March 15, 2021
WE 20010

Mr. Mike Dwyer
CAO
Township of Rideau Lakes
1439 County Road 8,
Delta, Ontario
K0E 1G0

Dear Mr. Dwyer:

Re: Bass Lake
Dam and Outlet Control Structure Design Report

Water's Edge was authorized by the Township of Rideau Lakes to complete the design services for modifications of the dam and control structure on Bass Lake. The purpose of the engineering design is to upgrade the existing dam and provide a proper control structure.

We have completed our assessment and design for the Design Services in accordance with the approved project Terms of Reference. Data sources for the analysis include:

- Physiography of Southern Ontario by Chapman & Putnam (digital data from the Ontario Geological Survey);
- Ontario Flow Assessment Tool III (OFAT) (from MNRF);
- Bass Lake Outlet Berm Investigations Report, August 29, 2019 by Jp2g Consultants Inc.;
- Various background documents assembled by the Township in support of this design;
- Communications with the Township and the Bass Lake Property Owners Association (BLPOA);
- Public Meeting (held via Zoom on July 28, 2020); and.
- Site inspection and topographic survey by Water's Edge staff.

A site inspection and survey were completed by Water's Edge staff on various occasions including April 22, 2020 and August 14, 2020. The site inspection was undertaken following a review of available resources to confirm site and general system characteristics.

1 BASS LAKE WATERSHED CHARACTERIZATION

The Bass Lake outlet has a contributing area of approximately 7.965 km^2 of which 4.393 km^2 is lake and wetlands. The lake is lined with cottages and homes. The Bass Lake outlet is located in a wetland and controls water elevations in the lake to some degree. During the summer, the dam can be dry due to lack of rainfall, evaporation, and/or infiltration or low groundwater levels. High flows typically occur during spring melt when the snow melts and the lake ice melts. The mean annual flow is 0.10 m^3/s while Moin & Shaw flood flows are 1.4, 2.3, 2.9, 3.6 4.3 and 5.0 m^3/s for the 1:2, 5, 10, 20, 50, and 100 year return periods. Flow from the lake, when it does occur, is directed through a broad wetland and forested or natural area before reaching County Road 1. A large culvert approximately 1600 mm in diameter, conveys flow under the road during low flows. High flows would cross the road and flow into Lower Rideau Lake approximately 75 downstream. The only development is located at County Road 1 and these are set back from the channel.

2 PROPOSED DESIGN

2.1 Dam and Water Level Rationalization

The need to rehabilitate the dam and provide a better control structure has long been discussed in various documents. A summary of this, as prepared by BLPOA, is provided in **Appendix A.**

The discussion on a design water level has also been discussed extensively over the past years. Water levels have been recorded over the past decade by the BLPOA. This is also discussed in the **Appendix A** document. A discussion of the water level issue is presented in **Appendix B**.

The outlet control structure design was first discussed in the Jp2g report where a variety of options were presented. However, based on additional information and final design detail, this current study has concluded that cross vane control structure is the preferred structure. This approach was discussed and approved in principle by the BLPOA. The recommended control structure is discussed in the **Appendix B** document as well.

2.2 Dam and Outlet Design Considerations

Having determined the design water level and the type of control structure, a design of the proposed structure and the dam was prepared.

Subsequently, it was recognized that a geotechnical study was required. The authorization for the geotechnical study was given in late September 2020. The study was completed and a report was submitted by Soil Engineers on January 21, 2021. This report was submitted to the Township and the BLPOA for comments. **Appendix C** contains the Geotechnical Report as prepared by Soil Engineers Ltd.

A revised set of plans were prepared and submitted to the Township and the BLPOA on February 19, 2021. These plans reflected the BLPOA comments on a previous draft as well as the recommendations of the geotechnical report. The BLPOA provided comments on this draft on March 2, 2021.

This report and the current drawings (dated March 15, 2021) reflect the most recent comments.

2.2.1 Dam Design Considerations

The proposed dam generally mimics the existing dam in height and size. However, the proposed dam will consist of properly placed and compacted material including a clay core to prevent exfiltration through the structure.

The outlet elevation will be 134.55 metres. The emergency overflow will be at 134.85 metres while the crest of the structure will be at 135.15 metres (300 mm of freeboard). While this elevation will work for the dam itself in terms of lake levels, flow controls and freeboard, during extreme events greater than the 1:100 year flood, it may be possible that flows will by-pass the dam through the forested area and ROW on the south side due to low topography.

The downstream and upstream dam faces will be 300 mm rip rap with Granular B to fill the interstitial spaces.

The ends of the dam will tie into existing topography within the existing, publicly-owned Rights of Way.

The clay core is to be in contact with the bedrock for a minimum of 2 metres. The clay core is to be placed in 200 mm lifts compacted to 98% SPD. A bentonite curtain will be present in front of the cross vane to minimize any leakage through the outlet structure. Semi-pervious material is to be placed in 200 mm lifts compacted to 98% SPD on the clay core with a 300 mm sand drainage layer on the downstream toe. The top width of the berm should be no less than 3 metres. The side slopes are to be a maximum of 2:1 upstream and 3:1 downstream. From existing grade, the height of the dam will be approximately 1.15 metres. This allows for a 300 mm of head on the cross vane and 300 mm of head for the emergency weir.

The proposed dam structure is to be seeded.

2.2.2 Outlet Considerations

The proposed outlet will consist of a cross vane structure as well as an emergency overflow weir.

The cross vane structure is comprised of large armourstone with a D_{50}=300 mm riverstone substrate. The width of the cross vane is approximately 5 metres. The profile allows for energy dissipation.

The weir will be 15 metres long. The downstream face of the 15 m emergency weir is to be D_{50}=600mm stone.

The theoretical, brad-crested weir spillway capacity of the cross vane is approximately just under 2 m^3/s while the capacity of the emergency spillway is just under 4 m^3/s for a total capacity of approximately 5.5 m^3/s. The 100 year flow is 5.0 m^3/s.

The nature of the structure will allow for fish passage which was not possible in existing conditions.

2.3 Erosion and Sedimentation

An Erosion and Sediment Control Plan will be required during construction of the proposed dam and cross vane construction.

The existing site contains organics, silt, and sediment accumulations. As such, the potential for disturbance and sediment movement is noted. It is also noted that there is significant in-stream vegetation which will stabilize the site and provide tertiary downstream treatment.

Given these conditions, the Erosion and Sediment Control Plan will include a primary control using a Dam and Pump technique to by-pass any flows around the worksite. In addition, appropriate silt fence placement, a flow check dam, and vegetation plantings will minimize erosion and sediment transport during construction and avoid impacts on the downstream.

Furthermore, construction will be conducted during low flow conditions to minimize the potential movement of sediment.

Currently, there are no significant erosion concerns. The flows will be maintained with the current range of flows and thus, no changes are anticipated regarding channel stability.

Further reference should be made to the Erosion & Sediment Control plan in the Engineering Drawings in Appendix D (Water's Edge, 2021).

3 DAM SAFETY CONSIDERATIONS

3.1 Assessment of HPC

The Hazard Potential Classification (HPC) system assigned to a dam provides information about a degree of the potential risk of dam failure. Evaluation of the potential risk is allocated based on incremental losses from potential dam failure, which involves comparing the impacts of with-failure and without failure conditions. There are four categories (Low, Moderate, High and Very High) for HPC, and the four categories are classified by the degree of the incremental losses based on the four criteria (Life Safety, Property Losses, Environmental Losses, Cultural – Built Heritage Losses).

Based on our assessment of the existing dam, and our evaluation of the proposed alterations, the HPC for this project area is categorized as Low Hazard Potential, defined as follows:

- Life Safety: there is no potential loss of life as no persons are exposed to water velocities and depth greater than the 2 x 2 rule (Technical Guide - River and Streams Systems: Flooding Hazard Limits, 2002).

- Property Losses: minimal damage limited to third party losses of not more than $300,00 dollars (indexed to Statistics Canada values year 2000). Damages would be principally limited to the dam owner's property and in the immediate vicinity of the dam.

- Environmental Losses: habitat losses would be minimal with a high capability of natural restoration. There would be no measurable reduction in the status of fish and wildlife populations after restoration.

- Cultural – Built Heritage Losses: reversible damage to municipally designated cultural heritage sites under the Ontario Heritage Act. Losses to contents of cultural - built heritage structures must be included in the above property losses limit.

3.2 IDF (Inflow Design Flood)

Based on the Technical Bulletin, The Inflow Design Flood (IDF) is justified as the most severe inflow flood for which a dam and its associated facilities are designed. The IDF will be between 25-year and 100-year as a subject area is determined by the Low HPC category.

The proposed outfall structure has an estimated capacity of approximately 5.5 m^3/s, which is greater than the 5.0 m^3/s expected for the 1:100 year event.

3.3 Lakes and Rivers Improvement Act Considerations

Ontario Ministry of Natural Resources released a Lake and Rivers Improvement Act Administrative Guide and Technical Bulletins. These documents provide technical direction for the Hazard Potential Classification (HPC) and Inflow Design Flood (IDF) for approval to construct, alter, improve or repair dam infrastructure.

We have assessed the HPC for this existing structure and determined it to be Low. Furthermore, the structure is approximately 1.15 metres in height and is located and maintains the existing wetland (during the summer low water period). The existing structure is to be upgraded with a formal structure and the dam is to have a formal outflow control structure.

Ontario Regulation 454/96 states that

"2. *(1) For the purpose of subsection 14 (1) and section 16 of the Act, approval is required,*

(a) to construct or decommission a dam that holds back water in a river, lake, pond or stream to raise the water level, create a reservoir to control flooding or divert the flow of water;

(b) to make alterations, improvements or repairs to a dam that holds back water in a river, lake, pond or stream to raise the water level, create a reservoir to control flooding or divert the flow of water, if the alterations, improvements or repairs may affect the dam's safety or structural integrity, the waters or natural resources;"

However, the regulation goes on to state that:

"(3) Despite clause 2 (1) (b), no approval is required to make alterations, improvements or repairs to a dam in the circumstances described in that clause if,

(a)at the time the alterations, improvements or repairs are commenced, the dam,

(i) is an existing earth embankment, concrete gravity, timber crib, or flow through rock fill dam,

(ii) holds back, forwards or diverts water in a river, lake, pond or stream that forms part of a wetland or is contiguous with a wetland, and

(iii) directly maintains or enhances the form or function of a wetland;

(b) the dam owner obtains the written opinion of a licensed engineering practitioner dated no more than one year prior to the commencement of the alterations, improvements or repairs stating that the dam has a low hazard potential classification;

(c) the proposed alterations, improvements or repairs will not result in a change to the hazard potential classification of the dam; and

(d) where the proposed alterations, improvements or repairs are to be made in accordance with plans and specifications prepared by a licensed engineering practitioner, the dam owner obtains a written opinion prepared by a licensed engineering practitioner dated no more than one year prior to the commencement of the proposed alterations, improvements or repairs, stating that the alterations, improvements or repairs will not result in a change to the hazard potential classification of the dam if completed in accordance with those plans and specifications. O. Reg. 31/20, s. 2.

(4) Following the completion of the proposed alterations, improvements or repairs, the dam owner shall,

(a) if the proposed alterations, improvements or repairs were to be made in accordance with plans and specifications prepared by a licensed engineering practitioner as specified in clause (3) (d), obtain, within three months after the completion of the alterations, improvements or repairs, a written opinion prepared by a licenced engineering practitioner confirming that the alterations, improvements or repairs were made in accordance with those plans and specifications and that the dam still has a low hazard potential classification; and

(b) keep for a period of 5 years from the date that the alterations, improvements or repairs are completed, the written opinion of a licenced engineering practitioner given under clause (3) (b) and, if applicable, under clauses (3) (d) and (4) (a). O. Reg. 31/20, s. 2."

As such, it is our opinion that no LRIA permit is required for the rehabilitation of the Bass Lake dam and control structure since the the dam is an existing earth embankment dam, holds back water in a river, lake, pond or stream that forms part of a wetland or is contiguous with a wetland, and directly maintains or enhances the form or function of a wetland. Furthermore, we state that the dam has a low hazard potential classification and we have proposed a 5-year post-construction monitoring plan.

3.4 Maintenance

The proposed replacement dam and new cross vane structure are intended to be low maintenance.

Annual inspections of the overall structure should occur to ensure that the structure is still operating as intended. This should include inspections of:

- Loss of dam material (stone or fill);
- Unusual seepage through the structure;
- Ensure that no trees or shrubs are growing on the structure;
- Operation of the cross vane;
- Any erosion of the structures (dam or cross vane);
- Vandalism;
- Maintaining access to the site for maintenance and repairs; and,
- Adequacy of the security fencing.

Since beavers are present, they may block the cross vane and decrease capacity for flow and therefore regular inspections for debris accumulations is required.

4 POST-CONSTRUCTION MONITORING REQUIREMENTS

To ensure that the completed works are in compliance with the intent of the design, we propose a monitoring program which consists of the following components:

- One Spring and one Fall inspection each year for a period of 2 years after completion of the works and then again in the fifth (5th) year;
- Spring and Fall photos to be taken at each cross section (looking upstream, downstream, left bank and right bank);
- Install monumented cross sections with annual re-surveys (Fall Inspection);
- Survey long profile through site with annual re-surveys (Fall Inspection); and
- Annual reports (After each Fall Inspection) are to be submitted to the Township and the BLPOA.

5 CONCLUSIONS AND RECOMMENDATIONS

The proposed replacement dam and control structure for the Bass Lake outlet has been designed to provide water level stability during summer months, safely convey excess flows during spring freshets, and possible fish passage. We note that:

1. The proposed rock cross vane will have a control elevation of 134.55 metres.

2. The HPC for existing and rehabilitated dam is categorized as Low Hazard Potential and the 1:100 -year frequency storm was selected as the IDF.

3. Annual dam safety inspections are to be completed and ongoing inspections should remove any beaver dam debris for long term stability.

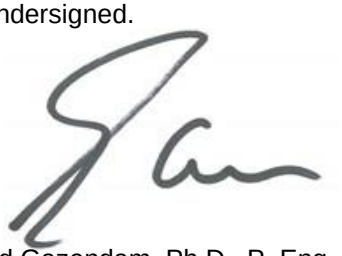
4. A RVCA permit is required while a LRIA permit is not required.

5. A DFO Request for Review is required and it is anticipated that a Letter of Advice will be provided given the low level of risk to fish and fish habitat.

6. A 5 year Post-Construction Monitoring Program has been recommended for implementation by the Township.

7. Design particulars and details can be seen in the Design Drawing set as presented in Appendix D.

Should you have any comments or questions on the above, please do not hesitate to contact the undersigned.



Ed Gazendam, Ph.D., P. Eng.,
President, Sr. Engineer

Attachments:

Appendix A: Dam Rationalization
Appendix B: Lake Levels and Control Structure Rationalization
Appendix C: Geotechnical Report
Appendix D: Detailed Design Drawing Package

APPENDIX A:

Dam Rationalization

Bass Lake – Rideau Lakes Township
Statement of Requirement - Official Water Control Structure

Background History

Bass Lake is a spring fed lake from a 7.8 km^2 catchment area with no inflow from other lakes, rivers or creeks. Bass Lake outlets to the Lower Rideau Lake via a channel at the north end of the lake. This outlet channel is approximately 1 kilometer in length and discharges to Lower Rideau Lake at an approximate water level elevation of 125 MASL. At 280 meters downstream in this outlet wetland there is a man-made earthen berm that has served as an outflow water control structure for the past 25 years (since 1995). Effective January 2021, this earthen berm is now fully situated on township owned land and remains in a state of serious deterioration. Its low-profile dimensions are: 1 meter in height, 3 meters in width, 40-50 meters in length.

In the 1993-94 period, waterfront property owners observed a dramatic lowering of lake water levels due to the loss of natural or man-made weirs at the lake edge of the outlet and the destruction of a large beaver dam downstream in the outlet. Consultations were made with representatives of the Rideau Valley Conservation Authority (RVCA) and the Ministry of Natural Resources (MNR) to determine what options could be undertaken to restore the lake's historical water level. In May 1995, the Bass Lake Lodge owner constructed an earthen berm on an ad hoc basis without regulatory approval.

In April of 1996, following complaints of higher than normal water levels, the RVCA investigated and issued a "Notice of Violation" against the Lodge owner. After a series of site visits and exchange of letters, RVCA proposed a number of improvements/modifications to the berm structure to ensure the seasonal water levels would be acceptable to majority of waterfront property owners and certainly no higher than previous years. In August 1996, the earthen berm was tacitly allowed to remain in place. No written approval has ever been granted for the existence of this berm, nor has any legal action been taken by the regulatory authorities for its removal.

Throughout this 25-year period, the lake community has experienced many alarming episodes or challenges directly involving this earthen berm that required seeking advice or assistance from the Township, RVCA or MNRF. The situation finally came to a head in May 2018 when there was a dramatic drop in lake water level allegedly due to an intentional major breach of the berm; remedial repairs by unknown parties; ownership and access issues; it's questionable structural stability; and the potential environmental and social impacts should the berm unexpectedly fail.

The Issue for Waterfront Property Owners

Bass Lake is considered by the RVCA to be part of the Lower Rideau Lake catchment area and it has a higher elevation (134 MASL) than the Lower Rideau Lake (125 MASL). The topography of the outlet wetland in front of the man-made earthen berm is no longer restricting outflow to any significant degree. Without a reliable natural or a man-made berm in the Outlet there will be a very dramatic lowering of the historical seasonal water level.

There is now an issue of potential lower seasonal water levels that may adversely affect the 230 Bass Lake property owners, the lake's eco-systems, provincial protected wetland surrounding the lake, tourism, local businesses and property values and taxes. (refer to Appendix A attached). In order to deal with this problem on a comprehensive and consensus basis, the first ever Bass Lake Property Owners Association (BLPOA) was formed in the Fall of 2018. The vast majority of lake property owners (80%) have petitioned for the establishment of an effective lake water level management plan for Bass Lake. Over the past 2 ½ years this Association has averaged a very strong membership comprising on average of 180-member properties.

The clear and present danger is that after 25 years the long-standing man-made berm in the outlet to Bass Lake remains highly susceptible to serious breaches or repairs as well as natural decay and degradation. In July 2018, the RVCA requested that the existing berm be either rehabilitated or replaced and approved as a legal and fully permitted structure. The BLPOA's primary mandate has been to establish an effective lake water level management plan for Bass Lake by actively pursuing a collaborative project involving the leadership of the Township, and the participation and support of the RVCA and the MNRF. This collaboration led to the Township conducting a Jp2g Consultants study and survey in the summer of 2019 followed in 2020 by a contract with Water's Edge Engineering Consultants for the design of a new water control structure, regulatory approval and finally construction contract tendering.

Target Seasonal Water Level – 2020 Bass Lake Referendum Results

A Referendum Form with three choices for an indicated preference for the target seasonal water level was promoted and distributed to as many Bass Lake property owners as possible given the COVID -19 restrictions in July 2020. A new control structure will generally "set" the long-term water surface elevation and Water' Edge had selected this level to the elevation desired on – 01 July (Canada Day). After July 1st, water levels would then be dependent on rain and groundwater levels. In spite of a "set" elevation, wet years would still have higher water levels and dry years may result in lower levels.

The results of this important Referendum were as follows on the Table below:

Category	Numbers	Percentages %
Total Referendum Responses	186	80.8 % of 230 Waterfront Properties
Higher Water Level experienced this year 2020 (01 Jul – 134.55 MASL)	165	88.7% 0f Responses
Historical Water Levels experienced years 2010-2016 (01 Jul - 134.45 MASL)	15	8.1% of Responses
A Compromise Level of 134.50 MASL	5	2.7 %
A dramatically lower level for 01 Jul benchmark, (Specifically 134.1 MASL)	1	0.5% of Responses

Summary

Bass Lake and its waterfront community are a significant contributor to the Rideau Lakes natural environment and the local economy. The BLPOA's objectives are in line with those of RVCA and MNRF with respect to maintaining better water quality, healthier wetlands and the protection of wildlife species and habitat. The involvement of local and provincial authorities is necessary to achieve a healthy Bass Lake and restore acceptable and manageable water levels that will result in a benefit to current and future landowners, businesses, tourists, and the regional ecosystem. Such a partnership will assist in moving forward to implement the recommendations presented in the 2014 RVCA Sub-Watershed Report.

The BLPOA is very appreciative that the Township has provided its leadership, authority and funding to establish a municipal capital project in 2020 and work with all Bass Lake property owners and ratepayers to implement a plan of action leading to a resolution of the long-standing issues we have faced at the outlet to Bass Lake.

Prepared By: BLPOA Board of Directors – January 2021

Appendix A - Major Impacts and Concerns

Provincially Protected Wetlands: In recent years, the Bass Lake wetlands have been "complexed "into the Big Rideau Wetland Complex thereby making them a Provincially Significant Wetlands (PSWs) and therefore is part of a regional system. This provincial designation requires that the PSWs and buffer zone are to be protected. This protection should include avoiding reduced water levels or any activity on the Lake that has an adverse impact on the PSWs.

Lake Eco-systems: A major and long-term drop-in lake water level will inflict adverse impacts on the lake's ecosystems and nature's filtration system. The habitat for small mouth bass and other fish species in the lakes five major bays and along the extensive shoreline shoals could be depleted and lost. Such a dramatic change will also eliminate various wildlife habitats and waterfowl nesting sites. The loss of these habitats would have regional impacts.

Blue-Green Algae Blooms: Major outbreaks of Blue-Green Algae blooms on Bass Lake were detected and reported for the first and only time in October/November of 2018. We do not believe that it was a coincidence that this outbreak followed record low water levels, resulting from the breach of the berm in the spring of 2018. The extremely low water levels and higher water temperatures likely increased the concentrations of those elements necessary for the growth of the blue-green algae. Blooms are a real threat to lake drinking water for those residents using the lake as a source, even with treated systems. Blooms are also toxic to fish, wildlife and swimmers. The die-off of these blooms can lead to oxygen depletion and contribute to massive fish kills. Not only will this harm the Bass Lake fishery but any release into the Lower Rideau would have a downstream impact.

Waterfront Accessibility & Recreational Activities: A significant drop in water level will severely impact most property owners who enjoy the amenities of recreational boating and swimming. A lower water level will cause shoals, logs and other hazards to appear thus endangering navigation. Dock structures will need to be relocated further out from historical shorelines and the recreational season will be dramatically reduced to ensure any boats can be safely launched and removed from the lake. Property owners in the many shallow bays and inlets of the lake would be most immediately impacted by a drop-in water elevation.

Commercial/Recreational Businesses: There are also two significant recreational businesses located in the North end of the Lake. They are the Bass Lake Lodge business with 14 Cottages and 29 RV Sites and the adjacent Bass Lake Trailer Park (65 lots). Both are located in the outlet bay at the North end of the lake. This bay is quite shallow (3- 8 ft) and a major drop in the historical water level could seriously impact the financial viability of these two businesses.

Property Values and Taxes: There are fourteen (14) private access roads around Bass Lake that service the 230 properties located on the Bass Lake waterfront. All of these properties are developed with at least 55-60% being full time primary residences. The remainder are seasonal (May-Oct) properties. Waterfront property owners on Bass Lake are a significant force in our Township. The most recent assessments by Municipal Properties Assessment Corporation (MPAC) has determined that the total value of all properties on Bass Lake is $84,000,000 which translates to a very significant tax revenue contribution of over $800,000 to support local governance, programs and infrastructure for our County and Township. This MPAC assessment will likely increase to over $95,000,000 during the upcoming MPAC reappraisal. The adverse impacts created by a drastic long-term lowering of the lake water level and decline in lake water quality on waterfront conditions would force a significant number of property owners around the lake to demand that their properties be reassessed by MPAC to reflect the negative impact on their property value.

APPENDIX B:

Water Levels and Control Structure Rationalization

WE #20010
August 20, 2020
Updated March 18, 2021

Mr. Mike Dwyer
CAO
Township of Rideau Lakes
1439 County Road 8
Delta, Ontario
K0E 1G0

Dear Mr. Dwyer:

RE: Bass Lake Outlet Study
Recommendations for Lake Level and Control Structure

As part of the detailed design of the Bass Lake Outlet Structure, the water surface elevation must be finalized and a proposed control structure must be finalized. We have addressed these in the following sections:

1) Recommended Water Level

The Township and the BLPOA had previously engaged Jp2g Consultants Inc. to examine possible water levels and control options. Their report (Jp2g, August 29, 2019) generally concluded that 79% of respondents thought that water levels should be maintained per the existing condition or raised higher. Subsequently the BLPOA polled the community again (using a Referendum) on this topic and received great response on their survey from all landowners on Bass Lake. The results of that survey show that almost 89.5% of the property owners want a level that is as high as it was experienced this year while 10% want a water level that is the average of the water levels experienced over the past decade.

Based on this, there is a strong support to maintain or raise the water level. However, what is a "normal" water level?

First of all, we need to consider the seasonal variations in water surface elevations. Spring freshet levels will be very different than that of mid-summer lake levels. Bass Lake has a limited contributing watershed. There are no rivers that supply water to it during the year. The water in the lake is generally dependent on runoff due to precipitation in the watershed and local groundwater levels. As such, once July 1st rolls around, the lake levels are entirely dependent on local runoff and evaporation from the lake. This typically will result in lower water levels during the summer. As such, we have a Spring "normal", Summer "normal" and Fall "normal".

Furthermore, Bass Lake may have historically been a depressional storage feature with a natural overflow and water levels during that time are unknown or, if available, come with caveats. However, since the placement of the outlet berm, water levels have somewhat been "controlled" by this berm. Furthermore, beaver activity is certainly present at the existing berm and continues to impact water levels. As we all know, beavers have an excellent ability to plug the flow of water and can also raise water levels. The Jp2g report noted that the top of berm elevation in August 2018 was approximately 134.23 metres (based on survey data provided by the RVCA). We note that the dam breach occurred in May 2018 which predates the survey, so this survey was performed after the repairs were completed. However, in our survey of April 22, 2020, the top of the berm, while it varies somewhat, was approximately 134.60 metres (with some water spilling over in sections). Those beavers have been busy!

What is important to understand is that a new control structure will generally "set" the long-term water surface elevation. We are targeting this to be the July 1 elevation. After July 1st, water levels would then be dependent on rain and groundwater levels. In spite of a "set" elevation, wet years would still have higher water levels and dry years may result in lower levels. It is recommended that July 1st be used as that is the time that most people would be on the lake and enjoying its amenities.

Table 1 presents the water surface elevations over the past decade. The record is not complete and various people and organizations have provided their input to the data. However, the data does provide a generally good idea of what the lake levels have been over the past decade.

Table 1: Recorded water surface elevations from 2010 to 2020

DATE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	AVERAGE 2010-2016	AVERAGE 2010-2020	ADJUSTED AVERAGE 2010-2020
01-May					134.50	134.50	134.50				134.61	**134.50**	**134.53**	134.50
15-May				134.40	134.49	134.43	134.47				134.62	**134.45**	**134.48**	134.46
01-Jun		134.42	134.52	134.45	134.50	134.40	134.42		134.33		134.61	**134.45**	**134.46**	134.47
15-Jun		134.40	134.47	134.53	134.55	134.48	134.35			134.45	134.59	**134.46**	**134.48**	134.48
01-Jul	134.50	134.40	134.40	134.50	134.50	134.47	134.32			134.40	134.55	**134.44**	**134.45**	134.45
15-Jul	134.48	134.43	134.37	134.48	134.44	134.46	134.28			134.35	134.52	**134.42**	**134.41**	134.42
01-Aug	134.45	134.38	134.30	134.45	134.43	134.44	134.25			134.30	134.49	**134.38**	**134.38**	134.38
15-Aug	134.40	134.32	134.28	134.40	134.43	134.45			134.17	134.24	134.49	**134.38**	**134.34**	134.35
01-Sep	134.35	134.25	134.24	134.34	134.42	134.44				134.21	134.51	**134.34**	**134.32**	134.32
15-Sep	134.32	134.20	134.20	134.31						134.17	134.50	**134.26**	**134.24**	134.24

Based on **Table 1**, we can observe the following:

1. There is plenty of missing data and we really cannot do much about that;
2. The data is only from 2010 and on. There is no long-term or historic data to glean from;
3. Data continued to be collected for 2020 (and as of March 18, 2021, the additional data was added to the list);
4. From 2010 to 2015, water levels appear to be relatively stable at the July 1st point and range from 134.40 to 134.50 metres;
5. From 2016 to 2018, the lake seems to be experiencing a drought period. During the summer period the lake levels are down 15 to 20 centimetres from the previous years;
6. Based on limited data, it seems that 2018 was setting record lows;
7. Water levels in 2019 seem to have rebounded to previous levels earlier in the decade;
8. Water levels in 2020 are generally at a decadal high and every recorded water surface elevation is setting a new record;
9. The long-term average July 1st water surface elevation is 134.45 metres (2nd last column);
10. The change from July 1st to September 1st ranges from 19 (2019) to 3 centimetres (2015). 2010 to 2014 consistently ranged from 15 to 16 centimetres. The average is 13 cm (5");
11. If the highest and lowest observed water surface elevations were removed from the calculation, the adjusted average elevation would still be 134.45 metres (last column);
12. The average and adjusted values are presented for all recording dates during the year; and,
13. The removal of extreme values does not impact the average water level values substantially.

Based on results of the Jp2g survey, the BLPOA referendum and the long-term data of **Table 1**, we recommend that the July 1st water level be "set" at 134.55 metres. This represents a decrease of 5 to 7 centimetres from the spring highs set in May and an increase of 10 centimetres (4") from the decadal average of 134.45 metres.

2) Recommended Control Structure

The Jp2g survey also noted that the preferred solution for managing the Bass Lake outlet was to rehabilitate the existing berm or the construction of a typical structural weir out of concrete or similar material. Their preferred solution was Option 3 (Rocky Ramp Weir). Our current design alternatives have taken this a step forward since a very wide rocky ramp weir would be unnecessary. The three options we are proposing include:

a) Cross Vane Structure
b) Rocky Riffle Control Structure.
c) Concrete Control Structure

In each case, an earthen berm would be constructed with each control structure option being constructed within the berm and the crest of the structure would be set at the design water level. Winter/spring lake levels would slowly be drawn down to the design elevation at a rate similar to that of current conditions where flows leaving the lake at a rate of about 5 to 6 m^3/s during ice off conditions in late spring.

A cross vane structure is comprised of natural materials and is fish-passage friendly.

Based on our experience and understanding of site conditions and requirements, we recommend that the Cross Vane structure be implemented at the site. The concept design of a cross vane structure is presented in **Figure 1**.

3) Summary

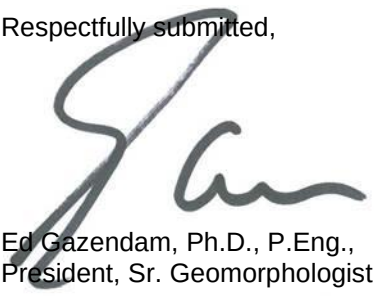
Various design water levels can be considered for the Bass Lake Outlet. In addition, there are a variety of ways to control the outflow from the lake in order to ensure that the lake levels remain relatively stable during the summer months. We are thankful for the opportunity to have presented our thoughts and designs at the Public Open House which was held on July 28, 2020.

In conclusion, we recommend that:

1 The Design water level be set at 134.55 metres;
2 The water levels at the outlet be controlled by a Cross Vane structure; and,
3 A final design be prepared for the outlet structure.

Should you have any comments or questions on these staff additional/replacements, please do not hesitate to contact the undersigned.

Respectfully submitted,



Ed Gazendam, Ph.D., P.Eng.,
President, Sr. Geomorphologist

APPENDIX C:

Geotechnical Report

Soil Engineers Ltd.
CONSULTING ENGINEERS
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A REPORT TO
WATER'S EDGE ENVIRONMENTAL SOLUTIONS TEAM LTD.

A GEOTECHNICAL INVESTIGATION FOR BASS LAKE OUTLET RECONSTRUCTION

BASS LAKE
TOWNSHIP OF RIDEAU LAKES

REFERENCE NO. 2010-S130

JANUARY 2021

DISTRIBUTION

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1 Copy - Soil Engineers Ltd. (Oshawa)
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TABLES

ENCLOSURES

1.0 INTRODUCTION

In accordance with the written authorization from Dr. Ed Gazendam, P.Eng., of Water's Edge Environmental Solutions Team Ltd., a geotechnical investigation was carried out at the site of Bass Lake outlet in the Township of Rideau Lakes.

The purpose of the investigation was to reveal the subsurface conditions and to determine the engineering properties of the disclosed soils for the outlet structure at Bass Lake outlet. The geotechnical findings and resulting recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The Township of Rideau Lakes is situated on Smith Falls Limestone Plain, where continuous tract of the soil overburden beds on bedrock at relatively shallow depths. Due to the gentle gradient, the surface drainage is poor, with numerous lakes and swamps in places.

The site of investigation is located beside Bass Lake Road, at the north outlet of Bass Lake, where wetland is present and connecting into a creek flowing to the north towards Lower Rideau Lake. There is an existing berm in place, approximately 35 m long and 1 m high. The project includes the construction of a new earth dam, with a cross vane for the outlet at about 10 m downstream of the berm.

3.0 FIELD WORK

The field work, consisting of three (3) sampled boreholes, was performed on December 21, 2020, at the locations shown on the Borehole Location Plan, Drawing No. 1. The ground elevation at each borehole location was determined with reference to the temporary benchmark, "Top of Iron Bar" at the east limit of the site boundary, as shown on Drawing No. 1. It has a geodetic elevation of 134.92 m.

The boreholes were advanced at intervals to the sampling depths by a track-mounted drill rig, with continuous-flight power-auger and equipment for soil sampling, up to the depth of auger refusal at 0.7 to 0.9 m. Standard Penetration Tests, using the procedures described on the enclosed "List of Abbreviations and Terms", were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or 'N' values) of the subsoil. Split-spoon samples were recovered for soil classification and laboratory testing.

Beyond the depth of auger refusal, at a depth of 0.7 m in Borehole 2, 'NQ' size rock coring was carried out for verification of bedrock and to establish the rock quality. The results are

shown on the corresponding Borehole Log. The field work was supervised and the findings were recorded by a Geotechnical Technician.

4.0 SUBSURFACE CONDITIONS

The investigation has disclosed that beneath a topsoil veneer, or an alluvium, the area is underlain by silty clay and silty sand till, overlying limestone bedrock at a depth of 0.7 to 0.9 m. Detailed descriptions of the encountered subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 3, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing No. 2. The engineering properties of the disclosed soils and bedrock are discussed herein.

4.1 Topsoil (Borehole 3)

The revealed topsoil is 45 cm in thickness. Topsoil thicker than that found in the borehole may occur in places.

4.2 Alluvial Deposit (Boreholes 1 and 2)

The alluvial deposit consists of silt and clay, with organics and remnants of plant debris, probably accumulated on flood plain or previous wetland. It is compressible and is considered void of engineering value. The organic material will generate volatile gases under anaerobic condition, if it is buried.

4.3 Silty Clay (Boreholes 1)

The silty clay deposit was contacted as the native stratum in the area of investigation. It is a glaciolacustrine deposit, laminated with silt and sand seams. Grain size analysis was performed on a representative sample and the result is plotted on Figure 4.

The silty clay extends to a depth of 0.8 m. The obtained 'N' values range from 1 blow per 30 cm of penetration to 5 blows per 15 cm of penetration, indicating the consistency is very soft to stiff. The natural water content values of the clay samples are 43% and 38%, indicating very moist or wet conditions.

The engineering properties of the clay deposit are given below:

- High frost susceptibility and soil-adfreezing potential.
- Low water erodibility.

- Low permeability, with an estimated coefficient of permeability of less than 10^{-7} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.15
2% - 6%	0.20
6% +	0.28

- The shear strength is derived from consistency and augmented by the internal friction of the sand and silt.
- A poor pavement-supportive material, with an estimated California Bearing Ratio (CBR) value of 3%.
- Moderately high corrosivity to buried metal, with an estimated electrical resistivity of 2500 ohm·cm.

4.4 **Silty Sand Till** (Borehole 3)

The silty sand till deposit was contacted below the topsoil. It consists of a random mixture of particle sizes ranging from clay to gravel, with sand and silt being the predominant fractions. Grain size analysis was performed on a representative sample and the result is plotted on Figure 5.

The obtained 'N' value is 10 blows per 30 cm of penetration, indicating the till is compact in relative density. The natural water content value is 18%, indicating the till is in very moist or wet conditions.

The engineering properties of the sand till deposit are listed below:

- High frost susceptibility and moderate water erodibility.
- Semi-permeable, with an estimated coefficient of permeability of 10^{-5} cm/sec and runoff coefficients of:

Slope	
0% - 2%	0.11
2% - 6%	0.16
6% +	0.23

- The shear strength is primarily derived from internal friction and is augmented by cementation.
- Fair pavement-supportive material, with an estimated CBR value of 8%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm·cm.

4.5 **Bedrock** (All Boreholes)

Refusal to auger drilling was contacted in the boreholes at 0.7 to 0.9 m from the prevailing ground surface, or between El. 133.4 m and El. 133.1 m.

Rock coring was conducted into the bedrock at Borehole 2, from a depth of 0.9 to 2.0 m. It is limestone bedrock, having the core recovery of 97% and 88%; the Rock Quality Designation (RQD) values are 30% and 50%.

The bedrock can be classified as poor to fair quality, probably becoming good quality at deeper levels. Effective rock excavation will require a rock-ripper and pneumatic hammer. Any excavation into the sound rock will require rock blasting.

Where excavation is to be carried out in sound bedrock, slight lateral displacement of the excavation walls is often experienced. This is due to the release of residual stress stored in the bedrock mantle.

5.0 GROUNDWATER CONDITION

Free groundwater was not evident in the shallow boreholes terminated above the bedrock, upon the completion of drilling.

Due to the presence of wetland in the vicinity, groundwater can be anticipated at shallow depths, probably through the fractures in bedrock.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has disclosed that the limestone bedrock exists at a depth of 0.7 to 0.9 m from grade. The overburden consists of topsoil and alluvial deposit, with silty clay or silty sand till.

The construction of a new dam is proposed at about 10 m downstream of the berm. The recommendations for the project are presented herein.

One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted.

6.1 Site Preparation

Site preparation will consist of installing a silt curtain at the upstream of the construction site and coffer-dams at the downstream, with bypass pumps to divert the water flow and to maintain a dry zone for construction.

Before construction and placement of earth fill, the existing topsoil and alluvial deposit, which is compressible, should be completely removed.

Soft clay and weathered soils should also be removed before earth filling for the dam, since the soft soil will be subject to long term settlement.

6.2 Construction of Outlet Structure

Preliminary design drawings of the outlet structure, provided by Water's Edge Environmental Solutions Team, are enclosed in the Appendix. It is an earth berm, with a central clay core, flanked on both sides with semi-pervious earth fill and riprap on the side-slope.

The material for the construction of embankment should be free of organics, compacted in lifts not exceeding 200 mm to at least 98% of the Standard Proctor Maximum Dry Density (SPMDD), with the water content close to its optimum moisture content. The fill placement and compaction should be inspected by either a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer under full-time basis.

Topsoil and organic soils should be removed. Soft clay and weathered soils should also be removed since they will be subject to long term settlement. The subgrade of the earth dam should consist of sound native soils or bedrock. It must be inspected by a geotechnical engineer before placement of earth fill. Cut off curtain wall consisting of clay or cement grout should be constructed at the toe of embankment to prevent under-seepage and erosion.

The on-site soils are generally too wet to achieve the specified density. They will require aeration by spreading thinly on the ground in the dry and warm weather, prior to placement and structural compaction.

The fill should be compacted using a heavy-weight, kneading-type roller. The thickness of each lift should be limited to 20 cm or less (before compaction), or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

The rock fragment and boulders will prevent transmission of the compactive energy into the underlying material to be compacted. Rock fragments over 15 cm in size must be sorted for other uses such as the rip-rap.

The shattered rock from blasting can be used as the rip-rap. It should be constructed over a geofabric filter (Terrafix 360 R, or equivalent). The revetment should extend to 0.3 m above the design high water level to allow for wave rush. Spillways should be provided with a liner consisting of rip-rap stone or gabion mattress above a filter fabric (Terrafix 360R, or equivalent).

6.3 Excavation

All excavation should be carried out in accordance with Ontario Regulation 213/91. The types of soils and rock are classified in Table 1.

Table 1 - Classification of Soils and Rock for Excavation

Material	Type
Bedrock	1
Silty Clay and Silty Sand Till	3
Wet and soft soils	4

Effective rock excavation will require a rock-ripper and pneumatic hammer. Any excavation into the sound rock will require rock blasting. A specialist should be consulted to assess the zone of influence of the shock wave in order to prevent any potential damage of the nearby structures in rock blasting.

Where excavation is to be carried out in sound bedrock, slight lateral displacement of the excavation walls is often experienced, due to the release of residual stress in the bedrock. Groundwater is anticipated in the excavation, especially through fractured rock. It can be collected into pump pits and removed by conventional pumping.

6.4 Site Classification for Seismic Design

The Site Classification for Seismic Site Response in the Ontario Building Code is to evaluate the impact of ground response during an earthquake. As a guide, the outlet structure should be designed to resist an earthquake force using Site Class ‘C’ (very dense soil and soft rock).

6.5 Slope Stability

Slope stability analysis was conducted for the embankment, using force-moment equilibrium criteria, with the soil strength parameters presented in Table 2.

Table 2 - Soil and Rock Strength Parameters

Soil Description	Unit Weight γ (kN/m^3)	Cohesion c' (kPa)	Internal Angle of Friction, ϕ'
Compacted Clay Core	21.5	5	20º
Compacted Earth Fill	21.0	0	26º
Riprap Revetment	23.0	0	40º
Bedrock	24.0	200	40º

Details of the analyses and the results of the various loading conditions are shown on Drawing Nos. 3 to 7, inclusive. The resulting Factor of Safety (FOS) is compared with the requirement stipulated in the Ontario Ministry of Natural Resources and Forestry (OMNRF) guidelines and summarized in Table 3.

Table 3 - Factors of Safety of Embankment

Loading Condition	FOS	Minimum FOS (OMNRF)
End of Construction	1.54	1.3
Long-Term Condition (Upstream Slope)	1.40	1.3
Long-Term Condition (Downstream Slope)	1.54	1.3
Rapid Draw-down (Upstream Slope)	1.24	1.2
Seismic Loading (Downstream Slope)	1.21	1.0
Seismic Loading (Upstream Slope)	1.00	1.0

Based on the analytical results, the slope satisfies the OMNRF requirements under all loading conditions and the dam is considered geotechnically stable.

6.6 Soil Parameters

The recommended soil parameters for the project design are given in Table 4.

Table 4 - Soil Parameters

Unit Weight and Bulk Factor	**Unit Weight (kN/m^3)**	**Estimated Bulk Factor**	
	Bulk	**Loose**	**Compacted**
Silty Clay	21.5	1.30	1.05
Silty Sand Till	22.0	1.25	1.03
Shattered Rock	24.5	1.40	1.30
Lateral Earth Pressure Coefficients	**Active K_a**	**At Rest K_o**	**Passive K_p**
Silty Clay/compacted Earth Fill	0.45	0.55	2.50
Silty Sand Till/Rip-rap	0.35	0.50	3.00
Bedrock	0.20	0.30	5.00
Coefficients of Friction			
Between Concrete and Bedrock			0.65
Between Concrete and Granular Fill			0.50

7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Water's Edge Environmental Solutions Team Ltd., and for review by the designated consultants and government agencies. Use of the report is subject to the conditions and limitations of the contractual agreement.

The material in the report it reflects the judgement of Basim Al Ali, P.Eng., and Bennett Sun, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

SOIL ENGINEERS LTD.

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Jan 29/2021

Basim Al-Ali, P.Eng.
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CHUN C. B. SUN
Jan 29, 2021
PROVINCE OF ONTARIO

Bennett Sun, P.Eng.

LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

SAMPLE TYPES

AS Auger sample
CS Chunk sample
DO Drive open (split spoon)
DS Denison type sample
FS Foil sample
RC Rock core (with size and percentage recovery)
ST Slotted tube
TO Thin-walled, open
TP Thin-walled, piston
WS Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—●—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH Sampler advanced by static weight
PH Sampler advanced by hydraulic pressure
PM Sampler advanced by manual pressure
NP No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0 Field vane test in borehole; the number denotes the sensitivity to remoulding

△ Laboratory vane test

□ Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

JOB NO.: 2010-S130

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

PROJECT DESCRIPTION: Bass Lake Outlet Reconstruction

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: Bass Lake Road, Township of Rideau Lakes

DRILLING DATE: December 21, 2020

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
134.2	Ground Surface							
0.0 133.9	Dark brown/black **ALLUVIAL DEPOSIT** a mixture of silt and clay occasional peat and organics	1A	DO	WH	0		16	
0.3 133.4	Grey, very soft to stiff **SILTY CLAY** a tr. of sand occ. silt seams	1B	DO	1			43	
		2	DO	8			38	
0.8	**Refusal to Augering** **Inferred Bedrock** **END OF BOREHOLE**				1 2 3 4			

Soil Engineers Ltd.

JOB NO.: 2010-S130

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

PROJECT DESCRIPTION: Bass Lake Outlet Reconstruction

METHOD OF BORING: Flight-Auger /n Rock Core

PROJECT LOCATION: Bass Lake Road, Township of Rideau Lakes

DRILLING DATE: December 21, 2020

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
134.0	Ground Surface							
0.0	Dark brown/black **ALLUVIAL DEPOSIT** a mixture of silt and clay occasional peat and organics	1	DO	WH	0	⊖	●	190
133.3								
0.7	Grey **LIMESTONE BEDROCK**	C1	REC RQD	97% 30%	1			
		C2	REC RQD	88% 50%	2			
132.0								
2.0	**END OF BOREHOLE**				3			
					4			

Soil Engineers Ltd.

JOB NO.: 2010-S130

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

PROJECT DESCRIPTION: Bass Lake Outlet Reconstruction

METHOD OF BORING: Flight-Auger

PROJECT LOCATION: Bass Lake Road, Township of Rideau Lakes

DRILLING DATE: December 21, 2020

El. (m) / Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	Depth Scale (m)	Dynamic Cone (blows/30 cm) 10 30 50 70 90 / Shear Strength (kN/m²) 50 100 150 200 / Penetration Resistance (blows/30 cm) 10 30 50 70 90	Atterberg Limits PL LL / Moisture Content (%) 10 20 30 40	WATER LEVEL
134.0	Ground Surface							
0.0	**45 cm TOPSOIL**	1	DO	WH	0		20	
133.5								
0.5	Grey, compact **SILTY SAND TILL** a tr. to some clay occ. silt seams and rock fragments	2	DO	10			18	
133.1					1			
0.9	**Refusal to Augering** **Inferred Bedrock** **END OF BOREHOLE**				2			
					3			
					4			

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GRAIN SIZE DISTRIBUTION

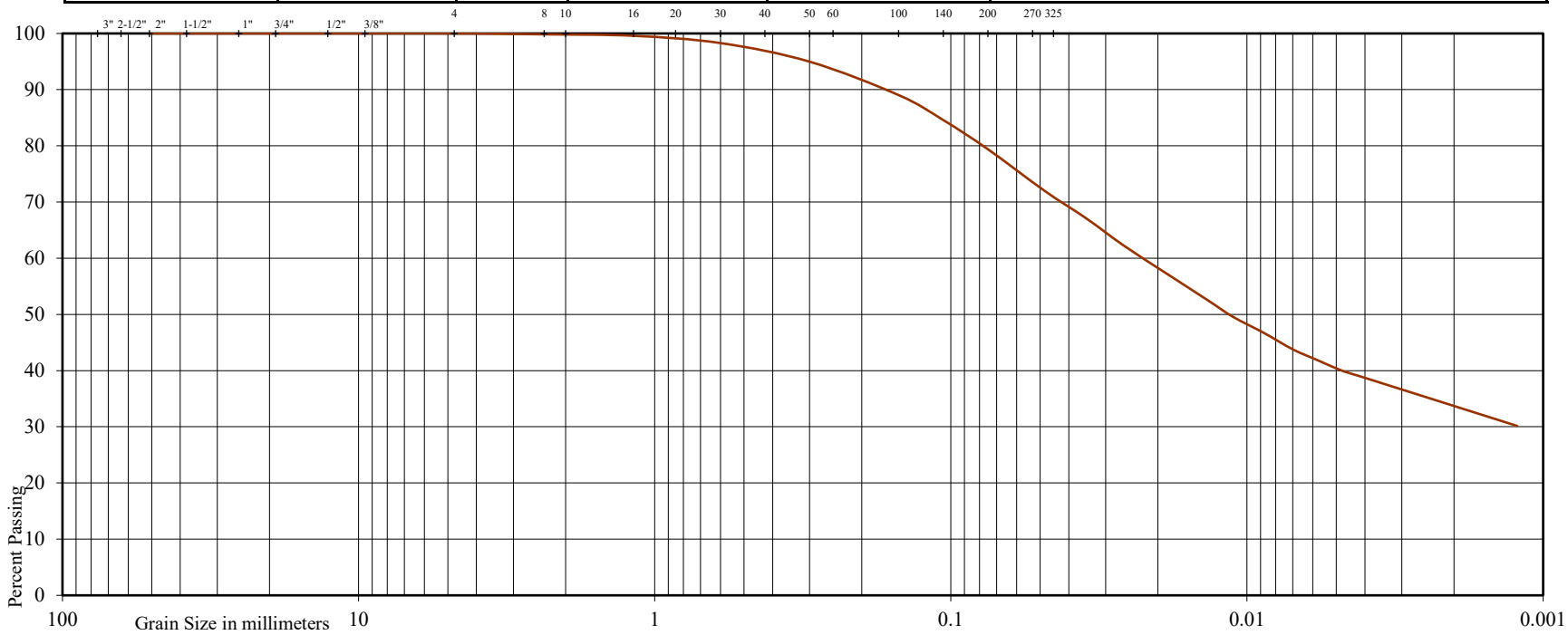
Reference No: 2010-S130

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Bass Lake Outlet Reconstruction

Location: Bass Lake Road, Township of Rideau Lakes

Borehole No: 1

Sample No: 1B

Depth (m): 0.5

Elevation (m): 133.7

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 43

Estimated Permeability (cm./sec.) = 10^{-7}

Classification of Sample [& Group Symbol]: SILTY CLAY, some sand

Figure: 4

Soil Engineers Ltd.

GRAIN SIZE DISTRIBUTION

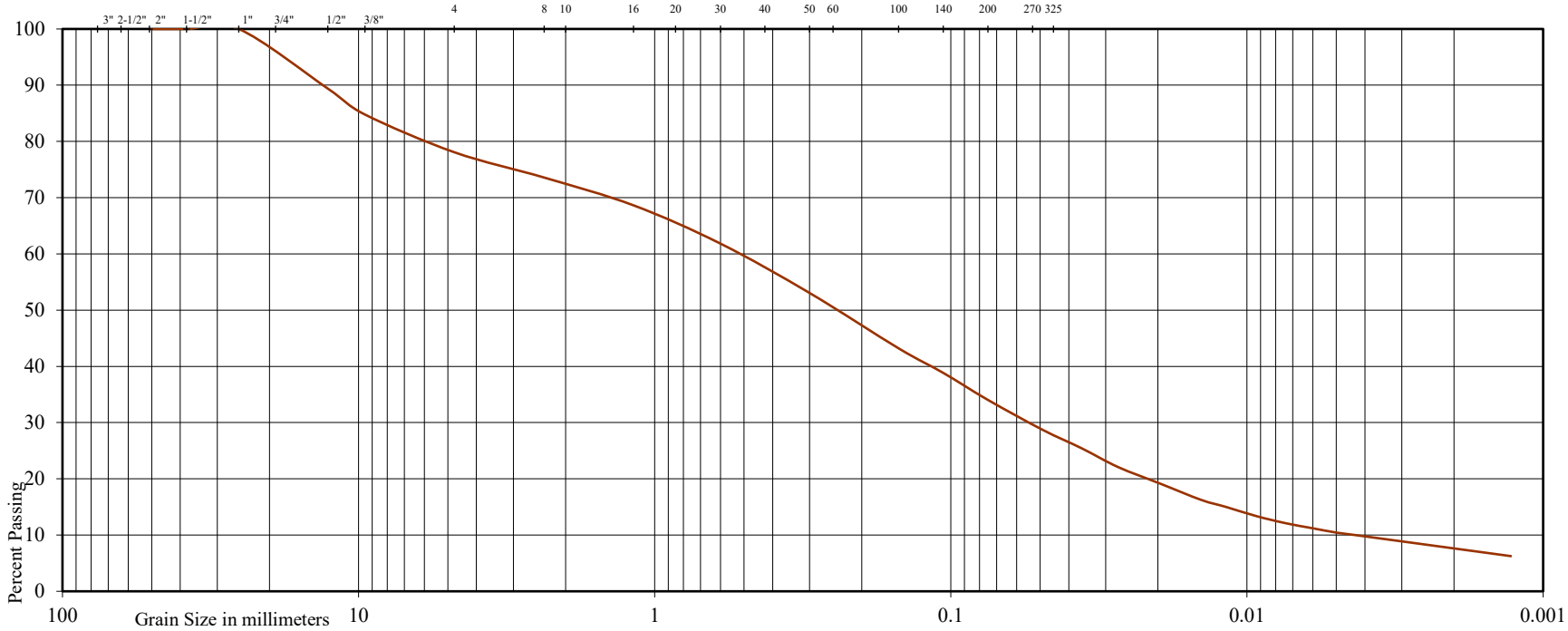
Reference No: 2010-S130

U.S. BUREAU OF SOILS CLASSIFICATION

GRAVEL		SAND				SILT	CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	V. FINE		

UNIFIED SOIL CLASSIFICATION

GRAVEL		SAND			SILT & CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	



Project: Bass Lake Outlet Reconstruction

Location: Bass Lake Road, Township of Rideau Lakes

Borehole No: 3

Sample No: 2

Depth (m): 0.7

Elevation (m): 133.3

Liquid Limit (%) = -

Plastic Limit (%) = -

Plasticity Index (%) = -

Moisture Content (%) = 18

Estimated Permeability (cm./sec.) = 10^{-5}

Classification of Sample [& Group Symbol]: SILTY SAND TILL, some clay and gravel

Figure: 5

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BOREHOLE LOCATION PLAN

REF. NO.: 2010-S130	DWG NO.: 1	DATE: January 2021

Soil Engineers Ltd.
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SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

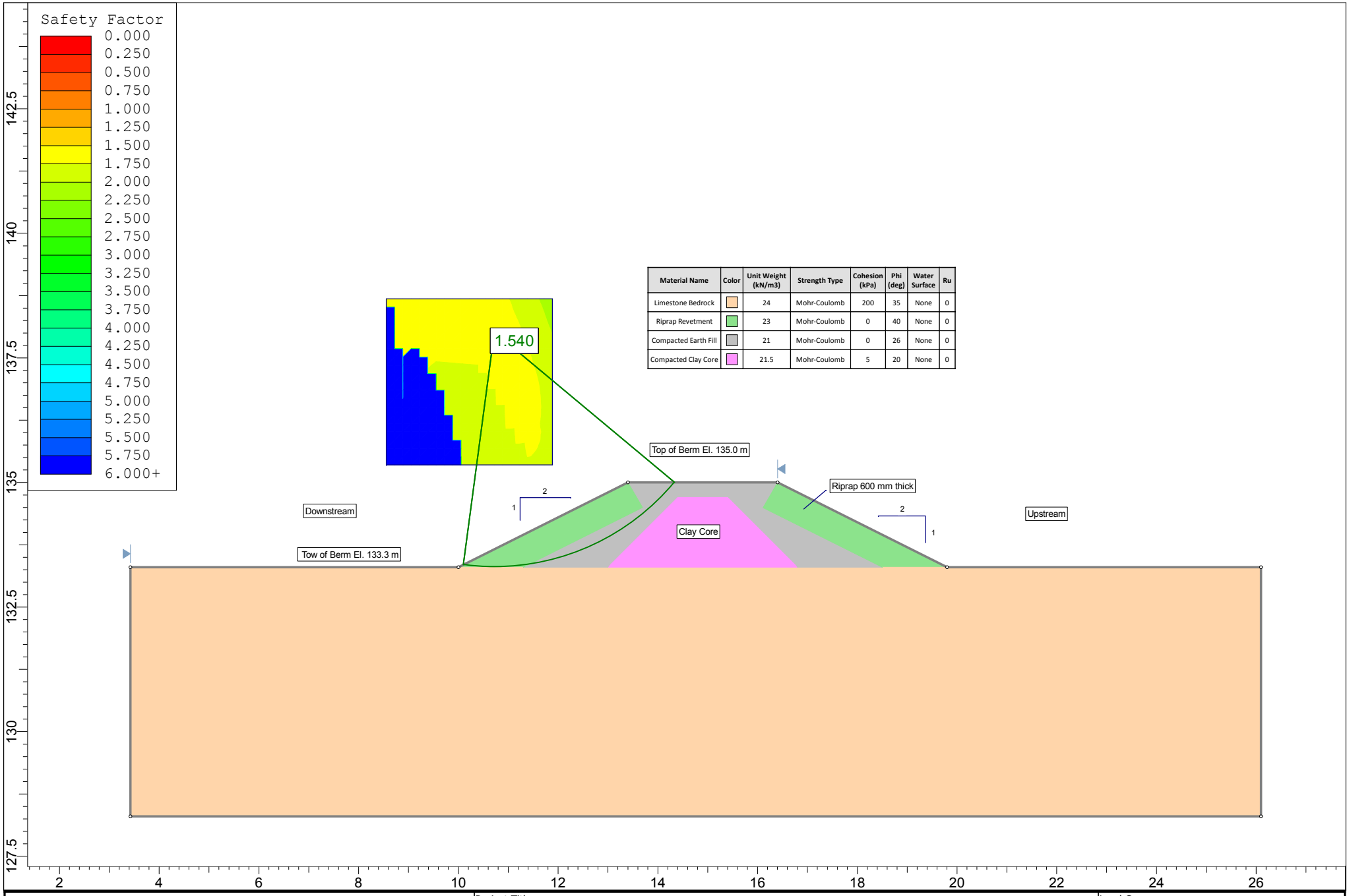
JOB NO.: 2010-S130
REPORT DATE: January 2021
PROJECT DESCRIPTION: Bass Lake Outlet Reconstruction

PROJECT LOCATION: Bass Lake Road, Township of Rideau Lakes

LEGEND

TOPSOIL | SILTY CLAY | LIMESTONE | ALLUVIU
SILTY SAND TILL

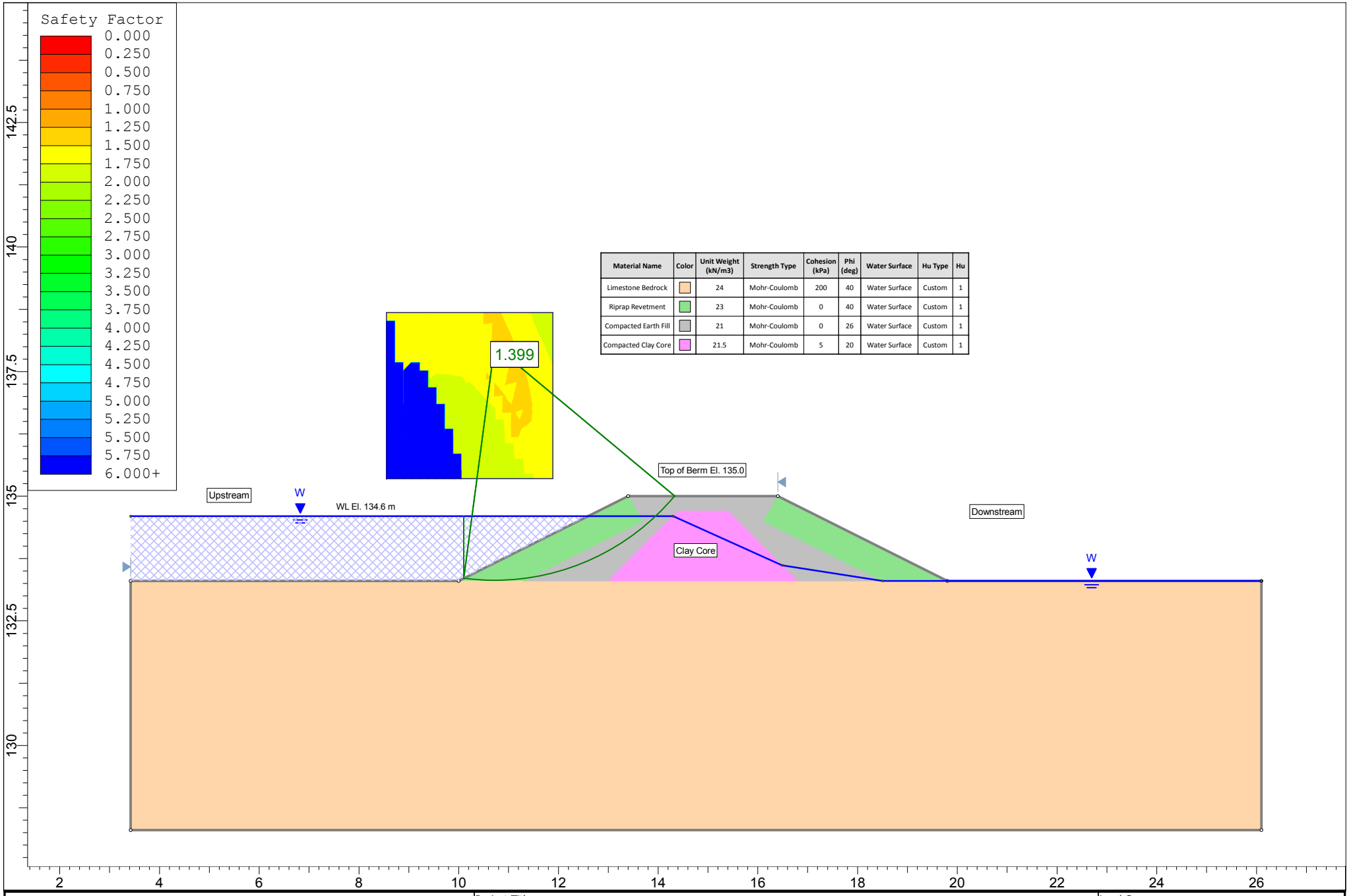
WATER LEVEL (END OF DRILLING) | CAVE-IN | WATER LEVEL (STABILIZED)



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Limestone Bedrock		24	Mohr-Coulomb	200	35	None	0
Riprap Revetment		23	Mohr-Coulomb	0	40	None	0
Compacted Earth Fill		21	Mohr-Coulomb	0	26	None	0
Compacted Clay Core		21.5	Mohr-Coulomb	5	20	None	0

Soil Engineers Ltd.
CONSULTING ENGINEERS
GEOTECHNICAL | ENVIRONMENTAL | HYDROGEOLOGICAL | BUILDING SCIENCE
90 WEST BEAVER CREEK, SUITE #100, RICHMOND HILL, ONTARIO L4B 1E7 · TEL: (416) 754-8515 · FAX: (905) 881-8335

Project Title: Bass Lake Outlet Reconstruction			Load Case: Typical Cross Section - End of Construction
Location: Bass Lake Road, Township of Rideau Lakes			
Drawn By: BA	Checked By: BL/BS	Scale: 1:100	Revision:
Date: 1/20/2021		Reference No.: 2010-S130	Drawing No.: 3



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Limestone Bedrock		24	Mohr-Coulomb	200	40	Water Surface	Custom	1
Riprap Revetment		23	Mohr-Coulomb	0	40	Water Surface	Custom	1
Compacted Earth Fill		21	Mohr-Coulomb	0	26	Water Surface	Custom	1
Compacted Clay Core		21.5	Mohr-Coulomb	5	20	Water Surface	Custom	1

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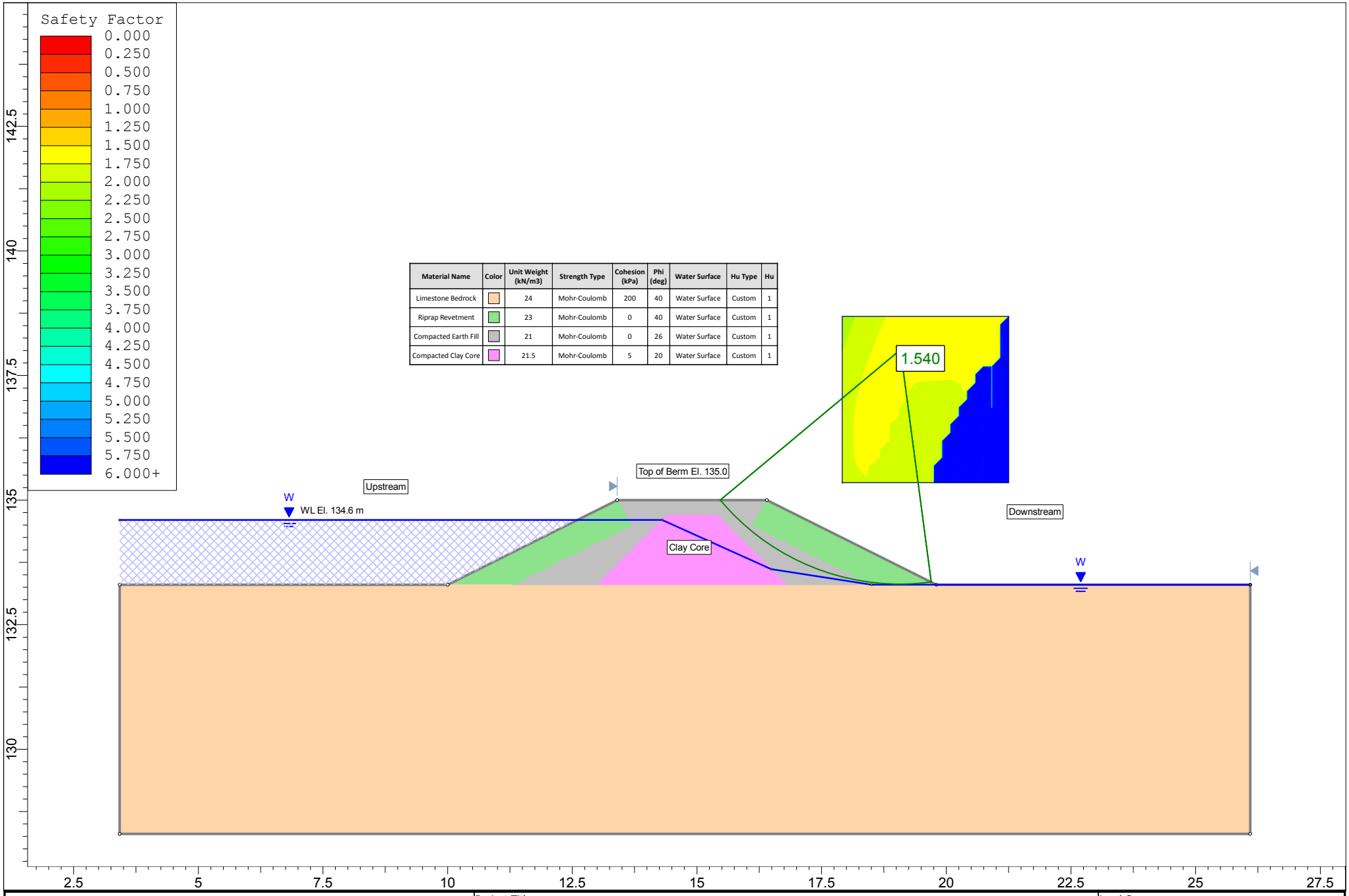
Project Title: Bass Lake Outlet Reconstruction			Load Case: Typical Cross Section - Long Term (Upstream Slope)
Location: Bass Lake Road, Township of Rideau Lakes			
Drawn By: BA	Checked By: BL/BS	Scale: 1:100	Revision:
Date: 1/20/2021		Reference No.: 2010-S130	Drawing No.: 4



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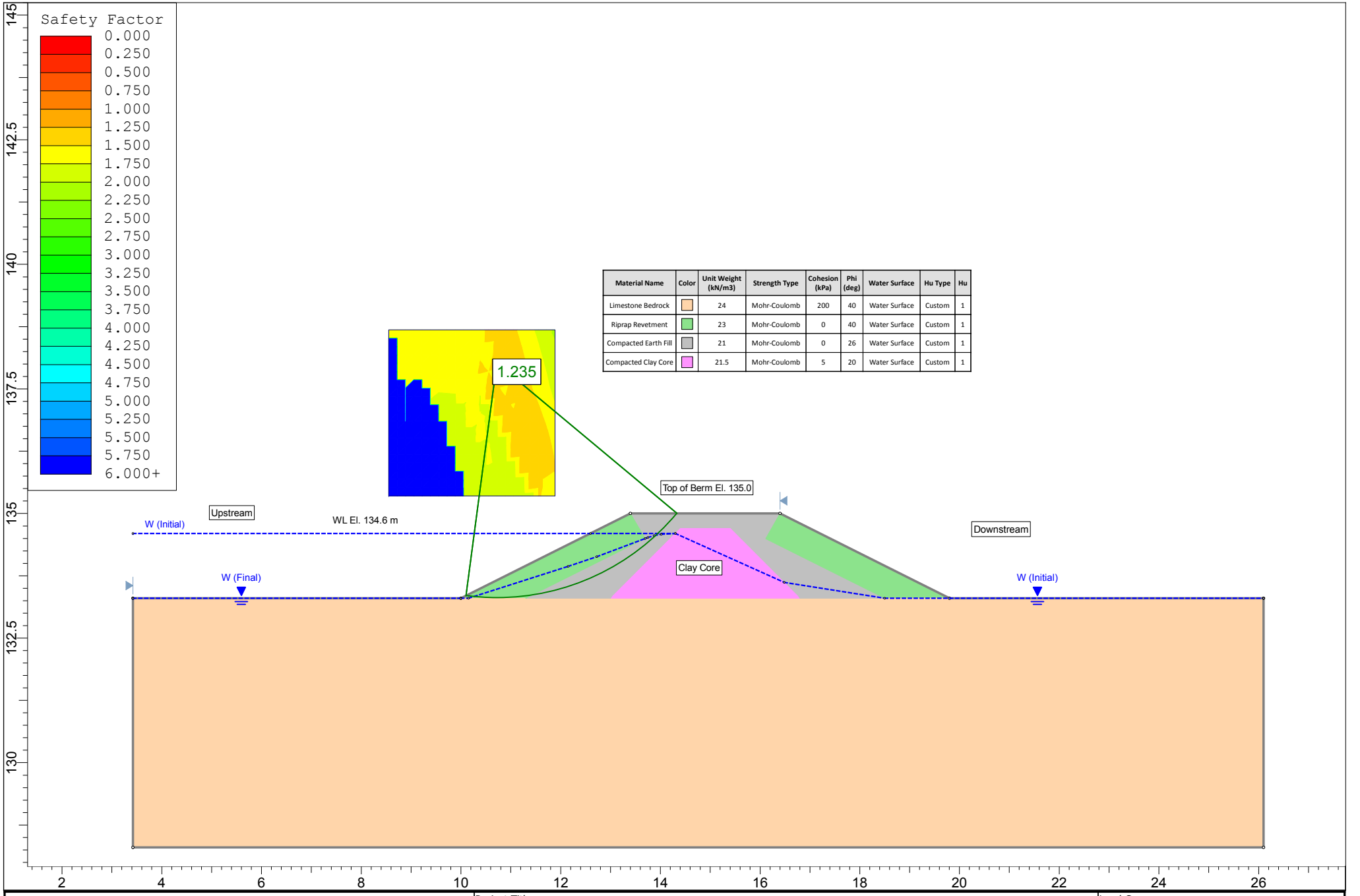
Project Title: Bass Lake Outlet Reconstruction			Load Case: Typical Cross Section - Long Term (Downstream Slope)
Location: Bass Lake Road, Township of Rideau Lakes			
Drawn By: BA	Checked By: BL/BS	Scale: 1:100	Revision:
Date: 1/20/2021		Reference No.: 2010-S130	Drawing No.: 5



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Limestone Bedrock		24	Mohr-Coulomb	200	40	Water Surface	Custom	1
Riprap Revetment		23	Mohr-Coulomb	0	40	Water Surface	Custom	1
Compacted Earth Fill		21	Mohr-Coulomb	0	26	Water Surface	Custom	1
Compacted Clay Core		21.5	Mohr-Coulomb	5	20	Water Surface	Custom	1

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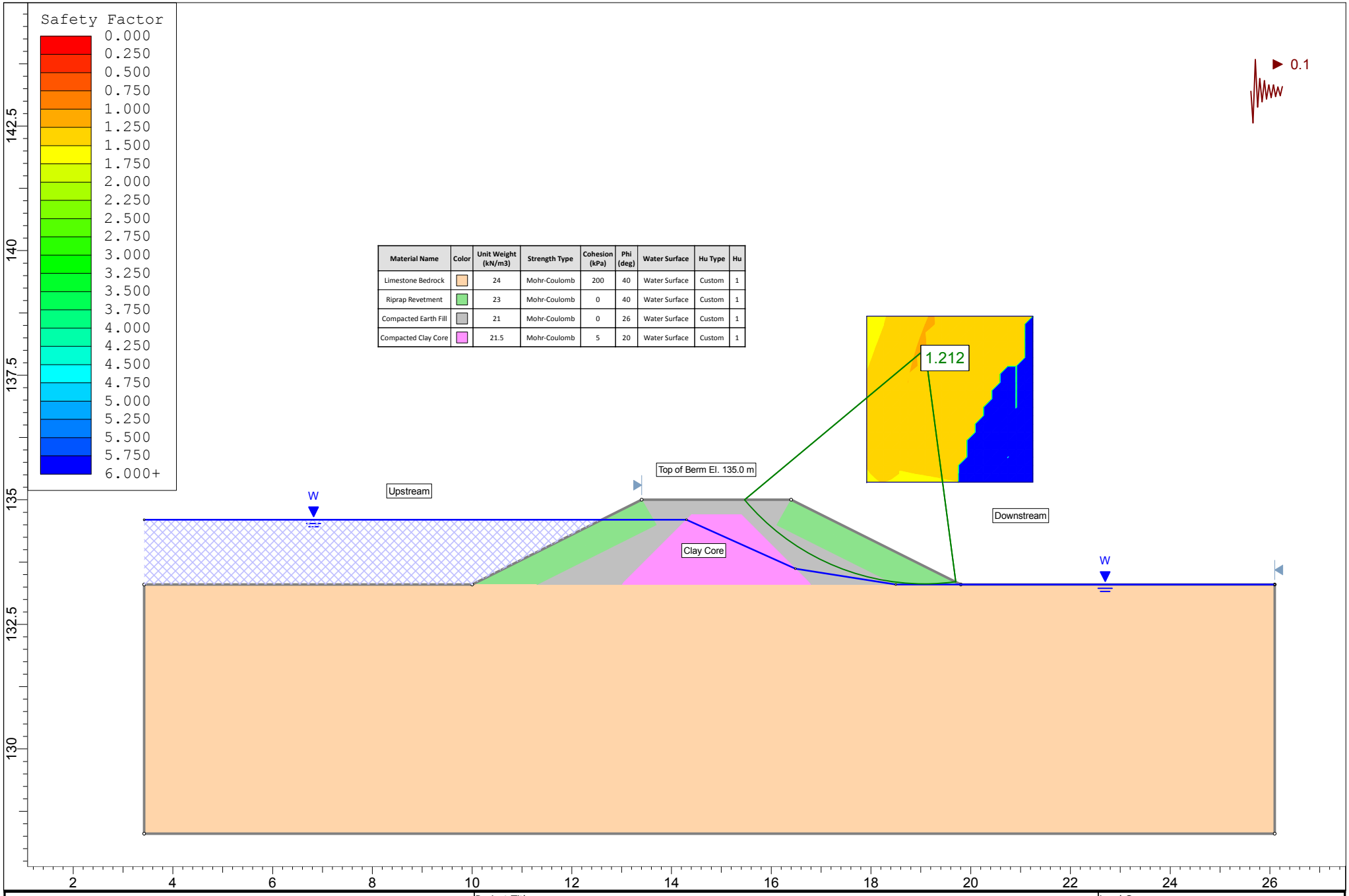
Project Title: Bass Lake Outlet Reconstruction			Load Case: Typical Cross Section - Rapid Draw-down (Upstream Slope)
Location: Bass Lake Road, Township of Rideau Lakes			
Drawn By: BA	Checked By: BL/BS	Scale: 1:100	Revision:
Date: 1/20/2021		Reference No.: 2010-S130	Drawing No.: 6



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Limestone Bedrock		24	Mohr-Coulomb	200	40	Water Surface	Custom	1
Riprap Revetment		23	Mohr-Coulomb	0	40	Water Surface	Custom	1
Compacted Earth Fill		21	Mohr-Coulomb	0	26	Water Surface	Custom	1
Compacted Clay Core		21.5	Mohr-Coulomb	5	20	Water Surface	Custom	1

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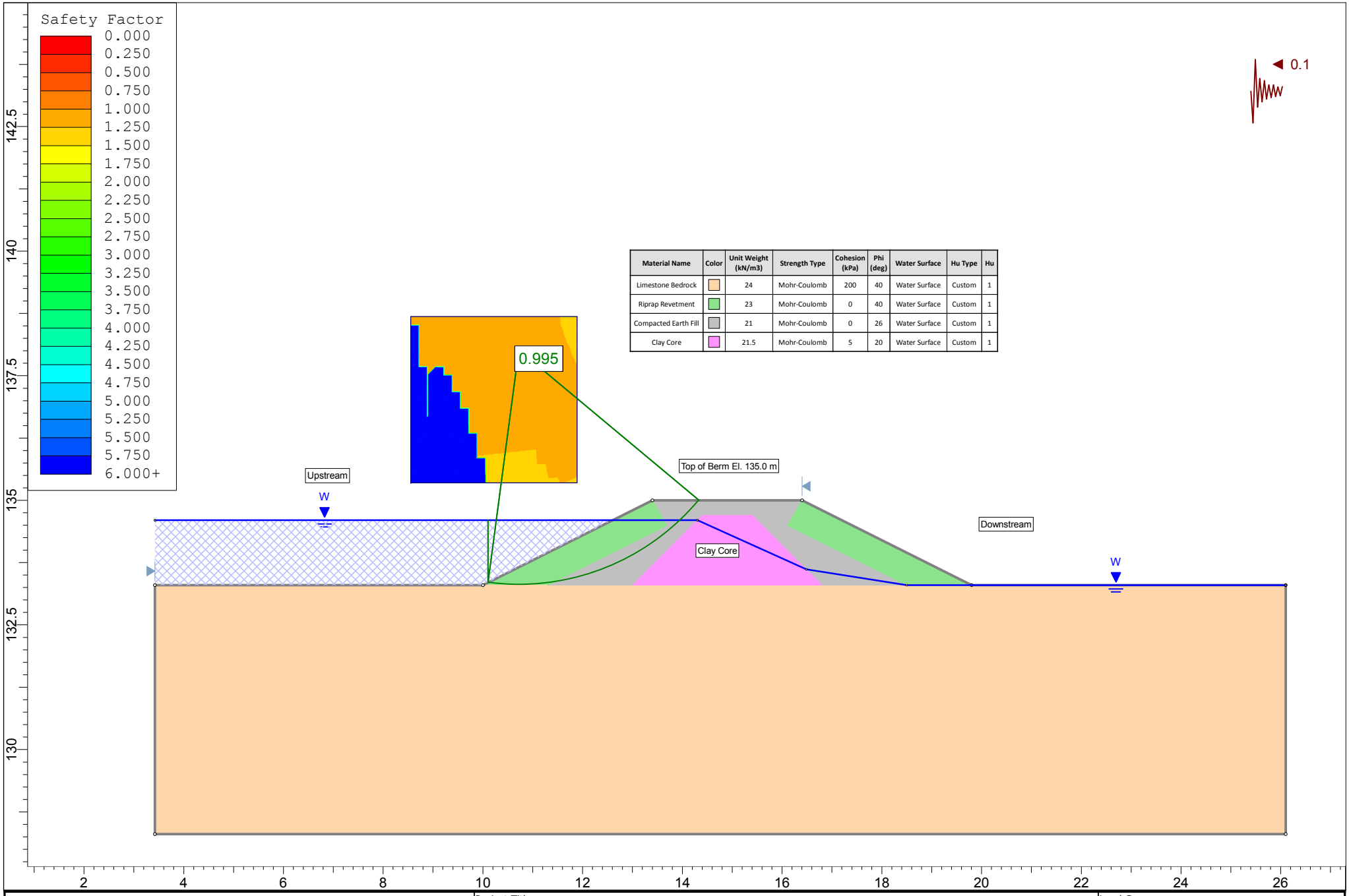
Project Title: Bass Lake Outlet Reconstruction			Load Case: Typical Cross Section - Sesimic Loading (Downstream Slope)
Location: Bass Lake Road, Township of Rideau Lakes			
Drawn By: BA	Checked By: BL/BS	Scale: 1:100	Revision:
Date: 1/20/2021		Reference No.: 2010-S130	Drawing No.: 7



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Limestone Bedrock		24	Mohr-Coulomb	200	40	Water Surface	Custom	1
Riprap Revetment		23	Mohr-Coulomb	0	40	Water Surface	Custom	1
Compacted Earth Fill		21	Mohr-Coulomb	0	26	Water Surface	Custom	1
Clay Core		21.5	Mohr-Coulomb	5	20	Water Surface	Custom	1

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Project Title: Bass Lake Outlet Reconstruction			Load Case: Typical Cross Section - Sesimic Loading (Upstream Slope)
Location: Bass Lake Road, Township of Rideau Lakes			
Drawn By: BA	Checked By: BL/BS	Scale: 1:100	Revision:
Date: 1/20/2021		Reference No.: 2010-S130	Drawing No.: 8

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APPENDIX

DESIGN DRAWINGS OF DAM
(BY WATER'S EDGE ENVIRONMENTAL SOLUTIONS TEAM LTD.)

REFERENCE NO. 2010-S130

APPENDIX D:

Design Drawings