada* (COSEWIC) and provincially under the *Committee on the Status of Species at Risk in Ontario* (COSSARO). Species and their habitat listed as Endangered or Threatened are regulated federally under the *Canadian Species at Risk Act* (SARA S.C. 2002 c.29) and provincially under the *Ontario Endangered Species Act* (ESA S.O. 2007 c.6). In some instances, species listed as Special Concern may also receive habitat protection under the *2014 Provincial Policy Statement* (PPS; MMAH 2014); see Section *2.6 Significant Wildlife Habitat*.

The NHIC identified records of Massasauga Rattlesnake (*Sistrurus catenatus*; Threatened), the Rusty-Patched Bumblebee (*Bombus affinis*; Endangered), Blanding's Turtle (*Emydoidea blandingii*; Threatened) and Eastern Wood-pewee (*Contopus virens*; Special Concern) within 1000m of the Site. A restricted species was also identified. The MNRF has requested that the name of this species is not released, however, the impact assessment and respective mitigations have accounted for the possible presence of this species on the Site.

ABBO Records indicated that ten (10) species have been observed within the 10 x 10km atlas block associated with the site:

- Barn Swallow (*Hirundo rustica*;Threatened)
- Bobolink (*Dolichonyx oryzivorus*; Threatened)
- Canada Warbler (*Cardellina Canadensis*; Special Concern)
- Chimney Swift (*Chaetura pelagica*; Threatened)
- Common Nighthawk (*Chordeiles minor*; Special Concern)
- Eastern Meadowlark (*Sturnella magna*; Threatened)
- Eastern Wood-pewee (Special Concern)
- Golden-winged Warbler (Vermivora chrysoptera; Special Concern)
- Olive-sided Flycatcher (*Contopus cooperi*; Special Concern)
- Wood Thrush (Hylocichla mustelina; Special Concern).

Queries of Cornell Lab's eBird atlas identified records of the following 13 SAR birds:

- Bald Eagle (Haliaeetus leucocephalus; Special Concern; records within 7km)
- Bank Swallow (*Ripari riparia*; Threatened; records within 4km)
- Barn Swallow (records at the Site)
- Canada Warbler (records within 1km)
- Chimney Swift (records at the Site)
- Eastern Whip-poor-will (Antrostomus vociferous; Threatened; records within 1km)
- Eastern Wood-pewee (records within 1km)
- Evening Grosbeak (Coccothraustes vespertinus; Special Concern; records within 1km)
- Golden-winged Warbler (records within 100m)
- Olive-sided Flycatcher (records within 8km)
- Red-headed Woodpecker (*Melanerpes erythrocephalus*; Special Concern; records within 11km)
- Rusty Blackbird (Euphagus carolinus; Special Concern; records within 5km)
- Wood Thrush (records within 4.5km)



The ORAA indicated that Blanding's Turtle, Massasauga Rattlesnake, Snapping Turtle (*Chelydra serpentine*; Special Concern), Five-lined Skink (*Plestiodon fasciatus*; Endangered) and the restricted species identified in the NHIC records is associated with the Site (Block 17PK08).

BCI indicated that three (3) Endangered bat species have ranges which include the Site:

- Little Brown Bat (Myotis lucifugus)
- Northern Long-eared Bat (Myotis septentrionalis)
- Eastern Small-footed Bat (Myotis leibii)

The Butterfly Atlas of Ontario identified that Monarch Butterfly (*Danaus plexippus*; Special Concern) is associated with the Site.

A review of iNaturalist for citizen science records, the Royal Ontario Museum Collections, the Canadian National Collection of Insects, Arachnids and Nematodes and University Collections from McMaster University returned no records of SAR species at the Site, or in areas within 1000m of the Site

Table 2 – Species at Risk with Potential to Occur in the Study Area.

Source	Species	Scientific Name	SARA	ESA
eBird.org	Bald Eagle	Haliaeetus leucocephalus	-	SPC
eBird.org	Bank Swallow	Ripari riparia	THR	THR
ABBO (Record) / eBird.org	Barn Swallow	Hirundo rustica	-	THR
MNRF / ORAA	Blanding's Turtle	Emydoidea blandingii	THR	THR
ABBO (Record)	Bobolink	Dolichonyx oryzivorus	-	THR
ABBO (Record) / eBird.org	Canada Warbler	Cardellina canadensis	THR	SPC
ABBO (Range) / eBird.org	Chimney Swift	Chaetura pelagica	THR	THR
ABBO (Record)	Common Nighthawk	Chordeiles minor	THR	SPC
ABBO (Record)	Eastern Meadowlark	Sturnella magna	-	THR
BCI (Range)	Eastern Small-footed Bat	Myotis leibii	END	END
eBird.org	Eastern Whip-poor-will	Antrostomus vociferous	THR	THR
ABBO (Record) / MNRF / eBird.org	Eastern Wood-pewee	Contopus virens	SPC	SPC
eBird.org	Evening Grosbeak	Coccothraustes vespertinus	SPC	SPC
ORAA	Five-lined Skink	Plestiodon fasciatus	END	END
ABBO (Range) / eBirg.org	Golden-winged Warbler	Vermivora chrysoptera	THR	SPC
BCI (Range)	Little Brown Bat	Myotis lucifugus	END	END
MNRF / ORAA	Massasauga Rattlesnake	Sistrurus catenatus	THR	THR



Source	Species	Scientific Name	SARA	ESA
OBAO	Monarch Butterfly	Danaus plexippus	SPC	SPC
BCI (Range)	Northern Long-eared Bat	Myotis septentrionalis	END	END
ABBO (Record) / eBird.org	Olive-sided Flycatcher	Contopus cooperi	THR	SPC
eBirg.org	Red-headed Woodpecker	Melanerpes erythrocephalus	THR	SPC
eBird.org	Rusty Blackbird	Euphagus carolinus	SPC	SPC
MNRF	Rusty-patched Bumblebee	Bombus affinis	END	END
ORAA (Record)	Snapping Turtle	Chelydra serpentine	SPC	SPC
ABBO (Record) / ebird.org	Wood Thrush	Hylocichla mustelina	-	SPC

^{*}ABBO = Atlas of the Breeding Bird of Ontario; BCI = Bat Conservation International; MNRF = MNRF Species at Risk by Area Web Application; OBAO = Ontario Butterfly Atlas Online; ORAA = Ontario Reptile and Amphibian Atlas.

2.6 Significant Wildlife Habitat (SWH)

Significant Wildlife Habitat (SWH) is defined in the *Significant Wildlife Habitat Technical Guide* (OMNR 2000) as natural heritage areas that are "ecologically important in terms of features, functions, representation and amount and contributing to the quality and diversity of an identifiable geographic area or Natural Heritage System". Development within and adjacent SHW is only permissible provided no negative impacts to the feature or its ecological functions. Habitat may be considered SWH according to four broad categories:

- Seasonal concentration areas (i.e., winter deer yards, colonial bird nesting sites, reptile hibernacula);
- Rare vegetation communities or specialized habitat for wildlife (i.e., alvars, rare forest types, moose aquatic feeding areas, amphibian woodland breeding ponds, turtle nesting habitat);
- Habitat of species of conservation concern (i.e., species identified as special concern federally or provincially, and species listed as rare or historical in Ontario based on records kept by the NHIC (i.e. S1- Critically Imperiled, S2- Imperiled, S3- Vulnerable and SH -Historic ranks); These ranks are not legal designations but are assigned in a manner to set protection priorities); and,
- Animal movement corridors (i.e., naturally vegetated corridors or man-made features such as power transmission and pipeline corridors that provide animal movement from one habitat to another).

No records of SWH or candidate SWH were found within 1000 m of the existing structure. Records of five locally rare species were identified by the NHIC:

^{**}END = Endangered; THR = Threatened; SC = Special Concern

^{***}SARA = Species at Risk Act (Federal); ESA = Endangered Species Act (Provincial)