
FUNCTIONAL SERVICING & STORMWATER MANAGEMENT REPORT

PRIMONT (THOROLD/WELLAND) INC.

Cataract Road Lands (Southwest Quadrant)
Lot 228 & Part Lot 174, Thorold, Ontario

Submitted For:
APPLICATION FOR AN OFFICIAL PLAN AMENDMENT

Project No.: 2026-0001-10

February 18, 2026

WALTERFEDY

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REV	DATE	WRITTEN BY	QA BY	SEALED BY	ISSUED FOR
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Cataract Road Lands (Southwest Quadrant), Lot 228 and Part Lot 174 Thorold

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1.0 INTRODUCTION

WalterFedy Inc. has been retained by Primont (Thorold/Welland) Inc. to provide civil engineering consulting services in support of an application for an Official Plan Amendment (OPA) for a portion of the property comprised of Lot 228 and Part Lot 174 City of Thorold, hereafter referred to as “**Cataract Road Property**”. The application pertains to the portion of the property or “**Subject Lands**”, located at the southwest quadrant of the intersection of Merritt Road and Cataract Road, Lands”) having an approximate area of 4.76 ha. The purpose of this OPA application is to seek the removal of the Subject Lands from the study area for the Port Robinson West Subwatershed Study Update and permit a future development application.

In addition to supporting the request for the removal of the Subject Lands from the Port Robinson West Subwatershed Study Update study area, this functional servicing and stormwater management report (FSR) will discuss the availability in the municipal and regional water and wastewater networks to accommodate the development and the options for extending municipal servicing to the Subject Lands. The FSR will provide a high-level overview of the servicing (wastewater, storm and water), and grading strategies interior to the future development. Comment on the stormwater management (SWM) strategy will be made based on the preliminary stormwater management modelling done as part of the pre-engineering phase for the noted property. The strategy will outline how the SWM strategy will comply with the City of Thorold, Region of Niagara, and Niagara Peninsula Conservation Authority (NPCA) guidelines and criteria.

1.1 Site Location and Background

The Cataract Road Property is located on the southwest quadrant of the intersection of Cataract Road and Merritt Road within the City of Thorold and the Region of Niagara. The lands are bound to the north by the unopened Merritt Road right-of-way, Cataract Road to the east, the municipal boundary with the City of Welland to the south and the municipal boundary with the Town of Pelham to the west. Refer to Figure 1 for the Site location.

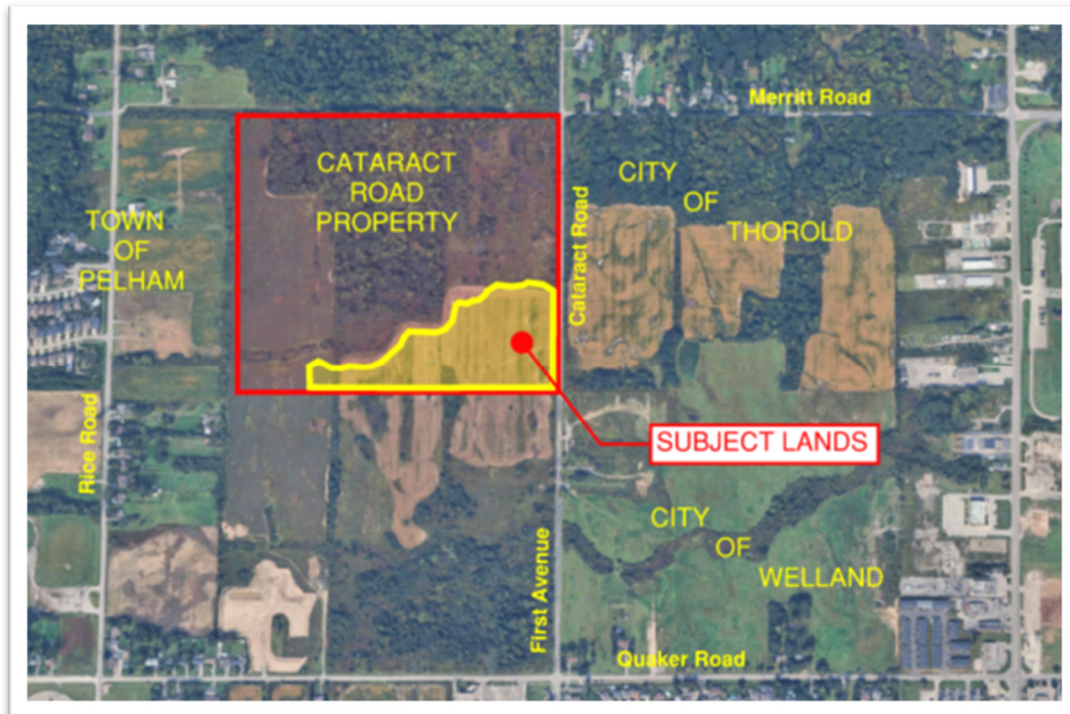


Figure 1: Site Location

Under the current condition, the lands are vacant with an existing wetland located in the northeast corner of the site and the remaining land is used for agricultural purposes. A tributary of the Singers Drain bisects the site from the west to the east, outletting to the wetland.

The Subject Lands, under the consideration of the OPA application, are located in the southwest corner of the Cataract Lands and are bound by the wetland to the north, Cataract Road to the east, the municipal boundary with the City of Welland to the south and the wetland and future channel for a tributary. A natural heritage features has been identified with the Subject Lands; however, no changes are proposed through this application, and they will be further examined through the draft plan of subdivision process.

A portion of the Cataract Road Property, adjacent to Cataract Road is located within Phase 2 of the Port Robinson West Secondary Area (PRWSA). This includes the Subject Lands, located in the southwest quadrant of the property. The Subject Lands are also located within the current City of Thorold Urban Boundary. The area located in the northwest quadrant is also located within the current City of Thorold Urban Boundary but is outside of the Port Robinson West Secondary Plan Area. An excerpt from the City of Thorold Official Plan has been included in Appendix A for reference.

As previously noted, the Subject Lands are included in the study area for the Port Robinson West Subwatershed Study Update which is understood to be undertaken shortly with a schedule of two years to completion. As such, a hold has been placed on the Subject lands as it relates to applications for development.

1.2 Proposed Concept

The proposed development of the Cataract Road Property will include residential lots and multi-unit blocks for a variety of housing products. Blocks have also been established for park lands, environmental areas and buffers, stormwater management facilities, and a block for the realignment of the Singers Drain Tributary currently bisecting the Cataract Road Property as well as a proposed local road network, connecting into existing and future roads. Refer to Appendix B for the development Concept Plan prepared by Urbantypology, dated November 6, 2025.

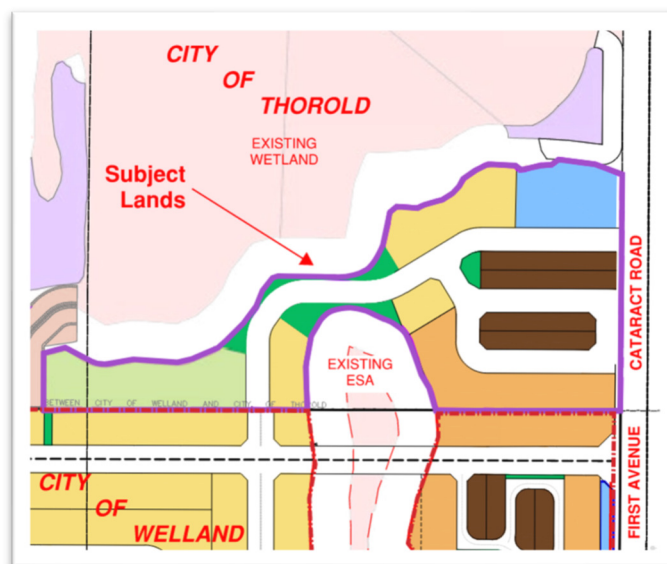


Figure 2: Excerpt of the Concept Plan

As previously noted, the area of focus for this report shall be the approximate 4.2 ha area comprising the Subject Lands located in the southeast corner of the Cataract Road Property. As illustrated on the appended Concept Plan, the development of the Subject Lands includes a mix of blocks for single-family lots and a mix of street townhome product. The concept also includes a park block, six open space blocks, a block for a municipal SWM Facility, a block for the existing environmental area and buffer to the south, and a road network that includes a connection to Cataract Road and a connection to the future residential development to the south, within the City of Welland. Refer to Figure 2 for an excerpt of the Concept Plan highlighting the development of the Subject Lands.

1.3 Reference Reports and Drawings

In the preparation of this FSR, the following reports/drawings were referenced:

1. Primont Welland Thorold Concept Plan; Urbantypology. November 6, 2025
2. Updated Report on Preliminary Geotechnical Investigation, Quaker Road, Welland Ontario (Draft); DS Consultants Ltd., July 22, 2022
3. Geotechnical Investigation and Hydrogeological Considerations, Proposed Residential Development, Quaker Road and First Avenue, Welland Ontario; Soil-Mat Engineers & Consultants Ltd., June 14, 2024
4. Hydrogeologic Study and Wetland Balance, 436 Quaker Road, Welland and Lot 228/Part Lot 174, Thorold, ON; Terra-Dynamics Consulting Inc., June 27, 2024
5. Draft Northwest Welland Stormwater Management Implementation Plan; Upper Canada Consultants, August 22, 2022
6. Stormwater Management Guidelines; Niagara Region, December 2022
7. Water-Wastewater Project Design Manual; Niagara Region, July 2023
8. Stormwater Management Policies & Guidelines; Niagara Peninsula Conservation Authority (NPCA), March 2010
9. Stormwater Management Planning and Design Manual; Ministry of the Environment, Conservation and Parks (MECP), 2003
10. Design Guidelines for Drinking-Water Systems; Ministry of the Environment, Conservation and Parks, 2016
11. Design Guidelines for Sewage Works; Ministry of the Environment, Conservation and Parks, 2016
12. Topo Graphis Survey Information provided by Upper Canada Consultants Ltd., received March 13, 2022

1.4 Review Agencies

City of Thorold

The City of Thorold is the primary authority for land use policy and as such, will be responsible for the review and approval of the Application for an Official Plan Amendment and subsequent development applications related to the Subject Lands.

Based on the 2024 Memorandum of Understanding for Engineering Services, the City of Thorold will be the approval authority for the approval of the design for local municipal infrastructure servicing the proposed development.

Region of Niagara

As of March 31, 2025, The Region of Niagara no longer holds planning authority over the lower tier municipalities. As per the 2015 Memo of Understanding (MOU) between the City and the Region, the Region will provide consultative services in areas of technical expertise, including archaeological resources, the natural environment etc. for complex applications.

The Region of Niagara will continue to have engineering approval authority; regional engineering reviews will be limited to the review of regional infrastructure and capacities available in regional infrastructure.

Niagara Peninsula Conservation Authority (NPCA)

The NPCA will be responsible to regulate development and activities near areas prone to natural hazards, including wetlands, shorelines, and watercourses to manage flooding and erosion. The NPCA will also be the permitting agency for works within the authority's regulated area.

Other Utilities and Authorities Having Jurisdiction

The development will require review by other utility providers for the supply and installation of services including, but not limited to, hydro, gas, and telecommunications (cable and fiber). As such, drawings will be circulated to relevant agencies for their comment during detailed design.

2.0 EXISTING INFORMATION

2.1 Existing Topography and Land Use

Under the current condition, the Cataract Road Lands are vacant with an existing wetland located in the northeast corner of the site and the remaining land is used for agricultural purposes. A tributary of the Singers Drain bisects the southern portion of the site and outlets to the wetland. The existing wetlands have been mapped as Provincial Significant Swamp Wetlands associated with the Niagara Street Cataract Road Woodlot Wetland Complex.

Based on aerial photography, land use within the Subject Lands were mainly agricultural with some open space areas along the north limits. An environmental area has also been identified in the southern portion of the Subject Lands, extending into the City of Welland area at the approximate midpoint of the development block. This area will be further examined in a subsequent Draft Plan application through a detailed EIS Assessment, the finding of which will be incorporated in the ultimate design for this phase of development.

Elevations along the Cataract Road centerline rise from an approximate elevation of 184.25 at the municipal boundary with the City of Welland, to a highpoint of approximately 184.70 m at about 410.0 m south of the intersection with Merrit Road. From the high point the elevation falls to the intersection with Merrit Road at an elevation of 182.05m.

This property itself generally falls from south to north with overland flows directed to the wetland, except for the southeast corner where an existing ridge, coinciding with the highpoint on Cataract Road and the limits of the Subject Lands, with overland flows being directed towards the Towpath Drain located in the City of Welland. Drawing C101, the Existing Conditions Plan, illustrating existing contours and site features has been attached for reference.

2.2 Geotechnical and Hydrogeological Conditions

2.2.1 Geotechnical Conditions

No site-specific geotechnical investigation has been completed at the time of writing, but as part of the preliminary geotechnical investigation for the Cataract Road Lands completed by DS Consultants Ltd. (DSCL) and the geotechnical investigation for the proposed residential development immediately south of the Subject Lands, in the City of Welland, DS Consultants (DSC) and Soil-Mat Engineers and Consultants Ltd. (Soil-Mat) advanced boreholes in and around the Subject Lands. The boreholes advanced by DSC include BH21-3, BH21-4, BH21-5 and BH22-01. Soil-Mat as part of their investigation advanced a single borehole, BH3. The depth and observations for the noted boreholes are summarized in Table 1, water level readings recorded at BH21-3 are summarized in Table 2.

Table 1: Borehole Depths and Observations

Borehole ID	Date	Depth at Termination	Observations
BH21-3	2021.10.27	7.3 mbg	Borehole was recorded as wet below 4.6 mbg; 50-mm-diameter monitoring well installed
BH21-4		6.7 mbg	Borehole was recorded as dry upon completion
BH21-5		6.7 mbg	Borehole was recorded as wet at 6.0 m depth during drilling
BH22-01	2022.03.06	35.6 mbg	Borehole was recorded as wet below 24.4 mbg; 50-mm-diameter monitoring well installed
BH3	2022.12.06	8.2 mbg	Borehole was recorded as open and dry upon completion

mbg – meters below grade

Table 2: Recorded Water Levels at Borehole BH21-3

Date	Water Level
2021.11.11	0.35 mbgl
2022.05.10	0.52 mbgl

mbgl – meters below ground level

Based on the borehole logs provided in the two reports, in-situ soil conditions can be described as a clayey silt and silty clay layer ranging in depths 0.2 m to 0.6 overlain with 200 mm to 350 mm of topsoil. Boreholes BH21-3, BH21-4 and BH21-5 note the top layer of clayey silt as disturbed and reworked, very moist with trace sand and silt seams. Borehole BH21-5 also noted trace organics within the top layer. Borehole BH3 notes occasional gravel within the firm to very stiff silty clay/clayey silt layer.

Logs for boreholes BH21-3, and BH21-4 note this upper clayey silt layer is underlain with a layer of brown silty clay, moist to very moist with trace sand, silt seams, very stiff to firm, transitioning to grey and moist to wet. In the case of BH21-3, the soil composition continues to the borehole termination, while logs for BH21-4 this clayey silt layer has a thickness of 3.7 m. This layer overlays reddish brown, moist compact to dense silt to the termination of the borehole.

Borehole BH21-5 logs records that the top clayey silt layer is underlain with brown moist and compact silt with trace sand and some clay to termination. In the case of BH3, the logs indicate the silty clay/clayey silt layer is underlain by sandy silt/silt to termination.

2.2.2 Hydrologic Investigation

A hydrologic investigation was completed for the Cataract Road Property and 436 Quaker Road in Welland (draft plan approved lands also retained by the applicant) by Terra-Dynamic Consulting Inc. (TDCI). Boreholes were advanced in 2021 and 2022 with the field work completed between May 2022 to November 2023.

The investigation found that the property is located on the Haldimand Clay Plain, a regional thick aquitard of silty clay/clayey silt soils and downgradient of the Fonthill Kame-Delta Complex which is considered a regional groundwater recharge area. Shallow groundwater flow is generally from northwest to southeast across the Site. The high-water table in the spring season of 2023 was generally less than 1 m below natural ground surface while during August 2022 the depth to the water table increased from west to east.

The wetlands are on low permeability silty clay, consisting of surface water depression wetlands and are sustained on precipitation alone. Watercourse monitoring identified intermittent or ephemeral conditions; pre-development monthly water balance modelling reasonably matches wetland water level monitoring supporting the conceptual model of palustrine wetlands (e.g. intermittent or no inflow) supported primarily by precipitation. A monthly water balance for the wetlands identified, on average, potential evapotranspiration as exceeding precipitation for June, July and August, with soil water holding capacities less than saturated also in September and October.

Based on the finding of the investigation, it was concluded that the residential development of the property predicted no negative impacts to the ecological and hydrologic integrity of the watershed. As the wetlands are primarily supplied by precipitation the implementation of buffers as prescribed in the Environmental Impact Study should be sufficient to sustain the wetlands. Additional groundwater recharge mitigation measures are not required. Given the low permeability of the native soil the use of infiltration trenches, soak away pits or pervious pipes would not be feasible.

2.3 Existing Servicing and Utilities

The Subject Lands are currently un-serviced by municipal “wet” services (water, wastewater and storm). Servicing of the Subject Lands has been included in the servicing scheme for the PRWSA and will be serviced via the extension of the existing regional and municipal water and wastewater systems. Refer to Section 3 for a review of potential servicing schemes to provide municipal servicing to the site. Storm and stormwater management servicing will be addressed locally.

Based on a desktop review, it has been concluded that there is no existing plant for the dry utilities (natural gas, hydro, telecommunications, etc.) available to service the Subject Lands. As previously noted, as the planning and engineering process progresses, utility providers will be engaged to ensure service can be made available for the proposed development.

The subject lands are adjacent to a Draft Plan approved subdivision in the Municipality of Welland. “Wet” services and “dry” utilities are planned along First Avenue up to the limits of Welland/Thorold in order to service the development, as such, the extension of these services can be accommodated to support the Thorold development accordingly.

2.4 Source Water Protection

According to the Province of Ontario's *Source Protection Information Atlas*, the Site is located within the Niagara Peninsula Source Protection Area. Table 3 provides the source protection details for the Site which is current as of **December 9, 2025**.

Figure 3 provides the mapping for the subject site as exported from the Source Protection Information Atlas.

Table 3: Source Protection Details

Source Protection Area	Niagara Peninsula
Water Quality	
Wellhead Protection Area	No
Wellhead Protection Area (WHPA-E):	No
Issue Contributing Area:	No
Significant Groundwater Recharge Area:	No
Highly Vulnerable Aquifer:	Yes ; score is 4
Event Based Area:	No
Water Quantity	
Wellhead Protection Area Q1:	No
Wellhead Protection Area Q2:	No
Intake Protection Zone Q:	No

Based on a review of the Niagara Peninsula Source Protection Plan and the 2017-2018 Tables of Drinking Water Threats, the Site is not located within areas where significant drinking water threats can occur.

To ensure that infrastructure proposed as part of this development does not become a significant threat in the future, proposed infrastructure should be designed in accordance with MECP's publication titled Design Guidelines for Sewage Works 2008 (updated May 2019) and the Niagara Region's Water-Wastewater Project Design Manual (July 2023). The design of infrastructure to this standard is done to maximize expected life and reduce the incidence of failure.

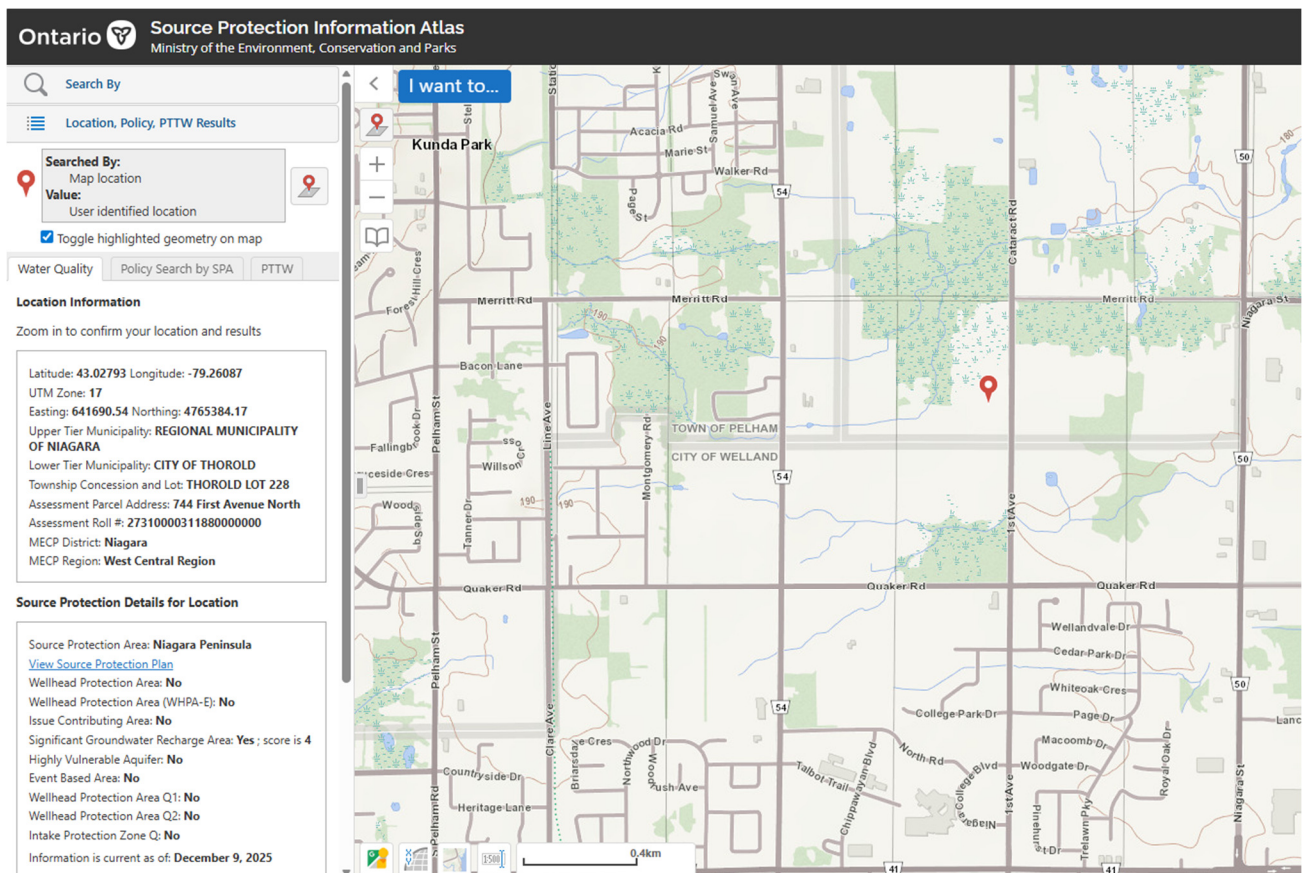


Figure 3 - Source Water Protection Mapping

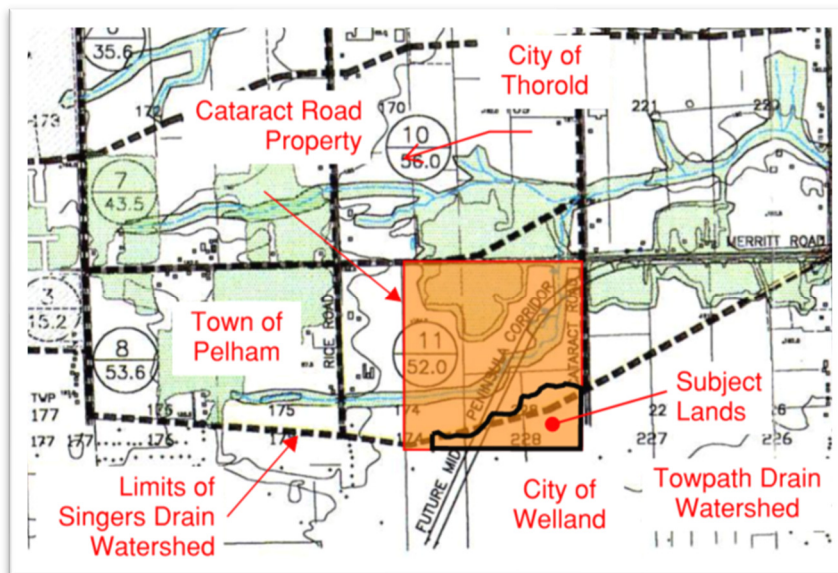
3.0 PORT ROBINSON WEST SUBWATERSHED STUDY UPDATE

As previously noted, the lands are subject to Policies in the City's Official Plan restricting planning applications until the completion of the Port Robinson West Subwatershed Study Update.

As noted in Section 2.1, and Illustrated on Drawing C101, the Subject Lands straddle an existing drainage split. The Pre-Development Storm Drainage Area Plan (Drawing DAP1 found in Appendix G) further details this split with Catchments 101 and 103 having an area of 3.12 ha and 0.60 ha respectively (total area = 3.72 ha), draining south, outletting to the Towpath Drain. Drainage from Catchment Area 102 (1.04 ha) flows north to the existing wetland before discharging to a subsidiary of the Singers Drain.

With the Cataract Road Property having an area of 30.24 ha, the area of the Subject Lands contributing to the Port Robinson West Subwatershed (Catchment 102) is approximately 3.4% of the total property. Further Catchment 102 constitutes less than 0.1% of the 1447.2 ha catchment area of the Port Robinson West Subwatershed. Based on high level preliminary design concepts, it is anticipated that under the proposed condition, the area draining to the existing wetland and subsequently the Singers Drain, will consist of "clean" runoff from rear yards, roof tops, park and open space suitable for recharging wetland water levels. Based on these high-level designs, it is anticipated that the area draining to the Port Robinson West Subwatershed will be reduced under the post-development condition, further reducing the Subject Lands contributions to the Port Robinson West Subwatershed. It should be noted that the existing wetlands provides natural attenuation of runoff peak storm flows entering the wetland.

Based on this review, it is requested that the Subject Lands be excluded from the Port Robinson West Subwatershed Study Update.



**Figure 4 – Excerpt of Singers Drain Watershed Mapping
(Taken from the Port Robinson West Subwatershed Study)**

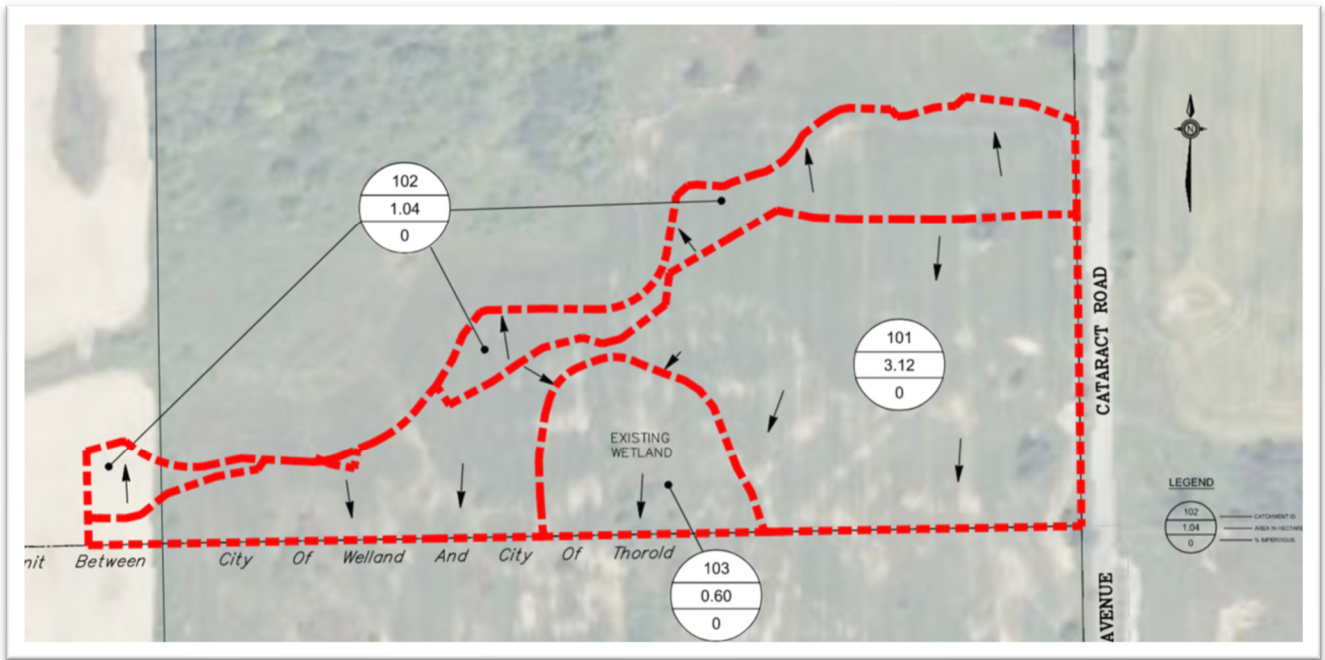


Figure 5 - Pre-Development Drainage Areas

4.0 PROPOSED SERVICING STRATEGY

4.1 Proposed Wastewater Servicing

4.1.1 Extension of External Servicing to the Subject Lands

As previously noted, there are no Regional or municipal wastewater sewers located within the vicinity of the Subject Lands. A review of the PRWSP servicing strategy found the Subject Lands would need to be serviced via a municipal wastewater sewer conveying flows north on Cataract Road to the intersection with Merrit Road where it would connect to a future regional trunk sewer (approximately 500 m). Under the current strategy, this trunk sewer would be extended from the existing 675-mm-diameter terminus located at the intersection of Hansler Road and Secord Street, approximately 2.6 kilometers east of the Subject Lands. This regional trunk would extend from the terminus, north on Hansler Road to Merrit Road, then continue west, extending all the way to the municipal boundary with the Town of Pelham. Flows in the existing trunk are conveyed to the Towpath Pump Station (WWPS), located east of the Subject Lands, where it is understood that this extension would be a development charge (DC) funded project. Refer to Appendix D for wastewater sewer layouts.

As discussed at the meeting on January 14th, 2026 with City of Thorold, City of Welland and Region of Niagara staff, review of the proposed PRWSP master servicing plan noted a few concerns regarding the servicing scheme as it related to the development of the Subject Lands, including:

- **Timing of the Construction and Anticipated Commissioning of the Regional trunk and Municipal Wastewater Sewers.**

The Subject Lands are located within the current municipal boundary and are appropriately zoned. Based on the discussion with municipal and regional staff, it is understood that the design of the regional trunk sewer has been initiated. Post-construction of the Regional trunk sewer, a local municipal sewer on Cataract Road would need to be designed, constructed and put into operation. It is understood that the Region and the City of Thorold have been collecting Development Charges to fund the proposed

works, but final construction costs are not available. As such, these projects are not anticipated within the foreseeable future, development of the Subject Lands would remain on hold.

- **Efficiency of the Current Layout of the Regional Trunk Extension.**

As noted to Regional and Municipal staff, there is very little developable area immediately fronting the proposed route of the regional trunk sewer. While direct service connections to the trunk are not permitted, the current route of the trunk sewer would require additional municipal sewers to extend service to the developable areas.

- **Lifetime Costs of the Infrastructure.**

As previously noted, the current layout for the regional trunk sewer will result in additional infrastructure that is not efficient. It is understood the Region of Niagara is facing significant deficits in funding required for necessary upgrades and maintenance of existing infrastructure. As such, a review of potential alternative servicing methods to increase the system efficiency is warranted.

Given these impacts to the developability of the Subject Lands, an alternative method to provide wastewater servicing to the Subject Lands was developed. This alternative servicing scheme calls for the extension of the future municipal wastewater sewer from the currently proposed terminus on First Avenue, north 40 m to a manhole located adjacent to the municipal boundary with the City of Welland. The wastewater sewer would then continue north on First Avenue from the manhole to the limits required to service the Subject Lands as well as a portion of the lands to the east of First Avenue, approximately 100 m. Flows in this sewer would be conveyed to the Region's trunk sewer on Quaker Road, and ultimately to the Towpath WWPS. The manhole at the municipal boundary would be fitted with flow monitoring equipment for the calculation of usage charges between the City of Thorold and the City of Welland. Refer to Appendix D for the proposed wastewater network layout.

Analysis of the alternative servicing scheme included a review of available capacity within the Quaker Road trunk sewer. This analysis confirmed that the Quaker Road has sufficient capacity for current and projected flows from the Subject Lands, as well as the estimated flows from the development of approximately 17.0 ha located on the east side of Cataract Road while operating within the criteria of the Region of Niagara. Refer to Appendix D for the wastewater sewer design calculations and drainage area plans.

Contrasting the alternative servicing scheme with the PRWSP servicing strategy, the noted benefit of the alternative offers the following benefits:

- **Timing of the Construction and Commissioning of the First Avenue/Cataract Road Municipal Wastewater Sewer.**

The alternative servicing scheme places the timing of the construction and commissioning of the wastewater sewer at the developer's discretion allowing for the acceleration of the development of the serviceable lands, including the Subject Lands. It is understood that the Region and the City of Thorold have been collecting Development Charges to fund the extension of the wastewater network to service the Port Robinson West Secondary Plan area, but given the reduced cost of the alternate servicing scheme, additional options of financing the proposed expansion are viable, such as the front ending of the costs by the developer(s) in exchange for Development Charge credits. This permits the works to potentially be driven by the developer allowing for the development and subsequent housing to be available on a reduced timeline.

- **Efficiency of the Alternate Layout of the Municipal Wastewater Sewer on First Avenue/Cataract Road.**

As summarized above, the alternate servicing scheme greatly reduces the length of required sewers and provides capacity for not only the Subject Lands, but lands to the east of Cataract Road. This efficiency in design reduces construction costs and municipal infrastructure as well as life cycle maintenance costs. It also affords the Region of Niagara to investigate a more efficient layout to service the remaining Port Robinson West Secondary Plan lands. Refer to Appendix F for construction cost estimates for the two servicing schemes.

- **Defraying of Construction Costs from the Region of Niagara**

The alternate servicing scheme greatly reduces the length of required sewers and provides capacity for not only the Subject Lands, but lands to the east of Cataract Road. This efficiency in design reduces construction costs reduces municipal infrastructure as well as life cycle maintenance costs to be borne by the lower tier municipalities.

- **Limited impact on Regional Infrastructure**

While flows from the proposed alternate servicing strategy will now longer be conveyed to the Region's future Merrit Road wastewater trunk sewer, the flows will remain within the Towpath WWPS sewershed and should not impact the planned upgrades to the facility.

Unlike the PRWSP servicing strategy, the proposed alternative servicing scheme would require a cross-boundary servicing agreement between the City of Thorold and the City of Welland. Based on discussions during the meeting with the City of Thorold, City of Welland and Regional of Niagara staff, there are similar agreements in place between the two lower tier municipalities that can be used as a framework for this future agreement. Preliminary discussions with the City of Welland regarding the extension of servicing to the Subject Lands through Welland have been favourable.

4.1.2 Wastewater Servicing of the Subject Lands

As previously noted, the intent of this FSR is to support the OPA application to have the Subject Lands removed from the study area of the Port Robinson West Subwatershed Study Update. As such, this report provides a brief overview of the wastewater servicing strategy for the proposed concept for the Subject Lands. Further detail will be provided in support of future development applications.

Wastewater generated by the proposed development will be conveyed to the service connection on Cataract Road via a network of wastewater sewers within the future road network. The sewer will be designed to operate within the criteria of the City of Thorold, and the Region of Niagara and will meet the requirements of the criteria set forth in the City of Thorold engineering guidelines.

4.2 Proposed Domestic and Fire Water Servicing

4.2.1 Extension of External Servicing to the Subject Lands

Like the wastewater servicing scheme, under the PRWSP servicing strategy water servicing to the Subject Lands will be via a proposed regional trunk main within the Merrit Road right-of-way. This trunk watermain connect to the regional water network at the existing terminus located at the intersection of Hansler Road and Second Street, approximately 2.6 kilometers east of the Subject Lands. The proposed watermain would continue north from the terminus on Hasler Road to Merrit Road, continuing west on Merrit Road to the municipal boundary with the Town of Pelham. A municipal distribution main would then extend on Cataract Road to the connection point for the Subject Lands, an approximate length of 500 m. Refer to Figure 5 for the proposed watermain layout.

The PRWSP servicing plan for the water presents similar concerns when it comes to the servicing of the Subject Lands with municipal water, including:

- **Timing of the Construction and Anticipated Commissioning of the Regional Trunk and Municipal Watermain.**
As previously noted, the Subject Lands are located within the current municipal boundary and are appropriately designated. Based on the discussion with municipal and regional staff, it is understood that the design of the trunk watermain has been initiated. Post-construction of the Regional watermain trunk, a local distribution watermain on Cataract Road would need to be designed, constructed and put into operation. It is understood that the Region and the City of Thorold have been collecting Development Charges to fund the proposed works, but final construction costs are not available. As such, these projects are not anticipated within in the foreseeable future, development of the Subject Lands would remain on hold.
- **Efficiency of the Current Layout of the Regional Trunk Extension.**
As noted to regional and municipal staff, there is very little developable area immediately fronting the Merrit Road. While direct service connections to a Regional watermain are not permitted, the current scheme for the region's watermain, additional lengths of municipal distribution watermain would be required to provide domestic and fire water servicing to the developable areas with in the PRWSP area.
- **Lifetime Costs of the Infrastructure.**
As previously noted, the current layout for the required municipal and regional water distribution system will result in additional infrastructure that is not entirely efficient. It is understood the Region of Niagara is facing significant deficits in the funds required for necessary upgrades and maintenance of existing infrastructure. As such, a review of potential alternative servicing methods to increase the system efficiency is warranted.

In order to permit the development of the Subject Lands ahead of the construction and commissioning of the infrastructure proposed under the PRWSP servicing plan, an alternative strategy is required to provide domestic and fire water servicing to the lands. This alternative servicing scheme calls for the extension of the future municipal water main from the currently proposed terminus on First Avenue, north 40 m to a meter chamber located adjacent to the municipal boundary with the City of Welland, the watermain would then be continue north on First Avenue from the meter chamber to the limits required to service the Subject Lands as well as a portion of the lands to the east of First Avenue, an approximate length of 100 m. The meter chamber at the municipal boundary would be house the metering infrastructure for the calculation of water usage charges between the City of Thorold and the City of Welland. Refer to Figure 6 for the proposed water network layout.

As part of the development process detailed water modelling will be required to ensure the Subject Lands can be adequately service the fire and domestic water demand generated by the development.

The primary benefits of the alternate servicing scheme are as follows;

- **Timing of the Construction and Commissioning of the First Avenue/Cataract Road Municipal Watermain.**
The alternative servicing scheme places the timing of the construction and commissioning of the watermain at the developer's discretion allowing for the acceleration of the development of the serviceable lands, including the Subject Lands. It is understood that the Region and the City of Thorold have been collecting Development Charges to fund the extension of the watermain network to service the Port Robinson West Secondary Plan area, but given the reduced cost of the alternate servicing scheme, additional options of financing the proposed expansion are viable, such as the front ending of the costs by the developer(s) in exchange for Development Charge credits. . This permits the works to potentially be driven by the developer allowing for the development and subsequent housing to be available on a reduced timeline.

- **Efficiency of the Alternative Layout of the Municipal Water Network.**

As summarized above, the alternate servicing scheme greatly reduces the length of required regional and municipal watermains. This efficiency in design reduces construction costs, municipal infrastructure as well as life cycle maintenance costs. It also affords the Region of Niagara to investigate more efficient layout to service the remaining Port Robinson Secondary Plan lands. Refer to Appendix F for construction cost estimates for the two servicing schemes. This efficiency in design reduces construction costs, municipal infrastructure as well as life cycle maintenance costs to be borne by the lower tier municipalities. Preliminary discussions with the City of Welland regarding the extension of servicing to the Subject Lands through Welland have been favourable

As previously noted, further modelling of the proposed watermain network by the City of Welland will be required to confirm the system can adequately meet the domestic and fire demands of the development and if additional looping or connections are required. Refer to Appendix E for the calculated fire and domestic water demands generated by the proposed development.

4.2.2 Water Servicing of the Subject Lands

As the intent of this FSR is to support the OPA application to have the Subject Lands removed from the study area of the Port Robinson West Subwatershed Study Update, this report provides a brief overview of the water servicing strategy for the proposed concept for the Subject Lands. Further detail will be provided in support of future development applications.

Water demands generated by the proposed development will be serviced via a watermain network located within the future road network. At a minimum, the network will be connected to the municipal network at a connection to the future watermain on Cataract Road. The system will be designed to operate within the criteria of the City of Thorold, and the Region of Niagara and meet will meet the requirements of the criteria set forth in the City of Thorold engineering guidelines. As previously noted, additional modelling will be required to establish the size of the proposed watermains as well as the need for additional connections/looping to meet the City's operating criteria.

4.3 Stormwater Management (SWM) and Storm Servicing of the Subject Lands

4.3.1 Major and Minor Storm Systems

As this FSR aims to support the OPA application to remove the Subject Lands from the Port Robinson West Subwatershed Study Update area, a summary of the major and minor storm systems for the proposed concept is provided. Further details will accompany future development applications.

As illustrated on the proposed Concept Plan, a SWM Facility Block has been proposed to provide quality and quantity control for the proposed development. A minor system will be designed to collect runoff from minor events via a network catchbasins, manholes and adequately sized sewers and convey these flows to the proposed SWM Facility.

Major flows resulting from runoff of larger events shall be conveyed overland via the proposed road network to the SWM Facility for quantity control purposes. The rights-of-way of the proposed road network will be designed to ensure these flows are contained within the right-of-way limits and not impact private properties.

4.3.2 Stormwater Management (SWM) Design

In accordance with the City of Thorold, Region of Niagara and NPCA guidelines and the Ministry of Environment's Stormwater Management Planning and Design Manual, an effective SWM design must address the following:

- Water Quantity Control to attenuate post development peak flows to pre-development levels.
- Provide a "Level 1" or "Enhanced" level of protection (i.e. 80% long-term suspended solids removal) as defined in the MOE' Manual as per the Stormwater Management Plan for the Welland Northwest Area Secondary Plan.
- Water Balance to ensure that post-development infiltration rates equal or exceed pre-development levels.

4.3.3 Existing Conditions

Under pre-development conditions, the Subject Lands are predominantly in an undeveloped state with surface runoff from the southern portion of the lands draining by sheet flow to the existing Towpath Drain and wetland within the City of Welland. The remaining lands drain to the existing wetland with drainage ultimately conveyed to the northeast and the Singers Drain. The pre-development conditions were modelled with the SWMHYMO hydrologic modelling program development J.F. Sabourin & Associates. The modelling utilized the City of Thorold 2-year to 100-year storm Chicago Storm IDF for a 4-hour duration. A 25 mm, 4-hour duration event was also used for water quality modelling. Pre-development drainage boundaries were established for the proposed SWMF based on the existing topographic survey provided by Upper Canada Consultants Inc. To be consistent with Upper Canada Consultants' draft Implementation report, a Curve Number (CN) of 74 was adopted for the modelling along with an initial abstraction of 8.924 mm. Both are representative of the silty-clay Hydrologic Soil Group C/D found throughout the site. Drawing DAP101 found in Appendix G depicts the drainage boundaries.

4.3.4 Preliminary SWM Modelling and Target Flow Rates

Hydrologic modeling was prepared to determine pre-development flow rates from the subject lands. The current 4.16 ha site is comprised of agricultural (crop) fields and open space. A tributary of the Singers Drain bisects the subject lands with the northern portion draining north to a tributary of the Singers Drain and the southern portion draining to the Towpath Drain. All drainage is via overland flow.

Pre-development catchment areas and approximate impervious level are summarized in Table 4.

Table 4: Pre-Development Catchment Areas

Catchment ID	Description	Outlet	Area (ha)	Impervious (%)
101	Existing agricultural / open space	Overland to Towpath Drain	3.12	0
102	Existing agricultural / open space	Overland to Singers Drain	1.04	0
Total			4.16	0

Based on SWMHYMO modeling for the 2- to 100-yr storm events, pre-development peak flows for each of the outlet locations as well as the total pre-development discharge is shown in Table 5. These flows will be used to compare with the post-development results.

4.3.5 Quality and Quantity Control

The proposed Concept Plan includes a Stormwater Management Facility (SWMF) Block to provide quality and quantity control for the proposed development to meet the requirement of the City of Thorold and NPCA. The proposed facility will outlet to the Towpath Drain via a storm sewer within the Cataract Road/First Avenue right-of-way, the design will also take into consideration the City of Welland's SWM criteria.

Table 5: Pre-Development Peak Flows (m³/s) From Subject Lands to Outlet Locations

Storm Event	Catchment 101 (South to Towpath Drain)	Catchment 102 (North to Singers Drain)	Total (101 + 102)
2-Yr	0.044	0.019	0.060
5-Yr	0.063	0.028	0.087
10-Yr	0.080	0.036	0.111
25-Yr	0.109	0.049	0.151
50-Yr	0.135	0.060	0.187
100-Yr	0.160	0.072	0.222

As described in Section 4.4 of this report, runoff collected in the major and minor storm systems will be conveyed to the SWMF for quantity and quantity control. Based on preliminary modelling and the MECP guidelines and the size of the Subject Lands, it is anticipated that the proposed SWMF will consist of an MECP dry pond facility to provide post-to-pre-development quantity control and quality control (Basic, 60% TSS removal). An oil-grit separator unit will be installed upstream of the dry pond to provide a water quality treatment train that will achieve an Enhanced (80% TSS removal) level of water quality protection for all flows collected in the minor system.

Section 3.0 of this report notes that areas draining to the existing wetland, including wetland-adjacent rear-yard and roof areas. Landscaped portions of the proposed park block and the proposed open space blocks contiguous with the wetland will remain uncontrolled. The runoff from these areas is considered “clean runoff,” not requiring quality control prior to discharge. As illustrated in Figure ??, under the post development conditions, the area discharging to the wetland has been reduced and as such, quality control of these flows is not warranted.

4.3.6 Stormwater Management Facility Design

The Dry Pond SWM facility will be designed in accordance with guidelines established by the MECP and NPCA. The SWMF will have a maximum depth of 1.8 m from bottom to spillover weir or 2.1 m from bottom to top of the pond. All side slopes are 5:1. A maintenance access to the bottom of the facility will be provided.

The facility will be designed with a compound outlet structure consisting of two (2) orifice controls – a low flow orifice to control the more frequent and the water quality event, and a second orifice to provide quantity control for the less frequent storm events. The SWM Facility will outlet to a future storm sewer on Cataract Road, conveying flows to First Avenue, and continuing south, outletting to the channelized Towpath Drain. Emergency spillover will be directed to the adjacent natural areas.

4.3.7 Water Balance

The Stormwater Management Plan for the Welland Northwest Area Secondary Plan identifies that ground water recharge rates under the post development condition shall meet or exceed the pre-condition rates. As the development process proceeds and further geotechnical and hydrogeological studies are complete these targets will be established. It is anticipated that these targets will be achieved through the use of LIDS and infiltration galleries developed through the future detailed design.

5.0 SITE GRADING

Proposed grading will conform to the slope requirements outlined under the Accessibility for Ontarians with Disabilities Act (AODA) and will be designed in accordance with City of Thorold and Niagara Region engineering standards. The grading strategy will respect existing grades along all property boundaries and is intended to:

- minimize grading and cut/fill requirements
- minimize changes to existing surface hydrology and hydrogeology
- match existing elevations at the limits of development
- provide clearly defined major overland flow routes toward municipal stormwater conveyance features while maintaining existing drainage patterns
- maintain sheet flow conditions where feasible to reduce concentrated discharge points
- Vegetation clearing should avoid sensitive periods for wildlife (e.g., breeding seasons in spring and summer) unless appropriate mitigation measures are implemented or a qualified biologist confirms that habitat is inactive

Excavations will be completed in accordance with the Occupational Health and Safety Act (OHSA) and recommendations provided within the Geotechnical Investigation. Compliance with O. Reg. 406/19 – On Site and Excess Soil Management will be required for excavation, handling, and off-site transport of excess soils. A Qualified Person (QP), as defined by the regulation, should be retained to provide site specific guidance on excess soil characterization, tracking, and disposal.

Stockpiles and equipment will be managed to prevent wildlife attraction or access. Loose materials (fill, brush, peat, rock, etc.) should be covered when possible, and open pipe ends should be capped to prevent wildlife entry. Trails, bins, storage areas, and vacant structures must be secured at the end of each workday. Stockpiles will also follow erosion and sediment control measures outlined in the appropriate ESC section of the report.

6.0 EROSION AND SEDIMENT CONTROL

Sediment and erosion controls to be implemented during construction will include stabilized construction entrances and a perimeter silt fence. Prior to the start of any construction, all erosion and sediment control measures installed will be inspected by the Consultant. The controls will be maintained, and accumulated sediments removed once their capture capacity has been decreased by one-third. The measures will also be periodically inspected and upgraded/alterd as Site conditions change. Periodic inspections will consist of visual observation of the effectiveness of the control measures and sediment migration offsite.

Any sediment tracked onto the roadway during the course of construction will be cleaned by the Contractor. To minimize the amount of mud tracked onto the roadway, a mud-mat will be installed at all construction exits and the Contractor will be required to ensure that vehicles leave through the exit. The mud-mat will be periodically inspected and cleaned/sewered as required to ensure it is functioning as intended.

To prevent sediment runoff from the Site, light-duty silt fencing (in accordance with OPSD 219.110) will be installed along the perimeter of the Site and at the base of all stockpiles. Stockpiles are to be visually monitored after rainfall events and will be hydraulically seeded if the stockpiles are to remain undisturbed for extended periods of time.

The outlets from the Site will be inspected for evidence of sediment migration offsite. In the event that sediments have migrated offsite, additional sediment controls shall be implemented as necessary to ensure that no additional sediment escapes from the Site. Any excessive sediment that has migrated offsite shall be removed and the area restored to pre-construction conditions.

As the servicing phase of the construction proceeds, each inlet structure will have an insert installed and/or filter fabric will be wrapped around the lids of all manholes to prevent intrusion of sediment into the storm sewer network. The inserts will be cleaned once they reach one-third their sediment accumulation capacity or as per the manufacturer's recommendations.

The Contractor is ultimately responsible for controlling sediment & erosion within the construction site for the duration of construction. Sediment laden water will not be allowed to be discharged to the conveyance features of this site. Additional erosion and sediment control materials (such as silt fence, straw bales, clear stone etc.) are to be kept on site for emergencies and repairs.

Additionally, the following shall be considered:

- Limit the size of disturbed areas by minimizing non-essential clearing and grading with retention of existing vegetation for as long as possible
- Refueling of machinery should occur >30m from surface water features and all machinery shall remain on the project side of silt and construction fence
- Storing/stockpiling materials >30m away from surface water features
- Developing a response plan to be implemented immediately in the event of a spill of a deleterious substance
- Keeping an emergency spill kit on the site
- Stopping work and containing deleterious substances to prevent dispersal; and
- Reporting any spills of sewage, oil, fuel, or other deleterious material immediately

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis presented in this report it is concluded that:

- The Subject Lands are appropriately identified for residential development under the City of Thorold Official plan and is located within the City's urban boundary
- Based on the finding of the hydrologic investigation, the residential development of the property predicted no negative impacts to the ecological and hydrologic integrity of the watershed
- The wetlands are primarily supplied by precipitation, as such the implementation of buffers as prescribed in the Environmental Impact Study should be sufficient to sustain the wetlands
- Additional groundwater recharge mitigation measures are not required and given the low permeability of the native soil the use of infiltration trenches, soak away pits or pervious pipes would not be feasible
- Review of the existing topographic information collected for the Subject Lands confirms that the drainage from the Subject Lands is split over two catchments. Catchment 102, with an area of 1.04 ha as identified on Drawing DAP101, outlets to the wetland to the north with the wetland providing attenuation of peak flows before being discharged to a tributary of the Singers Drain (Part of the Port Robinson West Subwatershed) while runoff from Catchment 101 and 102 with an total area of 3.72 ha flows overland to the south, outletting to the Towpath Drain located in the City of Welland

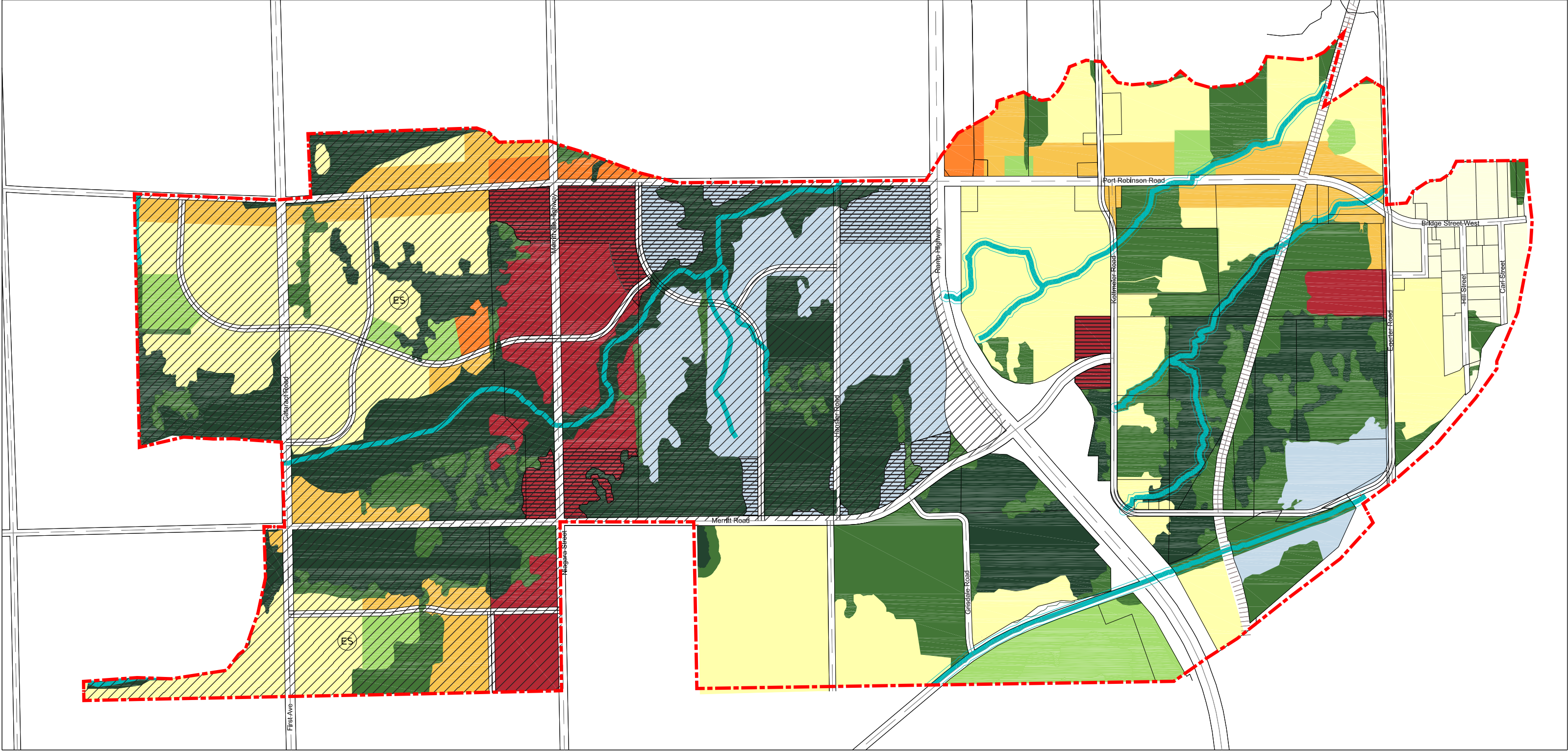
- The portion of the Subject Lands draining to the Port Robinson West Subwatershed (Catchment 102) constitutes a small fraction (less than 0.1%) of the overall 1447.2 ha subwatershed under the existing condition. Based on conceptual design it is anticipated that this area would be further reduced.
- The runoff directed to the wetlands will be “clean” consisting of run off from roofs, rear yards, open space and park lands and is suitable for discharge to the wetland.
- Feasible, economical, and efficient solutions exist to provide water and wastewater servicing to the Subject Lands and neighbouring properties outside the Port Robinson West servicing plan.
- Stormwater management measures can be provided in accordance with various agency guidelines for the post-development condition.

Further, it is recommended that:

- This report be circulated to the City of Thorold in support of the Official Plan Amendment Application.
- This report be circulated to the Agencies Having Jurisdiction for Review, including the City of Welland.
- That discussion between the Owner, Consultant Team, City of Thorold, City of Welland and the Region of Niagara regarding alternate servicing options continue.

APPENDIX A

Planning Schedule and Maps

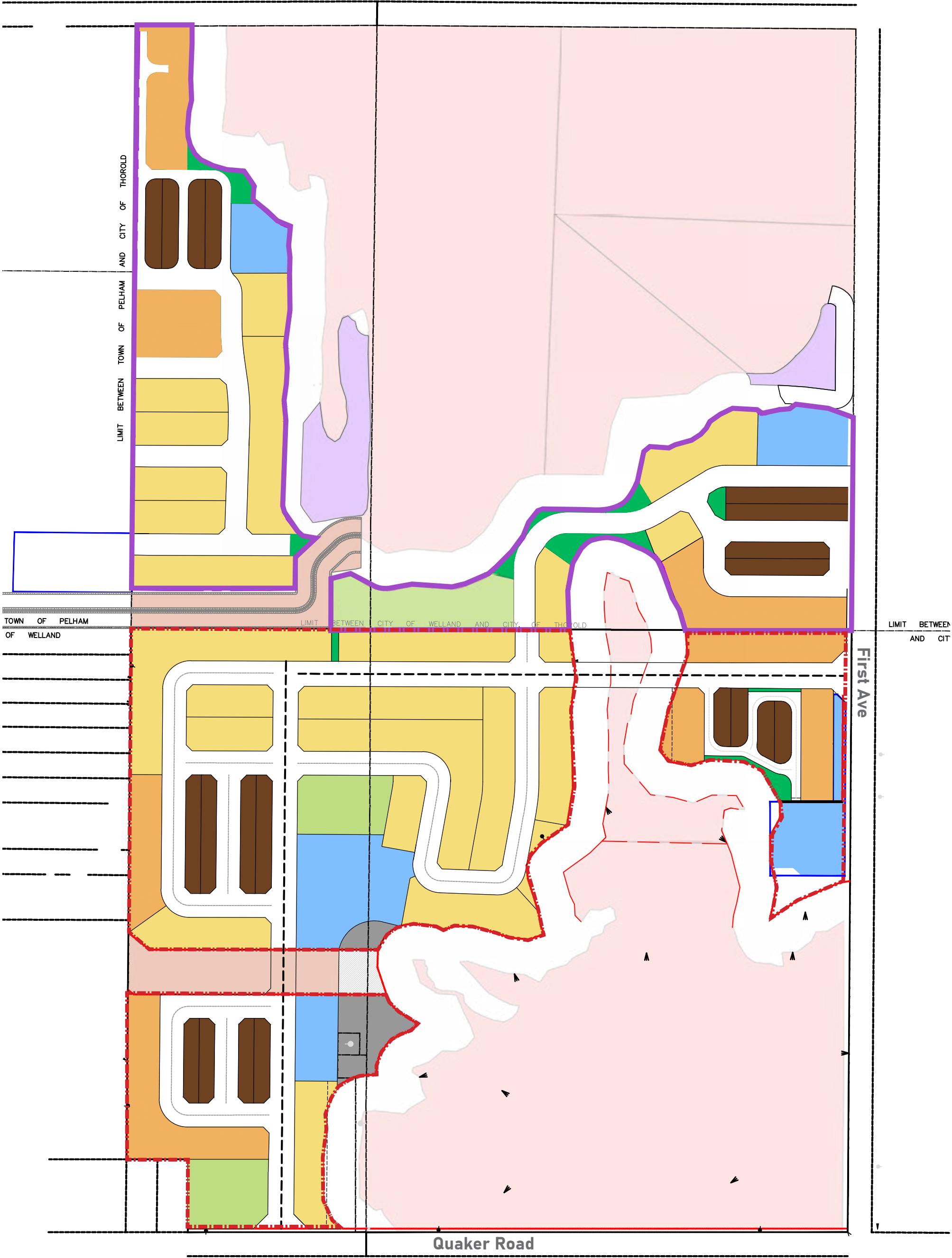


- | | | | |
|--|-------------------------------------|---|---|
|  | PRW Existing Residential |  | Environmental Protection One |
|  | PRW Low Density Residential |  | Environmental Protection Two |
|  | PRW Medium Density Residential |  | PRW Open Space |
|  | PRW Medium/High Density Residential |  | Elementary School |
|  | PRW Mixed Use Commercial |  | Watercourse |
|  | PRW Urban Commercial |  | Urban Area Boundary |
|  | PRW Business Park |  | Phase 2- Final Land Uses Subject to Future Subwatershed Study |
|  | PRW Industrial | | (as per Section B.1.10.1.2.10 (d)) |

Schedule A6- PRW Land Use Plan

APPENDIX B

Proposed Concept for the Cataract Road Lands



- | | | |
|--|--|--|
|  Single Detached |  Park |  Environment Area Buffer |
|  Front Drive Townhome |  SWM Pond |  Buffer (3m) |
|  Back-to-Back Townhome |  Previous SWM Pond Boundary |  Thorold - Developable Boundary |
|  Open Space |  Environment Area |  Welland - Developable Boundary |

APPENDIX C

Geotechnical Investigations



Terra-Dynamics Consulting Inc.

432 Niagara Street, Unit 2 St. Catharines, ON L2M 4W3

June 27, 2024

Primont (Thorold/Welland) Inc.
c/o Ian G. MacPherson, P. Eng.
Vice President, Land Development
9130 Leslie Street, Suite 301
Richmond Hill, Ontario L4B 0B9

Re: Hydrogeologic Study and Wetland Water Balance, 436 Quaker Road, Welland,
and Lot 228/Part Lot 174, Thorold, ON

Dear Mr. MacPherson,

1.0 Introduction and Background Information

Terra-Dynamics Consulting Inc. respectfully submits this DRAFT Hydrogeologic Study and Wetland Water Balance of 436 Quaker Road Welland, and Lot 228/Part Lot 174, Thorold (the Site, Figure 1, see attachments). The rectangular 60.8 hectare Site is located at the northwest corner of Quaker Road and First Avenue, within both the City of Welland (southern part of Site) and south of an unopened Merritt Road allowance within the City of Thorold (northern part of Site) (Figures 1 and 2, see attachments). This report has been completed as part of planning for future residential development of the currently agricultural lands. No tile-drainage is mapped for the Site (OMAFRA, 2023).

The Ministry of Natural Resources and Forestry (MNRF) have mapped at the Site approximately 17 hectares of Provincially Significant Wetland (PSW) associated with the Niagara Street Cataract Road Woodlot Wetland Complex (MNRF, 2009), this includes (Figure 2, see attachments):

1. 5.2 hectares of swamp along Quaker Road and First Avenue in the southeast corner of the Site,
2. 8.2 hectares of swamp in the northern portion of the Site, and
3. 3.6 hectares of marsh in the northeast corner of the Site close to Cataract Road.

A Wetland Water Balance was completed to:

1. Ensure no negative impacts to the natural heritage system; and
2. Inform future stormwater management design at the Site in such a manner that pre-development wetland water balance conditions are maintained.

The wetland water balance assessment evaluated the pre-development hydrologic regime of the Provincially Significant Wetland areas on-site associated with the Niagara Street Cataract Road Woodlot Wetland Complex (MNRF, 2009) as well as additional wetland vegetation mapped by GEI Consultants (2022).

2.0 Methodology

Primary tasks completed as part of the Hydrogeology Study and Wetland Water Balance included:

- A. Submission of a Water Balance Terms of Reference (Appendix A) to the Niagara Peninsula Conservation Authority (NPCA) and Niagara Region for review and comment. NPCA indicated they were satisfied (Appendix A) with the submission of an Updated Water Balance Terms of Reference reflecting a response to initial NPCA comments on the proposed Terms of Reference, however, as of the date of this report, no response was received from Niagara Region.
- B. Initial characterization of the physical setting was completed using published information from the following government agencies: (i) the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), (ii) the Ministry of Natural Resources and Forestry (MNRF), (iii) the Ministry of the Environment, Conservation and Parks (MECP), (iv) the Niagara Peninsula Conservation Authority (NPCA), and (v) the Ontario Geological Survey (OGS);
- C. Field investigations to refine site conditions have included:
 - (i) 2021 and 2022 geotechnical borehole investigations including laboratory soil grain-size analyses;
 - (ii) Construction of thirteen groundwater monitoring wells between 2021 and 2022;
 - (iii) Installation of eighteen wetland staff gauges deployed with water level dataloggers monitoring from July 2022 to November 2023, as well as wetland soil hand-augering;
 - (iv) Seasonal manual groundwater level measurements at 13 locations from May 2022 to November 2023, and water level dataloggers deployed at four monitoring wells from May 2022 to November 2023;
 - (v) Hydraulic testing of groundwater monitoring wells at 11 selected locations; and
 - (vi) Tow Path Drain surface water level monitoring at four locations from August to November 2023.
- D. Modelling of pre-development monthly water balance conditions through consideration of: surface water catchments, land cover, soils, climate normals and wetland hydroperiods in order to inform future site design.

3.0 Physical Setting

According to historical aerial photos, most of the Site was cleared for farming in 1934. Aerial photos indicate that areas of the north-central and southeast portions of the Site had gradually become re-vegetated by 2000, similar to the extent of the vegetation in 2016 (Niagara Navigator, 2023).

The Site is flat-lying with ground surface at approximately 185 metres above sea level (m ASL) along the western boundary sloping to both the northeast at 182 m ASL and the southwest at 181 m ASL, (Figure 2, see attachments), with little to no slope, being less than 1% slope on average.

The Site is regionally located on the Haldimand Clay Plain (Chapman and Putnam, 1984) described in the NPCA Port Robinson Subwatershed Study (part of the Site is within that study area, Figure 1, see attachments), as a physical feature that “...prevents significant infiltration to depth...” (NPCA, 1999). However, the upgradient Fonthill Kame-Delta Complex also plays a role in the hydrology of the Site as it

“is a thick deposit consisting mainly of permeable sand and gravel which provides a significant groundwater flow system within the surrounding clay plain” (Blackport et al, 2005). This is discussed in Section 3.5 and visualized in Figure 3.

3.1 Surface Water

3.1.1 Watershed and Catchments

Overall drainage of the Site is split approximately between two subwatersheds (Figure 1, see attachments): (i) Port Robinson West (NPCA, 1999) - northern part of the Site and, (ii) the Tow Path Drain Subwatershed Catchment – southern part of the Site. The drainage divide between these two subwatersheds roughly parallels the municipal boundary between the City of Thorold to the north and the City of Welland to the south (Figure 2, see attachments). The Port Robinson West, and Tow Path Drain Subwatersheds, are 1,409 ha and 503 ha in size, respectively, consequently the Site is 2% of the Port Robinson Subwatershed (~29 ha), and 6% of the Tow Path Drain Subwatershed (~32 ha).

On-site surface water drainage can be further refined into four pre-development catchments (Figure 4): (i) Singer’s Drain West; (ii) Singer’s Drain East, (iii) Tow Path Drain North; and (iv) Tow Path Drain South.

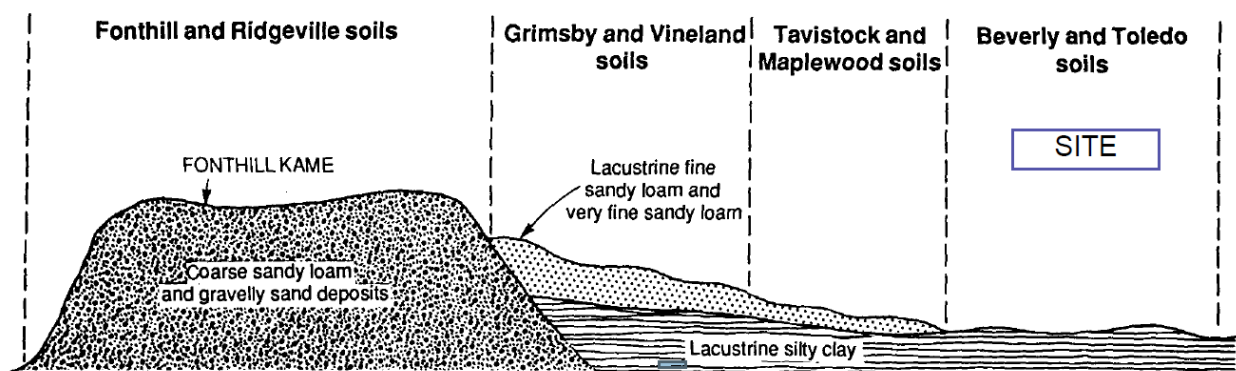


Figure 3 – Schematic landscape cross-section showing the relationship of soils on the Fonthill Kame-Delta Complex and its southern slopes (Kingston and Presant, 1989)

3.1.2 Watercourses

Within the northern part of the Site, i.e. flowing to Singer’s Drain, are two watercourses that begin off-site to the west of Rice Road (Figure 2, see attachments), and meet within the Provincially Significant Wetland (PSW) north of the Site, and eventually outlet north of the Site at Cataract Road. NPCA (2017) have previously mapped the northern watercourse as ephemeral and the southern watercourse as intermittent or ephemeral (Figure 2, see attachments). No baseflow was identified for these two watercourses at Rice Road during 2003 surface water monitoring completed as part of the Fonthill Kame-Delta Complex study (Blackport et al, 2005).

Within the southern part of the Site, i.e. flowing to Tow Path Drain, are also two watercourses, that meet within the PSW on-site, and flow roughly west to east from Rice Road and Quaker Road, outletting at First Avenue (Figure 2, see attachments). NPCA (2017) have previously mapped these two

watercourses as ephemeral, potentially becoming intermittent close to 1st Avenue. No baseflow was identified at upstream Rice Road during 2003 and 2004 surface water monitoring completed as part of the Fonthill Kame-Delta Complex study (Blackport et al, 2005). Investigations in 2018 by Aquafor Beech (2019) also identified dry conditions upstream of the Site (at the more southern watercourse) and intermittent conditions at 1st Avenue. These results correspond with more recent reporting for this portion of the Tow Path Drain that:

“throughout the length of the drain no signs of groundwater inputs were noted and flows in the drain are entirely dependent on precipitation surface water inputs within its catchment...the drain supports ephemeral flows with minimal flows during the spring freshet and ending by May...the drain flows through... a shallow 1-1.5 m wide straight dug channel/ditch with a shallow U shaped channel morphology...does not provide permanent fish habitat” (Beacon Environmental, 2022).

A series of four surface water staff gauges (SG-101, SG-102, SG-103 and SG-104) were installed on-site along Tow Path Drain in August 2023 (Figure 2, see attachments and Appendix F) and equipped with water level datalogger pressure transducers recording at 15-minutes intervals. The surface water monitoring was completed in addition to the original Terms of Reference (Appendix A). Clayey soils were observed beneath Tow Path Drain during the installation of the gauges via hand-augering completed to between 0.7-0.8 metres below ground surface. During the monitoring period (i.e. mid-August to mid-November 2023) August monthly precipitation was well-above average, while September, October and November monthly precipitation were well-below average (Table 1, see attachments). Water level monitoring of Tow Path Drain indicated surface water is only present intermittently as shown by dry conditions following precipitation events (Appendix F). Nearby groundwater levels were below ground surface during this monitoring period (BH21-13 and BH21-14) further confirming no groundwater discharge to surface water and an intermittent surface water classification consistent with other’s investigations. Water levels at the nearby wetlands were observed to rise following precipitation events (Appendix C). After precipitation events, the water levels at nearby wetlands responded one of two ways:

- (i) Where generally water depths were 10 cm or less, diurnal evapotranspiration water level fluctuations and dry/intermittent conditions after rain events (SW-2, SW-3, SW-4, SW-5 and SW-9); or
- (ii) Where water depths were greater than 10 cm, diurnal transpiration fluctuations overlaid on a gradual decline, similar to predicted evaporation rates (Schroeter & Associates, 2007) (SW-6 and SW-8).

Wetlands near the Tow Path Drain are primarily sustained by precipitation (Sections 3.6.2 and 4.2), not sustained by backflow retained in the Tow Path Drain, as shown in September 2023 when limited standing water was still present at wetland gauges (i.e. SW-3, SW-4, SW-5, SW-6, SW-8 and SW-9, Appendix E) while dry conditions were observed downgradient at SG-102 and SG-103 (Appendix F).

Surface water flows were measured to decrease downstream on August 10, 2023 (Table 2). This indicated a losing reach and this is presumed to be as a result of infiltration of surface water and/or water uptake of adjacent vegetation.

Table 2 - 2023 Tow Path Drain Surface Water Flow Measurements (L/s)

Date/Station	SG-101	SG-102	SG-103	SG-104
August 10	No flow	2.3	2.2	1.8
September 6	Dry	Dry	Dry	Dry
October 3	Dry	Dry	Dry	Dry
October 23	Dry	No flow*	Dry	No flow*
November 20	No flow*	No flow*	No flow*	0.6

Note: * - water present but not flowing

Staff gauge SG-102 was removed by wildlife or vandalism in November 2023.

3.2 Soils

The Site soils are mapped as silty clays: (i) Toledo – Loamy Phase, and (ii) Beverly – Loamy Phase, with (iii) a small portion of Berrien soils (Figure 4, see attachments), details include (Kingston and Present, 1989):

- i. Toledo Loamy Phase: silty clay texture (Table 3), (38% of site, 23.1 ha in northern part of Site and 2.26 ha in the southern part of the Site), poorly drained, slowly permeable, water levels stay near the surface much of the year, relatively high water-holding capacity and moderate to high surface runoff (HSG D, Table 4). The Singer's Drain PSW is perched on these low permeability soils.
- ii. Beverly Loamy Phase: silty clay texture (Table 3), (50% of site, 30.3 ha in central to southern part of Site), imperfectly drained, moderately to slowly permeable, water occupies the surface horizons for a period of time each year and is prolonged where subsoil has been overcompacted by heavy machinery, water-holding capacity ranges from medium to high, and surface runoff is moderate to high, (HSG C, Table 4).
- iii. Berrien: 40 to 100 cm sandy sediments over silty clay (Table 3), (6% of Site, 3.9 ha in southeast corner of Site), imperfectly drained, rapidly permeable but water perches because of underlying clayey soils, and slow surface runoff (HSG C, Table 4). However sandy sediments were not encountered during hand-augering in this area in 2023.
- iv. 6% of the Site's soils are not mapped (NM, Figure 4, see attachments) but are likely partially Toledo loamy phase and partially Beverly loamy phase, as silty clay/clayey silt/silt was recorded at boreholes within (i.e. BH21-3 and BH22-01) or immediately adjacent (e.g. BH21-16 and BH22-03) these areas (Section 3.3, Appendix B).

The Tow Path Drain PSW is mostly underlain by Berrien and Beverly loamy phase (soils >90%, i.e. HSG C) with <10% Toledo loamy phase (HSG D).

Table 3 – Horizon C Grain-size Analyses Summary¹

Soil Name/Location	Sand%	Silt%	Clay%	Texture ²
Beverly – Loamy Phase	7	49	44	Silty Clay
Toledo – Loamy Red Phase	9	50	41	
Berrien	8	46	46	

Note: ¹ - Kingston and Presant, 1989, ² - Texture as per Fetter (1994)

Table 4 - Hydrologic Soil Groups (USDA, 1986)

HSG Group	Soil description
A	sand, loamy sand or sandy loam
B	silt loam or loam
C	sandy clay loam
D	clay loam, silty clay loam, sandy clay, silty clay or clay

3.3 Surficial Geology

The Ontario Geological Survey (OGS) have mapped the Site as being covered by a layer of low permeability soils (clayey silt to silty clay) (Feenstra, 1984). This general characterization was confirmed by two geotechnical investigations of the Site (DS Consultants, 2022 and Soil-Mat Engineers and Consultants, 2023). These geotechnical investigations involved sixteen boreholes in 2021 and another sixteen boreholes in 2022 (Figure 2, see attachments). The boreholes are summarized on two geologic cross-sections (Figures 5 and 6, see attachments) which show the Site as underlain by silty clay to clayey silt, with some limited seams of fine sand to silt. It is noted that 0.5 m of silty sand was noted at surface at three locations in the northwest part of the Site (BH21-1, BH21-2 and BH21-12) overlying the clayey silt to silty clay aquitard and is shown on the north-south section (Figure 5, see attachments). The at-surface silty clay to clayey silt that covers most of the Site is often underlain by a sandy silt to silt at 5-6 metres below ground surface (m BGS). Most of the geotechnical boreholes were completed to between 7 and 8 m BGS. Four deep boreholes were also completed (i.e. 20 to 36 m BGS) without encountering bedrock but confirming that the underlying soils consist of silty clay, silt/sandy silt and clayey silt till. The thickness of the overburden ranges between 45 to 40 m, across the Site from west to east, respectively (NPSPA, 2013).

3.4 Bedrock

The Site is underlain by two bedrock formations, (i) Lockport Formation dolostone – northwest part of the Site, and (ii) Guelph Formation dolostone – the southeast part of the Site (NPSPA, 2013).

3.5 Hydrogeologic Setting

The Site is located on the Haldimand Clay plain which is a regional aquitard (Gartner Lee Limited, 1987). This aquitard consists of the Upper Whittlesey, Halton, Lower Whittlesey and Wentworth Aquitards (Burt, 2016). An aquitard is “a low-permeability geologic unit that can store groundwater, but that transmits groundwater slowly” (Niagara Peninsula Source Protection Authority, 2013). Upgradient of the Site is the Fonthill Kame-Delta Complex (Figure 7, schematic below) which is a regional groundwater recharge area (NPCA and AquaResource Inc., 2010).

The Port Robinson Subwatershed Study (NPCA, 1999) previously described the hydrostratigraphy as follows (the numbered bullets below correspond with the numbers on schematic Figure 7 as modified from NPCA, 1999):

1. The upper end of the subwatershed consists of permeably (sandy) deposits which often extend to bedrock;
2. The eastern part of the subwatershed is relatively flat, and is predominantly underlain by aquitard (clay) materials, with sandy pockets;
3. A thin, sand aquifer unit may separate the aquitard (Unit 2) from bedrock. This unit may be hydraulically connected to the sand deposits to the west;
4. The subwatershed is underlain by dolostone bedrock;
5. Precipitation falling within the western half of the subwatershed, could (a) runoff, (b) recharge radially from the topographic height, to the deeper aquifer units, such as bedrock, or the lower sand, or (c) discharge to surface in the vicinity of the clay contact, providing baseflow to area tributaries; and
6. The majority of precipitation falling within the eastern half of the subwatershed, will become runoff, however the limited precipitation that does infiltrate is expected to discharge to local tributaries.

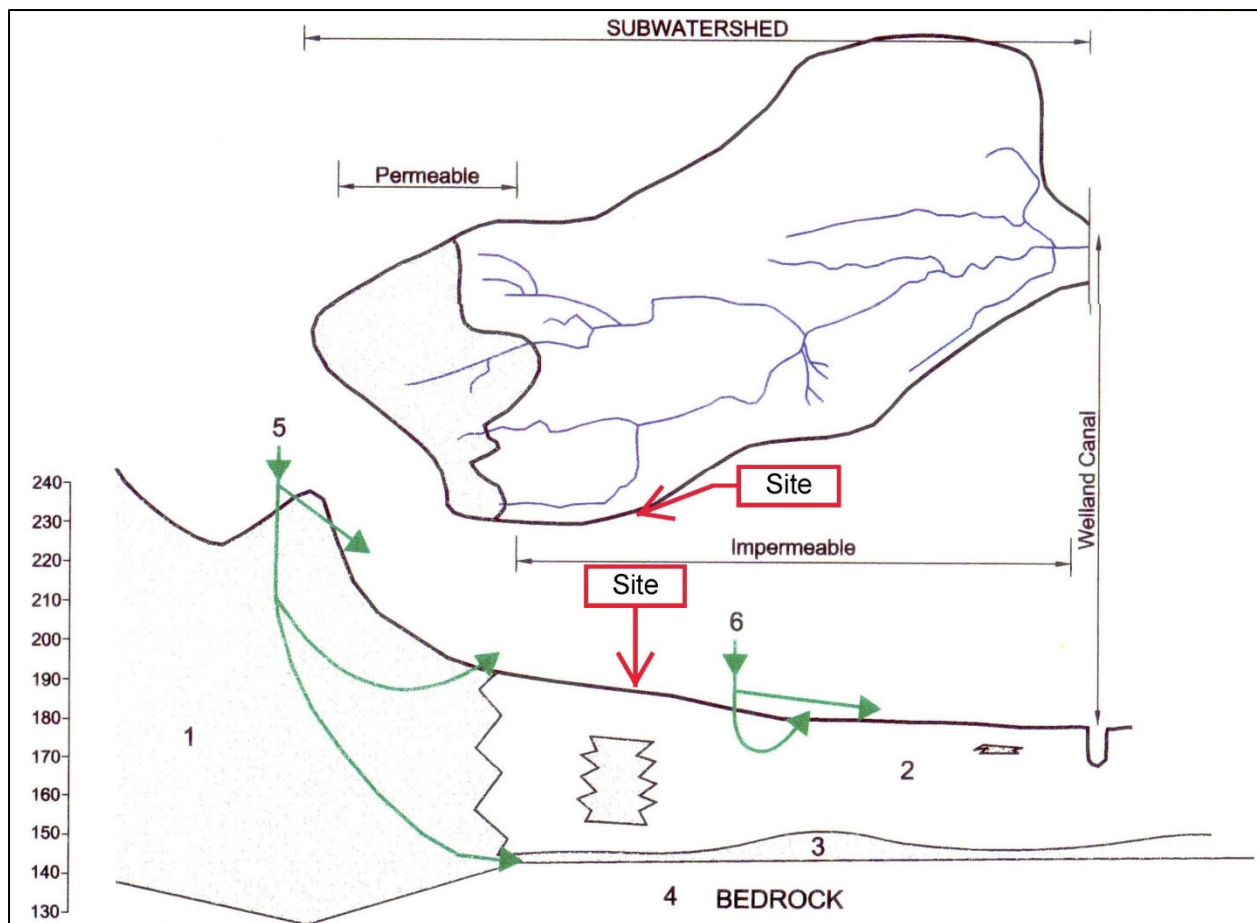


Figure 7 - Conceptual Hydrostratigraphy (modified after NPCA, 1999, section numbers are explained in Section 3.5)

3.5.1 Overburden Aquitard

The hydraulic conductivity of the regional Haldimand Clay Plain overburden aquitard is reported as 7×10^{-7} m/s, or less (GLL, 1987). Hydraulic conductivity testing at the Site generally confirmed similar or lower hydraulic conductivities with an average value of 3×10^{-9} m/s, with two minor exceptions in the northeast portion of the Site (i.e. BH21-1 and BH21-6) that had slightly higher values which is inferred at these locations to be as a result of fine sand or silt seams.

Two methods were used to determine on-site hydraulic conductivities:

- (i) Laboratory grain size analyses and the Excel-tool HydrogeoSieveXL (Devlin, 2015); and
- (ii) Hydraulic conductivity of select monitoring wells previously constructed on-site as part of the geotechnical investigations (Figure 2, see attachments).

These results are presented in Table 5 (below) and the analyses are provided in Appendix C.

Table 5 – Hydraulic Conductivity Analyses

Geologic Unit(s)	Location	Hydraulic Conductivity (m/s)	Depth (m BGS)	Analysis Method
Poorly sorted clay with fines	BH22-2	1x10 ⁻⁹	5	Devlin (2015)
	BH22-1	4x10 ⁻⁸	5	
	BH22-3	1x10 ⁻⁹	5	
	BH21-2	6x10 ⁻⁹	3	
	BH21-3	1x10 ⁻⁹	3	
	BH21-6	3x10 ⁻⁹	3	
	BH21-8	3x10 ⁻¹⁰	3	
	BH21-9	5x10 ⁻¹⁰	3	
	BH21-11	1x10 ⁻⁹	3	
	BH21-13	3x10 ⁻¹⁰	3	
	BH21-14	5x10 ⁻¹⁰	3	
	BH21-16	1x10 ⁻⁹	3	
Silty Clay with fine sand seams or Silt with some sand	BH21-1	5x10 ⁻⁷	4.1-6.1	Bouwer and Rice (1989)
	BH21-2	4x10 ⁻⁹	3.1-6.1	
	BH21-6	3x10 ⁻⁷		
Silty Clay	BH21-3	3x10 ⁻⁹	3.1-6.1	
	BH21-11	1x10 ⁻⁹		
	BH21-13	4x10 ⁻⁹		
	BH21-14	1x10 ⁻⁸		
	BH21-16	4x10 ⁻¹⁰		
	BH22-02	4x10 ⁻⁸		
	BH22-03	2x10 ⁻⁹		
MW-11	8x10 ⁻⁹			
Geometric Mean		3x10 ⁻⁹		

Note: BGS - Below ground surface

The infiltration rates of the on-site soils are calculated as less than 15 mm/hour according to the relationship between soil hydraulic conductivity (Appendix C) and infiltration rate as provided by Credit Valley Conservation (2012). Consequently, the native soils are considered unsuitable for infiltration trenches, soakaway pits and pervious pipes (MECP, 2003).

3.5.2 Overburden Groundwater Flow

The regional groundwater table was previously modelled as towards the Site from the Fonthill Kame-Delta Complex groundwater recharge area (Blackport & Associates, and Waterloo Hydrogeologic Inc., 2005). Groundwater flow in the water table is generally from northwest to southeast as shown on Figure 8 (see attachments) for November 2022. The horizontal gradient in November 2022 was low at approximately 0.005 to 0.008 m/m.

3.5.3 Overburden Groundwater Levels

Manual groundwater level measurements were collected seasonally at thirteen monitoring wells (Figure 2, see attachments, DS Consultants, 2022). The monitoring wells are generally screened in silty clay between 3.1 to 6.1 m BGS (Appendix B). Manual groundwater level measurements (Table 6, see attachments) were collected in spring, summer and fall of 2022 and 2023. Water level dataloggers were deployed collecting measurements every 15-minutes at four monitoring wells MW21-01, MW21-03, M21-13 and MW21-14.

The 'spring-high' groundwater levels were measured very close to surface in April, 2023 as generally less than 1 m BGS (Figure 9, see attachments). In August, 2022, the depth to groundwater increased across the Site from west to east from ~1 m BGS to 2.5 m BGS despite '*Abnormally dry to moderate*' drought climate conditions reported by Agriculture Canada (2023) for August 2022.

The greatest seasonal groundwater level variations were noted for the downgradient monitoring locations, while less seasonal variation was noted for the upgradient western locations (Figures 10, 11 and 12, see attachments). Dampened seasonal variation for the upgradient western locations is inferred to be as a result of horizontal groundwater recharge from the Fonthill Kame-Delta Complex Recharge Area to the Site. Observations from the groundwater levels include:

1. Upgradient western groundwater levels showed similar limited seasonal variation between spring season highs and summer season lows of 0.5 to 0.8 m (i.e. MW21-1, MW21-2, MW21-6 and MW21-11).
2. Downgradient eastern groundwater levels showed similar greater seasonal variation between spring season highs and fall season lows of 1.1 to 2.7 m (i.e. MW21-3, MW21-8, MW21-9, MW21-13 and MW21-4).

Observations from the water level dataloggers in the four groundwater monitoring wells include (Appendix D):

- i. Monitor MW21-01 (west/upgradient): The groundwater level in the monitoring well was consistently above ground surface, at above 184.3 m ASL except during the summer and early fall seasons, however, there were not ponded conditions at surface. With only about 0.5 m of seasonal

change from spring to August 2022, it is believed the fine sand seams noted on the borehole log receive lateral recharge from the Fonthill Kame-Delta Complex as limited drawdown only occurred during the summer growing season.

- ii. Monitor MW21-13 (located mid-site): The groundwater level showed a distinct seasonal decline of about 2.5 m from the spring season to October 2022, with groundwater level recovery beginning in the fall season of 2022, with some responsiveness to precipitation noted.
- iii. Monitor MW21-03 (located downgradient/east): A seasonal decline of groundwater levels of about 1 m from spring to October 2022, with groundwater level recovery beginning in the season of fall 2022 with limited responsiveness to precipitation events.
- iv. Monitor MW21-14 (located in the southwest): A seasonal decline of groundwater levels of about 1.5 m from the spring season to August/October 2022, with groundwater level recovery completed before winter 2023, and was very responsive to precipitation events.

Monitoring wells BH21-16 and BH22-03 were decommissioned by a licensed Ontario water well contractor in May 2023 in order to accommodate activities on-site.

3.5.3 Bedrock Aquifer

The confined dolostone bedrock aquifer underlying the Site is the primary local supply for private wells that may be located west, north or east of the Site as Niagara Region has mapped the Welland portion of the Site and south as part of the municipally serviced area. Regional groundwater flow modelling completed for NPCA of the Fonthill Kame-Delta Complex (Blackport et al, 2005) maps the bedrock potentiometric surface as flowing from the west towards the Site. Additional regional contouring of the potentiometric surface of the bedrock aquifer (and other water wells completed greater than 15 metres below ground surface) map it as west (176 m ASL) to east (175.5 m ASL) across the Site, with a groundwater divide to the north (175 m ASL) and south (174.5 m ASL) similar to the surface water divides (WHI, 2005). This suggests a downwards vertical gradient at the Site between the overburden water table and the bedrock aquifer.

3.6 Wetlands

The Site includes 17 ha of the Provincially Significant Niagara Street Cataract Road Woodlot Wetland Complex (MNRF, 2009), mapped to cover 27% of the Site (Figure 2, see attachments). The MNRF have described that the *“dominant wetland type ... (is) swamp, situated through a slough forest ecosystem. A slough forest ecosystem is characteristic of the Haldimand and Niagara Clay plain physiographic regions and consists of shallow to deep depressions...”* (MNRF, 2009). It is noted an area of marsh was also mapped by the MNRF in the northeast corner of the Site. General information regarding the Provincially Significant Wetlands mapped by the MNRF at the Site are summarized in Table 7. For example, the wetlands have been mapped as Palustrine wetlands, based upon having intermittent or no inflow, and either permanent or intermittent outflow and may rely on rainfall and some overland flow (MNRF, 2014).

Table 7 – Provincially Significant Wetland Information (MNRF, 2009)

Area	Size (ha)	Type	Dominant Vegetation	Wetland Hydrology	Soils
North Swamp Singers Drain	7.84	Swamp	Red maple	Palustrine	Clay/Loam
North Marsh Singers Drain	3.62	Marsh	Broadleaf cattail	Palustrine	Clay/Loam
South Toe Path Drain	5.21	Swamp	Rice cut grass	Palustrine	Clay/Loam

Additional wetland vegetation at the Site has been mapped by GEI Consultants (2022) and is summarized in Section 3.6.1 with respect to their Ecological Land Classifications and shown on Figure 13 (see attachments). It is our understanding the wetland extents were staked in June 28, 2021 with the Niagara Peninsula Conservation Authority (NPCA) and Niagara Region.

3.6.1 Wetland Ecological Land Classification (ELC) Mapping

The Wetland Ecological Land Classifications (ELCs) from GEI Consultants (2022) are summarized below in Table 8 with the associated wetland monitoring staff gauges listed and shown on Figure 13 (see attachments). However, it is our understanding that the wetlands monitored by staff gauges SW-1, SW-2, SW-13 and SW-14 are not being kept as part of the development plan.

Table 8 – Wetland Ecological Land Classifications (ELCs)

ELC	Description	Hydrologic Sensitivity*	Staff Gauges
MAS2-1	Cattail Mineral Shallow Marsh	Medium	SW-1, SW-13, SW-14, SW-15
SWT2-9	Grey Dogwood Mineral Thicket Swamp	Low**	SW-2, SW-17
SWD3-3/ CUW1/ SWT2-8/ CUT1-1	Swamp Maple Mineral Deciduous Swamp/ Mineral Cultural Woodland/ Silky Dogwood Mineral Thicket Swamp/ Sumac Cultural Thicket	Medium	SW-3, SW-7
SWT2-8/ MAM2-10	Silky Dogwood Mineral Thicket Swamp/ Forb Mineral Meadow Marsh	Medium/ Low	SW-16
SWT2-8/ MAS2-1	Silky Dogwood Mineral Thicket Swamp/ Cattail Mineral Shallow Marsh	Medium	SW-4, SW-5, SW-6, SW-8, SW-9,
MAM2-10/ MAS2-11	Forb Mineral Meadow Marsh/Dry and European Reed Shallow Marsh	Low**	SW-10, SW- 11, SW-12
SWD3-2	Silver Maple Mineral Deciduous Swamp	Medium	SW-18

Notes: * - Wetland Sensitivity from TRCA (2017), ** - ELC not listed in TRCA (2017) and assigned based upon previous investigations in the Niagara Peninsula and/or correspondence with GEI

3.6.2 Wetland Water Level/Hydroperiod Monitoring

A hydroperiod is defined as “the seasonal pattern of the water level of a wetland...It characterizes each type of wetland, and the constancy of its pattern from year to year ensures a reasonable stability for that wetland. It defines the rise and fall of a wetland’s surface and subsurface water by integrating all of the inflows and outflows” (Mitsch and Gosselink, 2007).

Eighteen wetland water level staff gauges were installed by Terra-Dynamics between May 10 and 24, 2022 to monitor wetland hydroperiods at locations chosen by GEI Ecological Staff (Figure 13, see attachments, Appendix E Location Photos). During installation of the staff gauges, silty clay soils were confirmed to be between 0.4 and 0.5 m BGS by hand-augering at each of the eighteen locations.

Manual water level measurements began at all locations in the spring season of 2022 on May 24, with some locations also monitored earlier on May 10, 2022 (Table 9, see attachments). Water level data loggers were deployed at each staff gauge beginning July 21, 2022 to measure water levels at 15-minute intervals, and the water level plots are located in Appendix E. The staff gauges for wetland water level monitoring were constructed with well-points that allowed measurement of both surface water levels and shallow water levels to 0.1 m below ground surface.

Surface water was present at each monitored wetland staff gauge on May 10, 2022 with three locations becoming dry by May 24, 2022 (SW-2, SW-5 and SW-16) (Table 9, see attachments), following three months of below average precipitation (Table 1, see attachments). The wetland hydrographs from July 2022 to November 2023 using the water level datalogger information are presented in Appendix E. The primary influence of precipitation in supplying water to the wetlands is supported in comparison of the water levels to the monthly wetland water balance modelling (Section 4.2).

The observed wetland hydrographs at the Site were fairly similar in overall patterns over the July 2022 to November 2023 monitoring period (Appendix E). These perched surface water level patterns are summarized below:

- a) Summer 2022: Dry during Summer 2022,
- b) Fall 2022: Surface water levels recovered in Fall 2022,
- c) Winter 2022-2023: Surface water levels maintained
- d) Spring 2023: Surface water levels declined to dry
- e) Summer 2023: Mostly wet conditions attributed to above-average July/August precipitation (Table 1, see attachments).
- f) Fall 2023: Surface water level decline and recovery. It is noted that as of the November 20, 2023 datalogger download, recovery was not yet noted at SW-5, SW-9 or SW-10.

Mitsch and Gosselink (2007) report that the *“hydroperiods of many bottomland hardwood forests and swamps have distinct periods of surface flooding in the winter and early spring due to snow and ice conditions followed by spring floods but otherwise have a water table that can be a meter or more below the surface”* (Figure 14), this characterization appears reasonable for the wetlands at the Site.

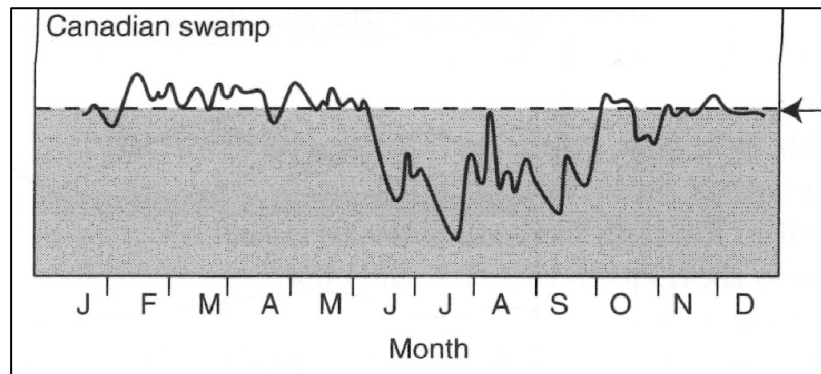


Figure 14 – Canadian Swamp Hydroperiod (Mitsch and Gosselink, 2007)

Note: arrow indicates wetland ground surface

3.6.3 Wetland Characterization

The wetlands are proposed classified as a *surface water depression wetlands* (Figure 15) (Mitsch and Gosselink, 2007).

A surface water depression wetland is summarized as a: “*wetland...dominated by surface runoff and precipitation, with little groundwater outflow due to a layer of low-permeability soils...*”. Low permeability silty clay soils have been noted beneath the wetlands as per this description.

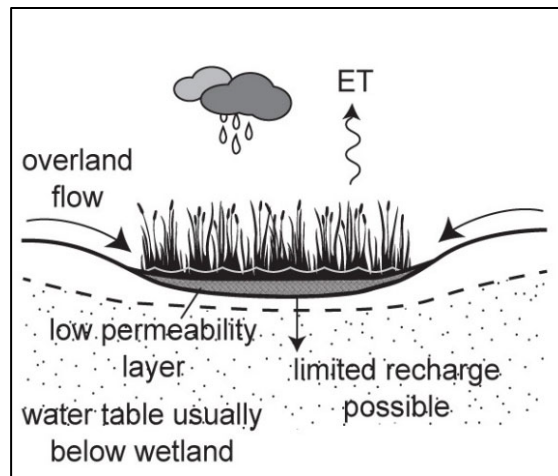


Figure 15 - Surface water depression wetland (Mitsch and Gosselink, 2007)

3.6.3 Soil Water Holding Capacity

The wetlands are primarily underlain by Hydrologic Soil Group (HSG) C soils with the northern wetlands underlain by HSG D or a combination of C/D soils (Section 3.2). The wetlands underlain by HSG C are assigned a soil water holding capacity (SWHC) of 400 mm, where underlain by HSG D 350 mm, and where underlain by HSG C/D 375 mm. These SWHC values are based upon previous swamp wetland values used by NPCA in their water budgeting study (AquaResource Inc. and NPCA, 2009).

3.6.4 Wetland Surface Water Catchments

As described in Section 3.1.1, and shown on Figure 4, the Site can be subdivided into four catchments: (i) Singer's Drain West, (ii) Singer's Drain East, (iii) Tow Path Drain North and (iv) Tow Path Drain South.

Smaller catchments were not modelled as the wetland water level monitoring (Section 3.6.2) and wetland modelling (Section 4.2) support precipitation as the primary source of water sustaining the wetlands.

3.7 Pre-development Subwatershed Water Balance Modelling

NPCA previously completed pre-development water balance modelling for 1991-2005, as part of provincial water budgeting for the source water protection program (AquaResource Inc. and NPCA, 2009). This modelling was completed at 1-hour time steps with a filled-in meteorological dataset including solar radiation and a crop coefficient for improved calculation of evapotranspiration. The modelling used lumped parameter catchments incorporating data such as soils, land cover and slope.

The Site is located within two NPCA modelled catchments: (i) Beaversdam Shriners Creek Welland Canal North W320 (BDSC_WCN_W320) and (ii) Central Welland River Tow Path Drain W100 (CWR_TPD_W100) (Figure 1, see attachments). It was determined that the modelled results for Catchment BDSC_WCN_W320 best suit the Site for application with respect to pre-development water balance conditions (i.e. slope, soils, land cover and evapotranspiration).

Modelled annual and monthly water balance results were obtained for Catchment BDSC_WCN_W320 (Tables 10 and 11, respectively, without decimal places) (AquaResource Inc. and NPCA, 2009). The annual surplus as shown on Table 10 is precipitation minus evapotranspiration, i.e. the water available for runoff and recharge.

Table 10 - Water Balance 15-year (1991-2005) Averages

Catchment	Precipitation	Actual Evapotranspiration	Annual Surplus	Infiltration*	Recharge	Runoff
	(mm/year)					
BDSC_WCN_W310	968	650	318	76	38	242
CWR_TPD_W100	968	469	499	97	49	401

Notes: * - Infiltration is interflow plus recharge

Table 11 - Monthly Runoff and Infiltration (Catchment BDSC_WCN_W310)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Runoff (mm)	38	27	54	45	17	9	3	3	4	3	18	20
Infiltration (mm)	13	12	23	16	5	1	0	0	0	0	3	7

4.0 Wetland Water Balance Assessment

A monthly wetland water balance assessment has been completed for the Site's wetlands, as informed by the Conservation Authority Guidelines for Development Applications (Conservation Ontario, 2013) and TRCA's guidance for water balances (2012).

It is noted that the MECP (2003) water balance approach is typically concerned with the evaluation of post-development to prevent (i) increased runoff, and/or (ii) reduction in groundwater recharge. However, given the current wetland characterization, any on-site water surplus contribution to hydrologic function with respect to the wetlands is via additional surface water flow, not groundwater discharge. Consequently, the purpose of the pre-development on-site water balance assessment modelling is to evaluate if runoff maintains monthly saturated conditions at the wetlands.

4.1 Monthly Water Balance Example

An example of water balance modelling from the University of Waterloo is shown below (Figure 16). Annual groundwater recharge begins in the fall following 'soil water utilization' and 'deficit' in the summer. Soil water utilization corresponds with evapotranspiration exceeding the precipitation supply. Annual groundwater recharge occurs during the same time period that groundwater levels rise. However, in this example it is noted that the soil water holding capacity (SWHC) modelled was only 100 mm compared to the higher SWHC 350 to 400 mm for the on-site wetlands (Section 3.6.3) which retain a greater amount of water.

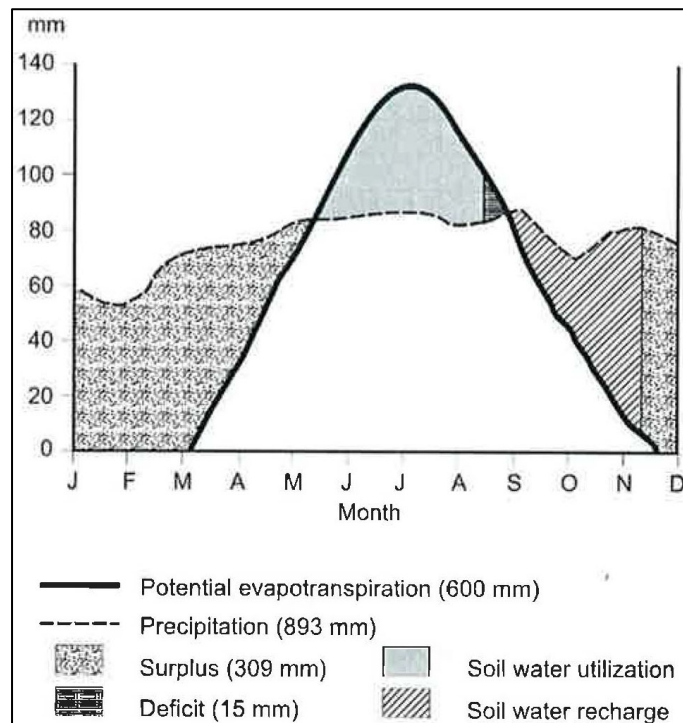


Figure 16 – Brantford Average Water Balance (Sanderson, 2004)

4.2 Wetland Monthly Water Balance

A monthly water balance for the wetlands was completed using the U.S. Geological Survey (USGS) Monthly Water Balance Model (McCabe and Markstrom, 2007), which only considers direct precipitation to the wetland as a water supply. For temperature and precipitation, three time intervals were modelled for the three soil water holding capacities identified (Section 3.6.3) (a) climate normal inputs (1981-2010) from Welland Station ID 6139445 (Environment Canada, 2023a), (b) 2022, and (c) 2023. Monthly wetland water balance modelling results are presented in a series of attached tables for (a) the climate normals (Tables 12a, 12b and 12c), (b) 2022 (Tables 13a, 13b and 13c) and (c) 2023 (Tables 14a, 14b and 14c).

In summary, the average/climate normal results (1981-2010) were:

1. Potential evapotranspiration exceeded precipitation for June, July and August, i.e. soil water utilization occurred on average;
2. Soil water holding capacities were less than saturated for the months of June to October; and
3. Soil water recharge occurred in September and October.

These conditions are presented below in Tables 15a, 15b and 15c:

Table 15a –Average Monthly Wetland Water Balance (mm), HSG C (SWHC 400 mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	78	61	70	75	85	83	86	82	97	89	99	92
Evapotranspiration (mm)	10	12	21	40	72	106	122	97	60	32	17	11
Soil Moisture (mm)	400	400	400	400	400	373	333	314	346	398	400	400
Soil Water ¹ Depletion (mm)	0	0	0	0	0	27	67	86	54	2	0	0

Notes: ¹ Difference between the SWHC and the modelled soil moisture

Table 15b – Average Monthly Wetland Water Balance (mm), HSG D (SWHC 350 mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	78	61	70	75	85	83	86	82	97	89	99	92
Evapotranspiration (mm)	10	12	21	40	72	106	122	97	60	32	17	11
Soil Moisture (mm)	350	350	350	350	350	323	283	265	297	349	350	350
Soil Water ¹ Depletion (mm)	0	0	0	0	0	27	67	85	53	1	0	0

Notes: ¹ Difference between the SWHC and the modelled soil moisture

Table 15c – Average Monthly Wetland Water Balance (mm), HSG C/D (SWHC 375 mm)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (mm)	78	61	70	75	85	83	86	82	97	89	99	92

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evapotranspiration (mm)	10	12	21	40	72	106	122	97	60	32	17	11
Soil Moisture (mm)	375	375	375	375	375	348	308	289	321	374	375	375
Soil Water¹ Depletion (mm)	0	0	0	0	0	27	67	86	54	1	0	0

Notes: ¹ Difference between the SWHC

The monthly soil water modelling of 2022 and 2023 (Tables 13/14, attached) differed from average conditions as a function of the primary influence of precipitation not being average (Table 1, attached):

1. Potential evapotranspiration exceeded precipitation earlier in May 2022 and 2023 (below average precipitation), and later in September 2023 (below average precipitation) but not in July/August (above average precipitation);
2. Soil water holding capacities were also less than saturated for May 2022 and 2023 (below average precipitation) but not less than saturated for August 2023 (above average precipitation);
3. Soil water recharge occurred earlier in July 2023 (above average precipitation) but not in September 2023 (below average precipitation).

The 2022 and 2023 modelled results reasonably match the observed wetland hydroperiod monitoring water levels (Appendix F), further supporting the primary role of precipitation in sustaining the wetland hydroperiods. It is noted that the hydrographs extend to November 20, 2023 prior to most of the November 2023 precipitation recharging to a “surplus” condition (Tables 14a/14b).

4.3 Wetland Water Balance Assessment

The extensive investigation and monitoring program and water balance modelling support the wetlands at the Site being supported primarily by precipitation. Consequently, development of the Site is not predicted to negatively affect the wetland hydroperiods as long as the proposed Environmental Impact Study buffers are observed.

4.4 Wetland Risk Evaluation

4.4.1 Magnitude of Hydrological Change

TRCA’s wetland risk evaluation (2017) decision tree (Figure 17) includes four key hydrological change criteria:

- 1) Impervious cover in catchment;
- 2) Change in catchment size;
- 3) Dewatering; and
- 4) Impact to recharge areas.

The magnitude of hydrological change assessment was completed of the proposed southern development within the City of Welland of about 30.2 hectares.

(1) The amount of impervious cover within the areas proposed for development in Tow Path Drain South is calculated to be between 10 and 25% (A.T. McLaren Limited, 2024, WalterFedy, 2024a, Appendix G). Development of Tow Path Drain North as proposed (A.T. McLaren Limited, 2024 and WalterFedy, 2024a, Appendix G) is calculated to be greater than 25%.

(2) The post-development surface water catchments are proposed as follows: (a) Tow Path Drain North: 9% reduction in catchment area and (d) Tow Path Drain South: no reduction in catchment area (WALTERFEDY, 2024b).

(3) Construction dewatering is not expected to affect wetlands due to the low permeability of the soils on-site (Section 3.5.1). The aquitard underlying the Site is generally of sufficiently low permeability that groundwater control pumping methods are likely not feasible (Preene, 2020). However, an exception to this may be the northwest corner of the Site where the most permeable materials were identified at-surface and in the water table. Development in this area may require exclusion methods (e.g. cut-off collars for municipal servicing) to prevent long-term dewatering of adjacent wetlands.

(4) No impacts to wetland recharge areas are predicted as TRCA (2017) defines this as “*replacement of existing soils with significantly less permeable materials*” and the on-site soils are already of low permeability. In addition, there are no locally significant recharge areas to be impacted as these are defined by TRCA (2017) as “*highly porous sedimentary deposits or otherwise having high hydraulic conductivity*”.

“*The highest magnitude category with one or more criteria satisfied determines the potential magnitude of change*” with the magnitude thresholds of less than 10% change as low, 10-25% as medium and greater than 25% as high (TRCA, 2017). Hydrologic risk is assigned based upon the magnitude of impervious cover to be introduced in upgradient catchment areas; medium in Tow Path Drain South and high in Tow Path Drain North. However, as discussed in Section 4.3.2, negative hydrologic impacts to the downgradient wetlands are not predicted with the implementation of wetland buffers as recommended by GEI in their future Environmental Impact Study.

4.4.2 Sensitivity of the Wetlands

The risk assignment (Figure 17) is to consider the type of wetlands, and their hydrological sensitivity (TRCA, 2017) which is tabulated in Table 6. None of the wetlands were classified as high hydrologic sensitivity, however, some were classified as medium (i.e. Cattail Mineral Shallow Marsh, Swamp Maple Mineral Deciduous Swamp, Silky Dogwood Mineral Thicket Swamp, Silver Maple Mineral Deciduous Swamp) and others as low (i.e. Grey Dogwood Mineral Thicket Swamp, Forb Mineral Meadow Marsh).

4.4.3 Risk Assignment

As per Figure 17, a medium risk is assigned based upon (i) either a high or medium magnitude of hydrological change, and (ii) a medium wetland sensitivity. The TRCA recommended study, modelling and mitigation requirements are:

- (i) Pre-development monitoring as outlined in the Wetland Water Balance Monitoring Protocol (TRCA, 2016).

- Pre-development monitoring has occurred and informed the conceptual model and impact assessment for the Site.
- (ii) Continuous hydrological modelling at daily aggregated to weekly resolution.
- Existing modelling (completed at 1-hour time steps) completed by NPCA was utilized for this report (AquaResource Inc. and NPCA, 2009) as part of a monthly analysis. Re-visiting this modelling to extract weekly results would not provide discernable benefit.
- (iii) Design of a mitigation plan to maintain the wetland water balance, in some cases an interim mitigation plan may also be required.
- Mitigation is not indicated to be required as precipitation is the primary water supply for the wetlands. EIS proposed buffers are predicted to be sufficient to maintain pre-development conditions for the wetlands.

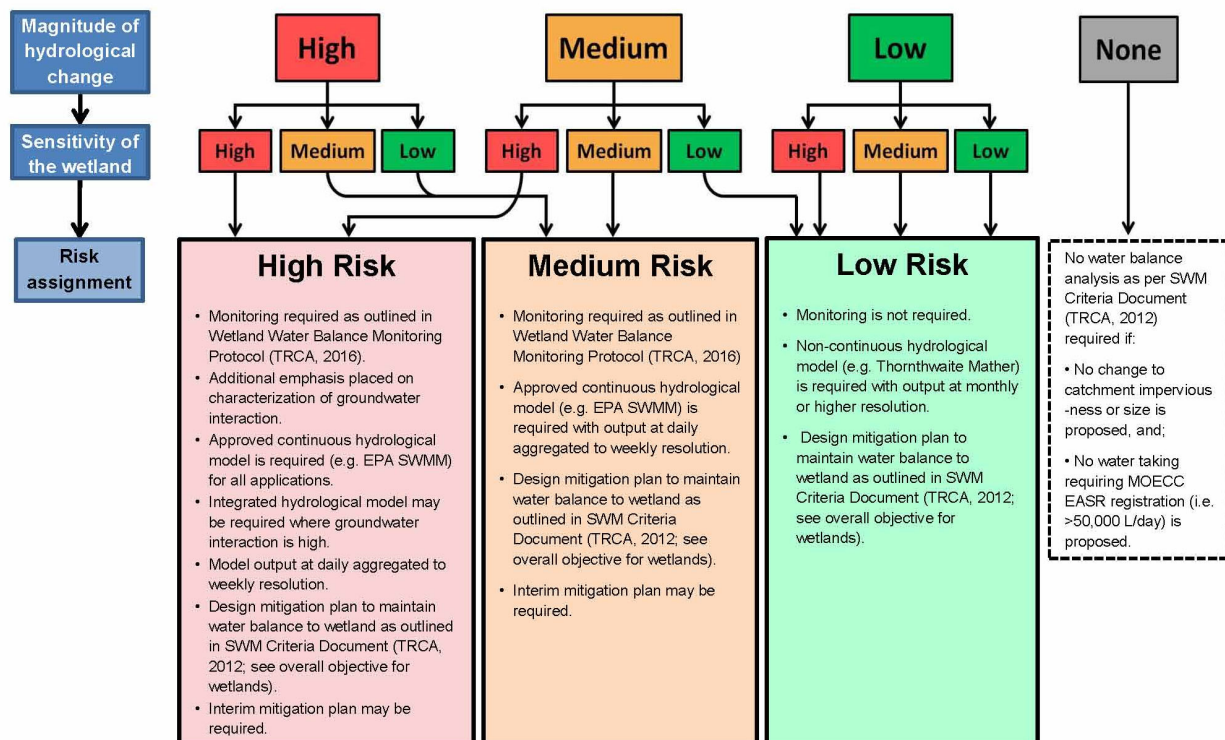


Figure 17 - Wetland Risk Evaluation Decision Tree (TRCA, 2017)

5.0 Key Hydrologic Areas and Features

The Niagara Region Official Plan (2022) lists under Policy 3.1.10.1 that:

Development or site alteration shall not be permitted unless it can demonstrated that it will not have negative impacts on:

- a. *the quantity and quality of water in key hydrologic areas, key hydrologic features, sensitive surface water features, and sensitive ground water features;*

- b. the hydrologic functions of key hydrologic areas, key hydrologic features, sensitive surface water features, and sensitive groundwater features;*
- c. the interaction and linkage between key hydrologic areas, key hydrologic features, sensitive surface water features, and sensitive groundwater features and other components of the natural environment system;*
- d. the natural hydrologic characteristics of watercourses such as base flow, form and function, and headwater drainage areas;*
- e. natural drainage systems and shorelines areas; and*
- f. flooding or erosion.*

Key hydrologic areas have been defined as *“Significant groundwater recharge areas, highly vulnerable aquifers, and significant surface water contribution areas that are necessary for the ecological and hydrologic integrity of a watershed”*

Key Hydrologic Features have been defined as *“Permanent streams, intermittent streams, inland lakes and their littoral zones, seepage areas and springs and wetlands”* (Niagara Region, 2022).

5.1 Highly Vulnerable Aquifers (HVAs)

There are no Highly Vulnerable Aquifers (HVAs) mapped at the Site. It is noted that potential HVAs are mapped adjacent to the Site, however, these are related to potential historical water wells requiring decommissioning at those lands (NPCA, 2011). The off-site HVA mapping has no bearing on development at the Site. However, it should be noted that as monitoring wells at the Site are no longer required, they must be decommissioned by a licensed water well contractor (MECP, 2023).

5.2 Significant Groundwater Recharge Areas (SGRAs)

Significant Groundwater Recharge Areas (SGRAs) have been mapped at the Site which were mapped based upon prescribed Technical Rules for source water protection studies (MECP, 2009). However, site-level investigations have confirmed the Site as underlain by a low permeability aquitard unsuitable for on-site infiltration activities (i.e. <15 mm/hour infiltration and often high water table conditions). No negative impacts to the ecological and hydrologic integrity of the watershed are predicted and additional groundwater recharge mitigation measures are not required.

The NPCA SGRA mapping was intended as a screening layer to be informed by site-level investigations. NPCA had recommended two levels of SGRA significance (NPCA, 2009) however that is not currently reflected in SGRA mapping. Two levels of significance were recommended as the Source Protection Committee chose an MECP SGRA threshold that is very low and includes clayey silt where infiltration may not be suitable. During development of the Niagara Peninsula Source Protection Plan, no policies were included for SGRAs (NPSPC, 2014).

5.3 Key Hydrologic Features

No negative impacts to the Tow Path Drain are predicted as it has been identified as intermittent and having no baseflow or groundwater inputs.

No negative impacts to the wetlands are predicted as they are primarily sustained by precipitation.

6.0 Conclusions and Recommendations

6.1 Conclusions

The following conclusions are provided:

1. The Site is 60.8 hectares in area. Within the Site the Ministry of Natural Resources & Forestry have mapped Provincial Significant Swamp Wetland associated with the Niagara Street Cataract Road Woodlot Wetland Complex, and GEI Consultants have also mapped additional non-PSW wetlands at the Site. The coverage of wetlands on-site mapped by GEI is currently 27.2 hectares, with 17 hectares being provincially significant (63%).
2. The Site is located on the Haldimand Clay Plain, a regional thick aquitard of silty clay/clayey silt soils and downgradient of the Fonthill Kame-Delta Complex which is considered a regional groundwater recharge area.
3. Native soils are low permeability and not suitable for infiltration trenches, soakaway pits or pervious pipes.
4. Surface water drainage is almost evenly split and roughly along the municipal boundary with flow to the north and Thorold via Singer's Drain, and flow to the south and Welland via Tow Path Drain.
5. Watercourse monitoring at the Site has identified intermittent or ephemeral conditions.
6. Shallow groundwater flow is generally from northwest to southeast across the Site. The high water table in the spring season of 2023 was generally less than 1 m below natural ground surface while during August, 2022 the depth to the water table increased from west to east.
7. Groundwater levels are consistently above ground surface at monitoring well BH21-01 in the northwest corner of the Site. With only about 0.5 m of seasonal change in summer 2022, it is believed fine sand seams receive lateral recharge from the upgradient/off-site Fonthill Kame-Delta Complex.
8. The wetlands are on low permeability silty clay, consisting of surface water depression wetlands.
9. Wetland water levels monitored at eighteen locations, selected by GEI Consultants, since the summer season of 2022 resemble published hydroperiods for Canadian swamps and reasonably match modelled monthly water balance results for being sustained by precipitation alone.
10. A monthly water balance for the wetlands identified, on average, potential evapotranspiration as exceeding precipitation for June, July and August, with soil water holding capacities less than saturated also in September and October.

11. Pre-development monthly water balance modelling reasonably matches wetland water level monitoring supporting the conceptual model of palustrine wetlands (e.g. intermittent or no inflow) supported primarily by precipitation.
12. The Toronto Region Conservation Authority wetland risk screening tool assigned a 'potential' medium risk to the hydrological and ecological integrity of the wetlands, based upon either a high or medium magnitude of hydrological change and medium wetland sensitivity. However, the risk protocol does not include scoping precipitation supplied wetlands.
13. Residential development of the Site should not negatively impact the hydrology of the wetlands because the wetlands are primarily supplied by precipitation and therefore implementation of buffers as prescribed in the Environmental Impact Study should be sufficient.
14. No negative impacts to the ecological and hydrologic integrity of the watershed are predicted and additional groundwater recharge mitigation measures are not required.

6.2 Recommendations

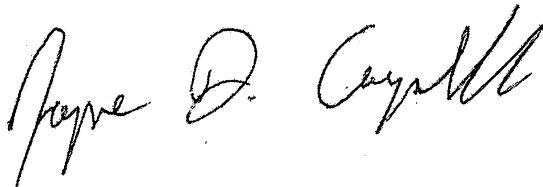
The following recommendations are provided:

1. Evaluate continuance of the wetland and surface water monitoring programs at the Site following acceptance of this report by NPCA and Niagara Region; and
2. Decommission the on-site monitoring wells once no longer required using a licensed in Ontario water well contractor.

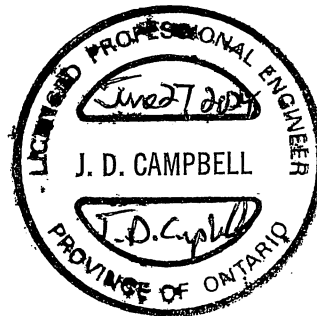
We trust this information is sufficient for your present needs. Please do not hesitate to contact us if you have any questions.

Yours truly,

TERRA-DYNAMICS CONSULTING INC.



Jayme D. Campbell, P. Eng.
Senior Water Resources Engineer



cc. Daniel Stummer, Primont (Thorold/Welland) Inc.
Eric Salembier, WALTERFEDY
Antonette Zimic/Rick Hubbard, GEI

Attachments

Figure 1 – Location of Subject Lands

Figure 2 – Site Details

Figure 4 – Soils and Surface Water Catchments

Figure 5 – Hydrogeologic Cross-Section North-South A-A'

Figure 6 – Hydrogeologic Cross-Section West-East B-B'

Figure 8 – Water Table Flow, November 2022

Figure 9 – Depth to Water Table, April 2023

Figure 10 – Western Upgradient Groundwater Levels

Figure 11 – Eastern Downgradient Groundwater Levels

Figure 12 – Southwest Groundwater Levels

Figure 13 – Wetland and Surface Water Monitoring

Table 1 – Precipitation Analyses

Table 6 – Monitoring Well Details and Manual Water Levels

Table 9 – Early Wetland Manual Water Levels

Tables 12a/12b/12c - USGS Monthly Wetland Water Balance (1981-2010)

Tables 13a/13b/13c - USGS Monthly Wetland Water Balance (2022)

Tables 14a/14b/14c - USGS Monthly Wetland Water Balance (2023)

Appendix A – Terms of Reference

Appendix B – Borehole and Monitoring Well Logs

Appendix C – Hydraulic Conductivity Analyses

Appendix D – Groundwater Datalogger Charts

Appendix E – Wetland Monitoring

Appendix F – Tow Path Drain Surface Water Monitoring

Appendix G – Supporting Information

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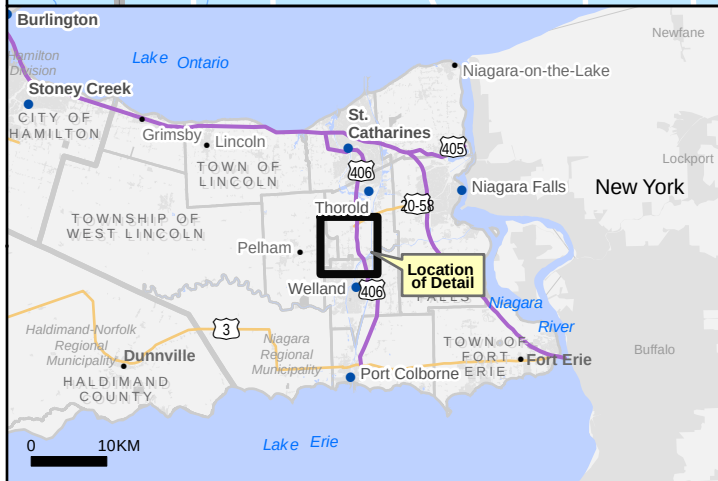
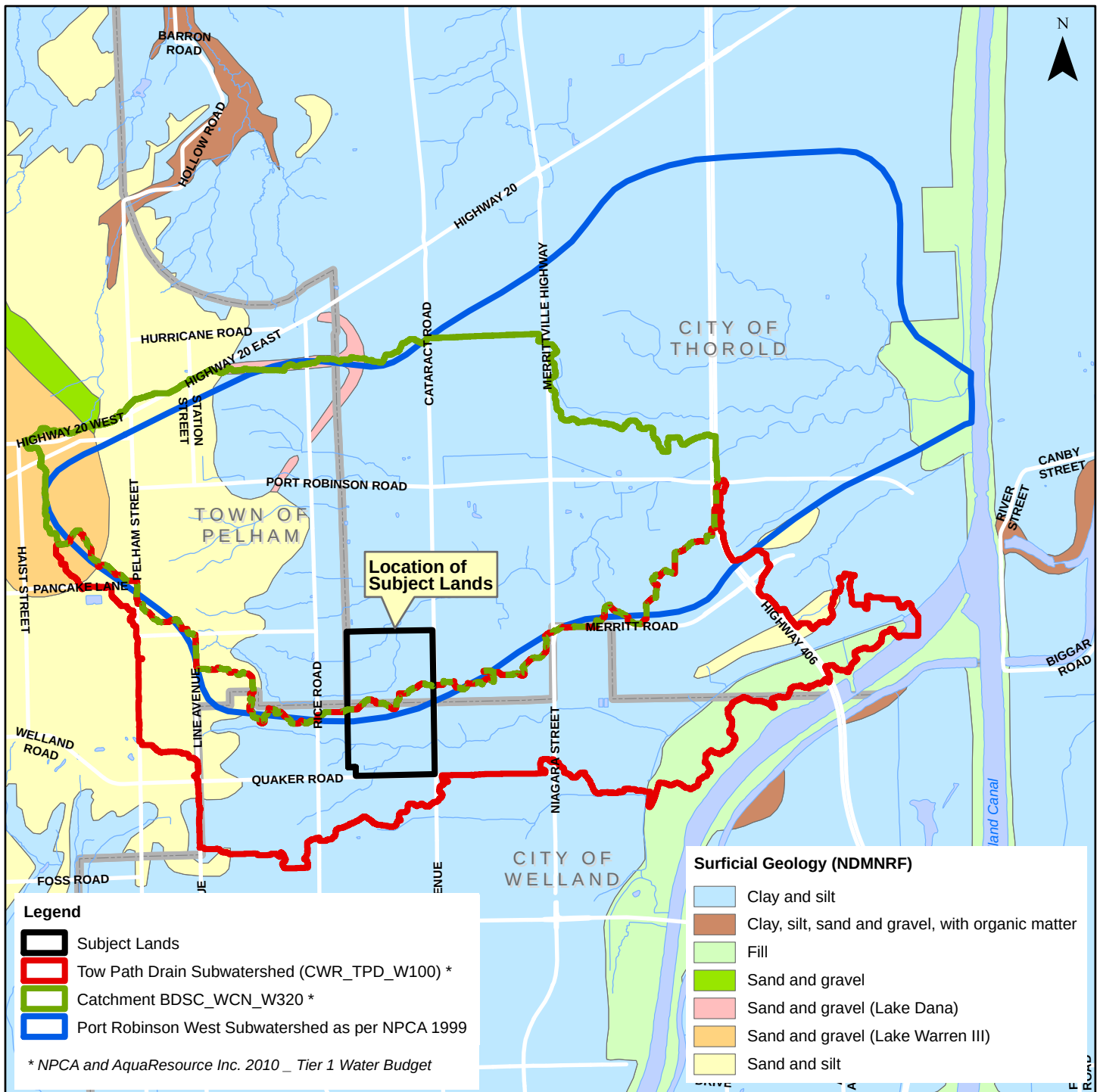
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Location of Subject Lands

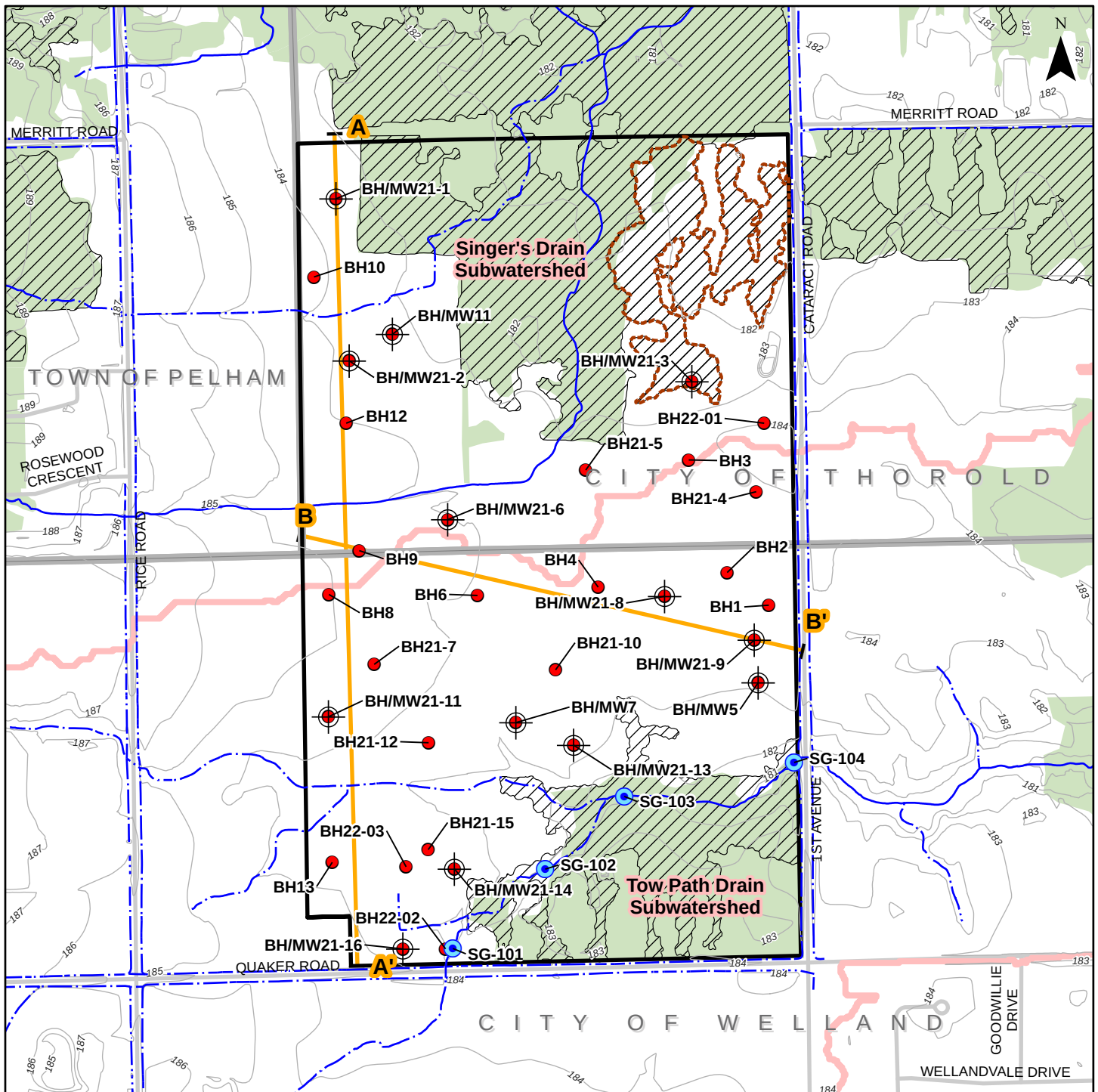
Hydrogeologic Study and
Wetland Water Balance
436 Quaker Road, Welland and
Lot 228/Part Lot 174, Thorold, ON
Primont (Thorold/Welland) Inc.



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Figure 1



Site Details

Hydrogeologic Study and Wetland Water Balance
436 Quaker Road, Welland and
Lot 228/Part Lot 174, Thorold, ON
Primont (Thorold/Welland) Inc.

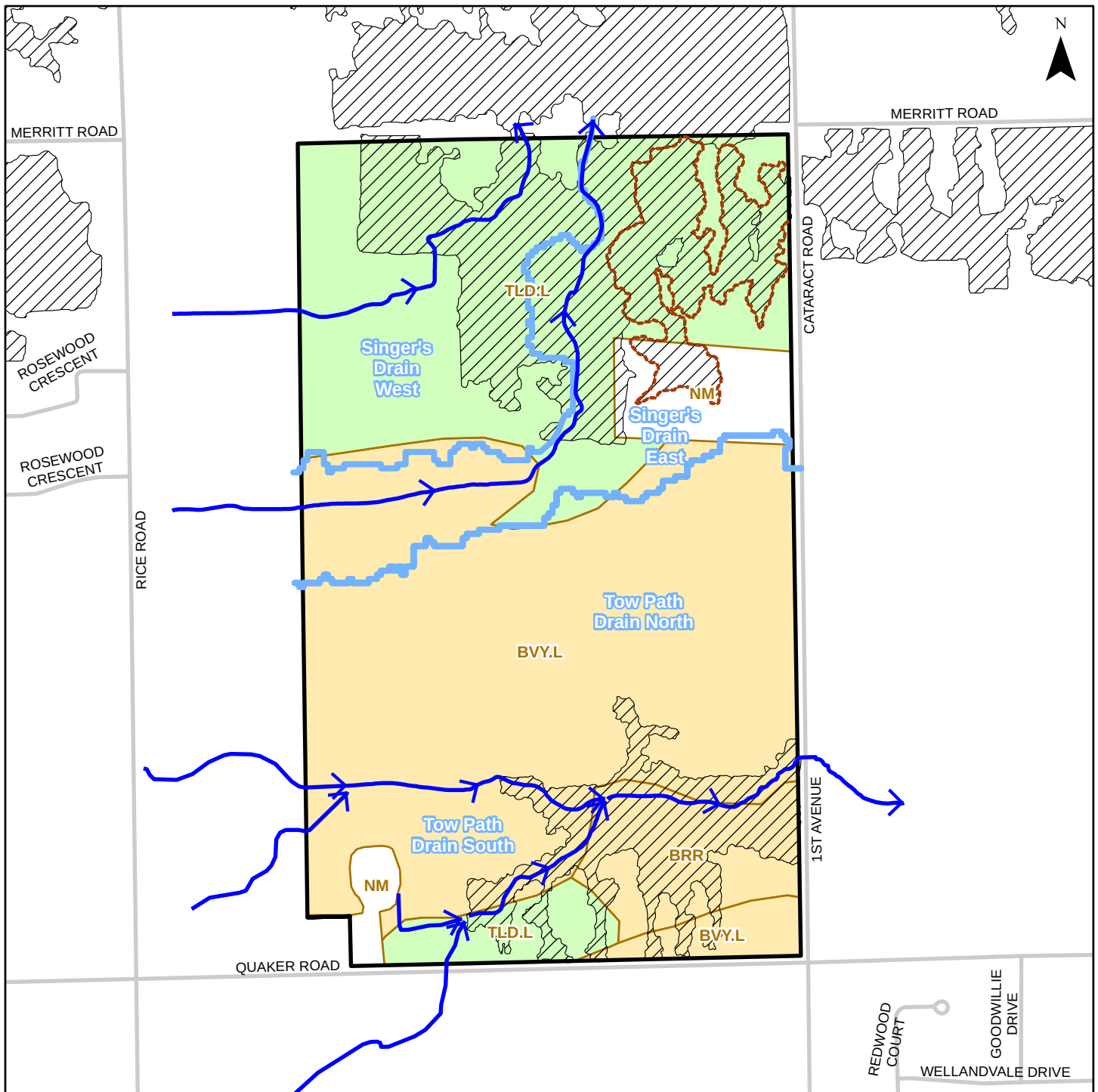


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Figure 2



Legend

- Subject Lands
 - ➔ Surface Water Flow Direction
 - Catchment Areas
 - Niagara Street Cataract Road Woodlot Wetland Complex Provincially Significant Wetlands (MNRF)
 - Marsh Area (MNRF)
- Soils (OMAFRA)**
- | | |
|-----------------------------|----------------------------|
| BRR Berrien | TLD.L Toledo - Loamy Phase |
| BVY.L Beverly - Loamy Phase | NM Not Mapped |
- Hydrologic Soil Group (OMAFRA)**
- | | |
|--|--|
| C | D |
|--|--|

Soils and Surface Water Catchments

Hydrogeologic Study and Wetland Water Balance
436 Quaker Road, Welland and
Lot 228/Part Lot 174, Thorold, ON
Primont (Thorold/Welland) Inc.



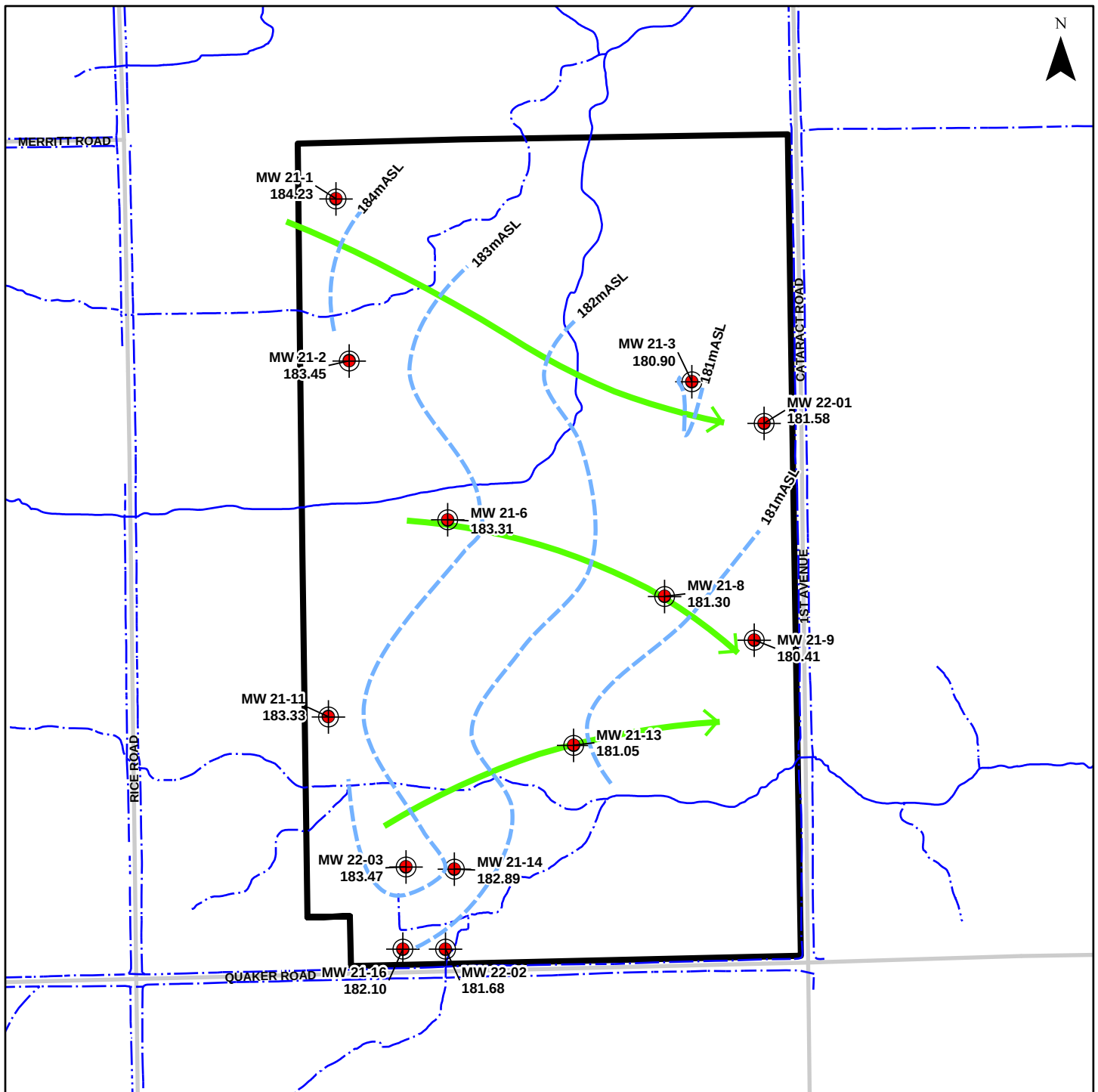
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Figure 4



Legend

- Subject Lands
- Monitoring Well Location and Groundwater Elevation (m ASL)
- ➔ Groundwater Flow Direction
- Water Table Elevation Contours (mASL)
- NPCA Watercourse Permanency**
 - Ephemeral
 - Intermittent or Ephemeral

Water Table Flow, November 2022

Hydrogeologic Study and Wetland Water Balance
436 Quaker Road, Welland and
Lot 228/Part Lot 174, Thorold, ON
Primont (Thorold/Welland) Inc.

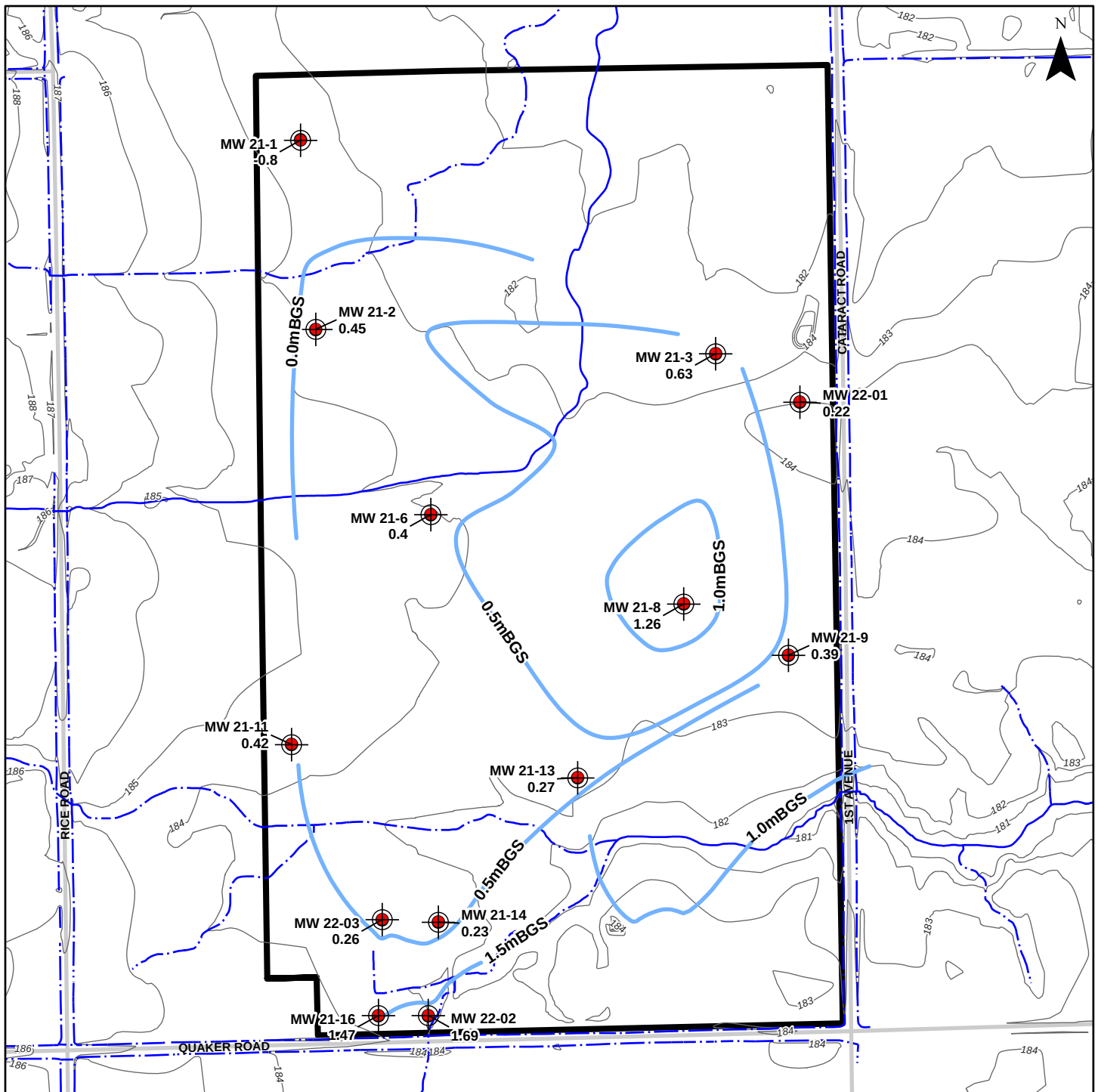


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Figure 8



Legend

- Subject Lands
- Monitoring Well Location and Depth to Water Table (m)
- Depth to Water Table (mBGS)
- Ground Surface Contour (NPCA)
- NPCA Watercourse Permanency**
- Ephemeral
- Intermittent or Ephemeral

Depth to Water Table, April 2023

Hydrogeologic Study and Wetland Water Balance
436 Quaker Road, Welland and
Lot 228/Part Lot 174, Thorold, ON
Primont (Thorold/Welland) Inc.



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Figure 9

Figure 10 - Western Upgradient Manual Groundwater Levels

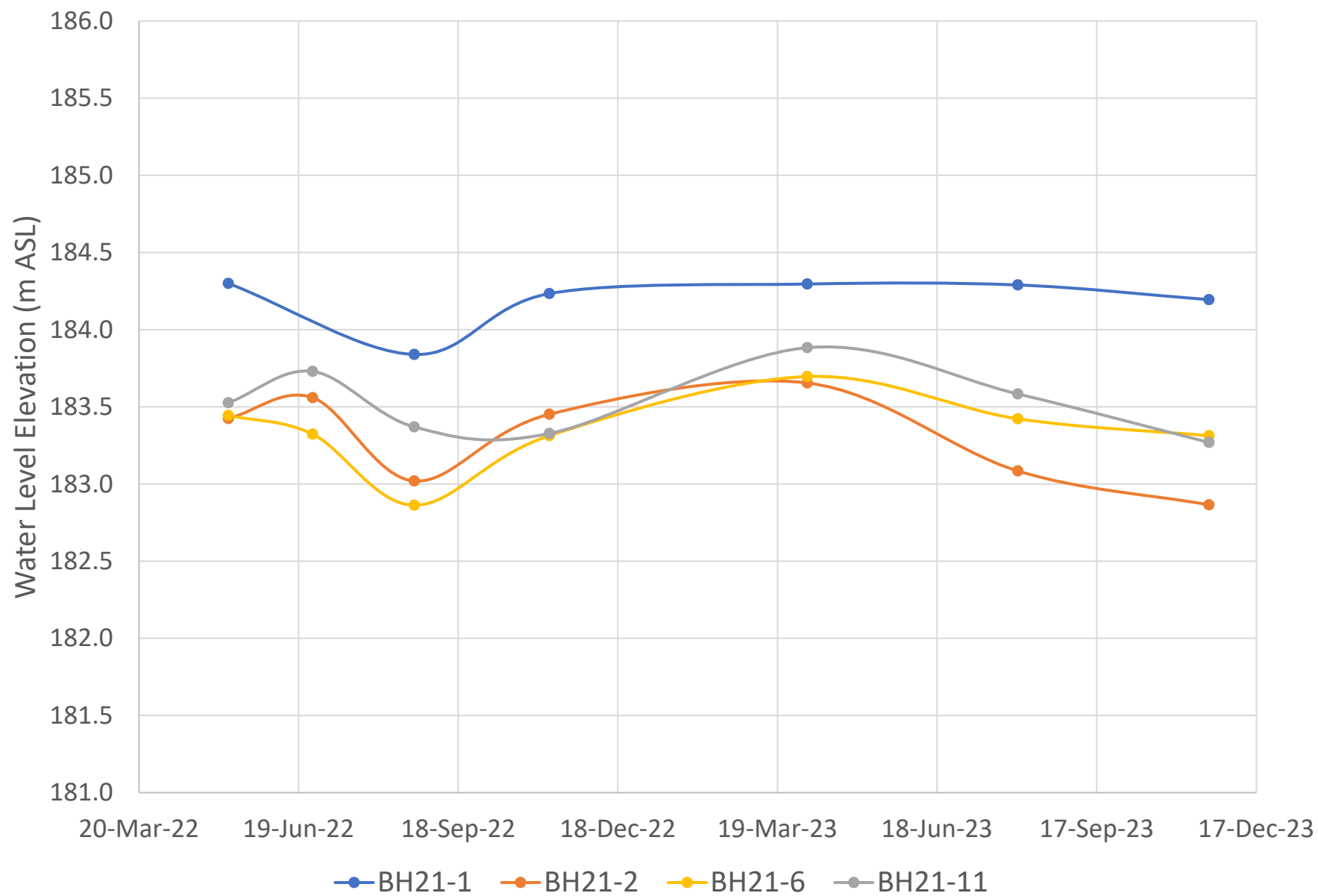


Figure 11 - Eastern Downgradient Manual Groundwater Levels

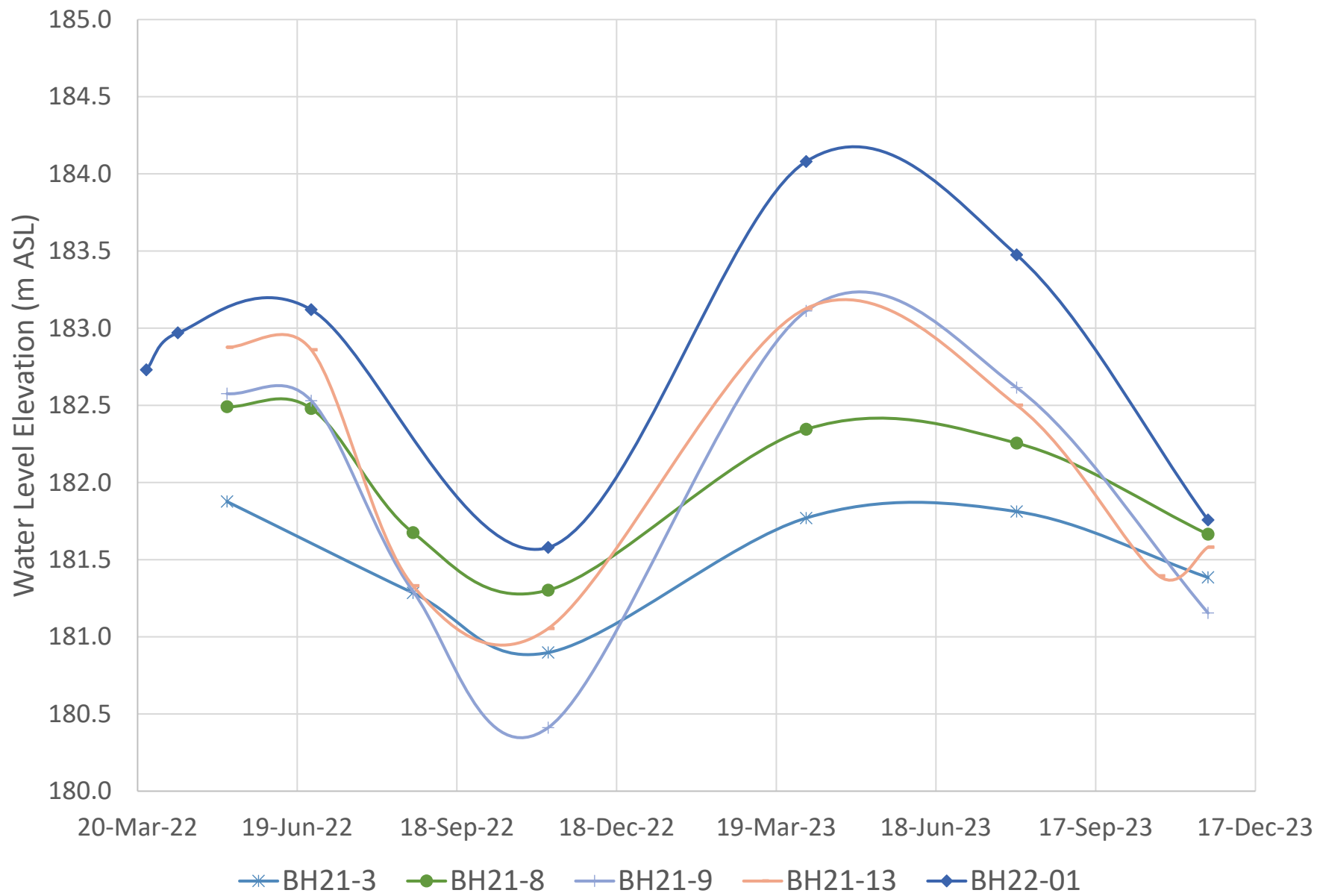
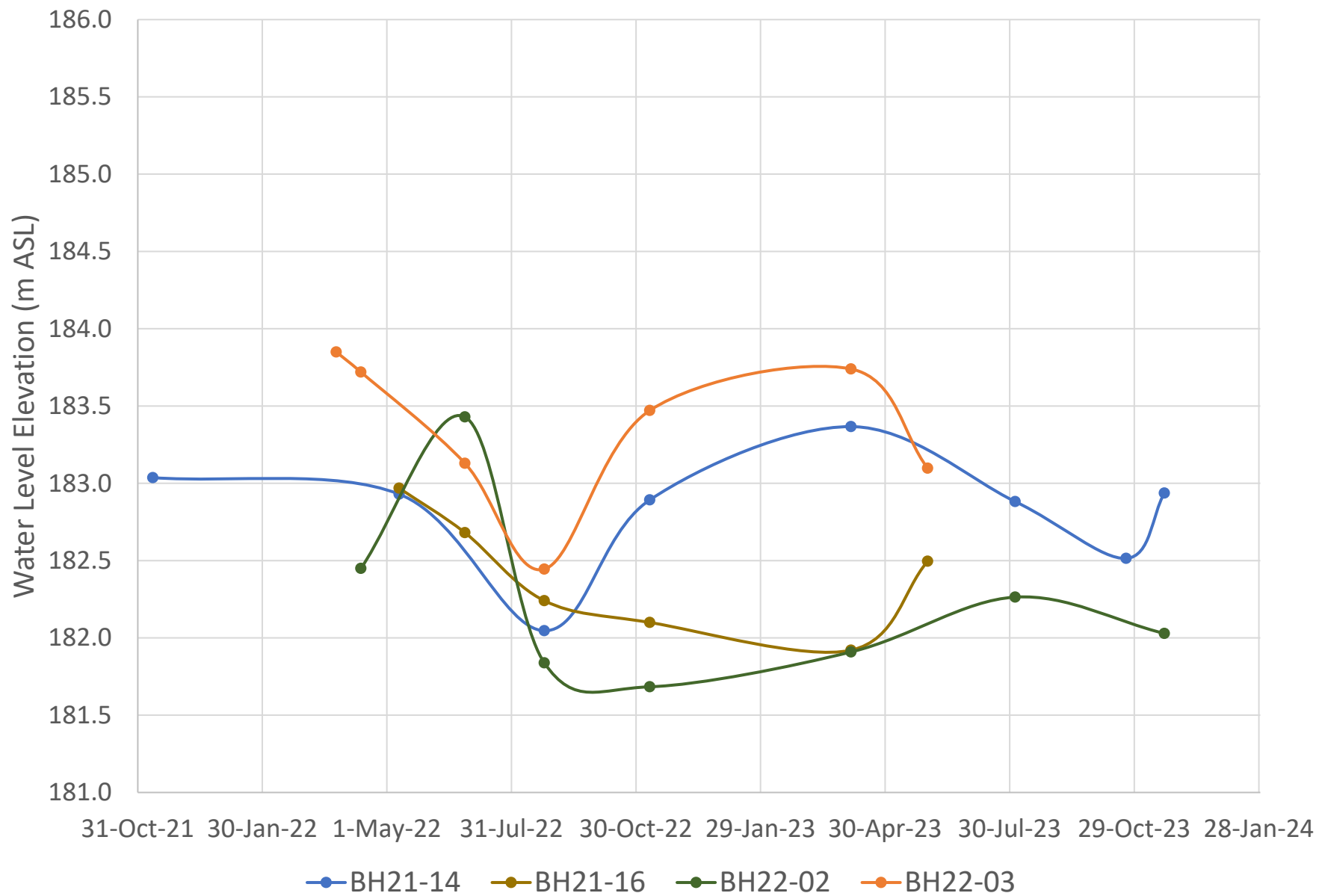


Figure 12 - Southwest Manual Groundwater Levels



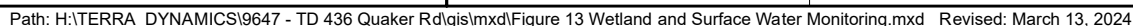


Table 1
Welland-Pelham Precipitation Analyses

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year Sum
Average* Precipitation (mm)	78.2	61.3	69.7	75.4	85.2	82.9	85.9	82.4	96.8	89.3	98.5	92	998
2021 Welland-Pelham	40.9	47.7	35.2	48.4	39.8	52.2	163.3	63.1	177	124.6	67.1	65.2	925
1-month Average +/-	52%	78%	51%	64%	47%	63%	190%	77%	183%	140%	68%	71%	93%
3-Month Average +/-	67%	67%	59%	64%	54%	58%	101%	111%	152%	136%	130%	92%	
2022 Welland-Pelham	62.1	99.7	59.2	53.4	63.7	72.6	72.5	51.2	86	107.5	104.9	64.4	897
1-month Average +/-	79%	163%	85%	71%	75%	88%	84%	62%	89%	120%	106%	70%	90%
3-Month Average +/-	72%	98%	106%	103%	77%	78%	82%	78%	79%	91%	105%	99%	
2023 Welland-Pelham	86.8	68.6	109.8	98.1	34.6	74.4	163	138.7	30.1	62.9	53.6	110.3	1031
1-month Average +/-	111%	112%	158%	130%	41%	90%	190%	168%	31%	70%	54%	120%	114%
3-Month Average +/-	99%	98%	127%	134%	105%	85%	107%	150%	125%	86%	52%	81%	

Notes: * - Welland Environment Canada (1981-2010, ID 6139445), Grey shading - monthly value between 95-105%, Blue shading >105%, Orange < 95%

Table 6
Monitoring Well Details and Water Levels

Well I.D.	Ground Elevation (m ASL)	Stick-Up (m)	TOC Elevation (m ASL)	Well Depth Below TOC (m)	Well Depth below ground (m)	Date	Water level (m below TOC)	Water Level below ground (m)	Water Level Elevation (m ASL)
BH21-1	183.5	0.82	184.32	6.17	5.35	10-May-22	0.02	-0.80	184.30
						24-Aug-22	0.48	-0.34	183.84
						9-Nov-22	0.09	-0.73	184.23
						5-Apr-23	0.02	-0.80	184.30
						3-Aug-23	0.03	-0.79	184.29
						20-Nov-23	0.13	-0.70	184.20
BH21-2	184.1	0.80	184.90	7.26	6.46	11-Nov-21	1.50	0.70	183.40
						10-May-22	1.48	0.68	183.42
						27-Jun-22	1.34	0.54	183.56
						24-Aug-22	1.88	1.08	183.02
						9-Nov-22	1.45	0.65	183.45
						5-Apr-23	1.25	0.45	183.66
						3-Aug-23	1.82	1.02	183.09
						20-Nov-23	2.04	1.24	182.87
BH21-3	182.4	0.82	183.22	7.12	6.31	10-May-22	1.34	0.52	181.88
						24-Aug-22	1.93	1.12	181.29
						9-Nov-22	2.32	1.50	180.90
						5-Apr-23	1.45	0.63	181.77
						3-Aug-23	1.40	0.59	181.81
						20-Nov-23	1.83	1.02	181.39
BH21-6	184.1	0.82	184.92	5.49	4.67	11-Nov-21	1.36	0.54	183.56
						10-May-22	1.48	0.66	183.44
						27-Jun-22	1.60	0.78	183.32
						24-Aug-22	2.06	1.24	182.86
						9-Nov-22	1.61	0.79	183.31
						5-Apr-23	1.23	0.40	183.70
						3-Aug-23	1.50	0.68	183.42
						20-Nov-23	1.61	0.79	183.31
BH21-8	183.6	0.85	184.45	6.42	5.57	11-Nov-21	2.22	1.37	182.23
						10-May-22	1.95	1.11	182.49
						27-Jun-22	1.97	1.12	182.48
						24-Aug-22	2.77	1.93	181.68
						9-Nov-22	3.14	2.30	181.30
						5-Apr-23	2.10	1.26	182.35
						3-Aug-23	2.19	1.35	182.26
						20-Nov-23	2.78	1.94	181.67
BH21-9	183.5	0.94	184.44	7.24	6.30	11-Nov-21	1.19	0.25	183.25
						10-May-22	1.86	0.92	182.58
						27-Jun-22	1.91	0.97	182.53
						24-Aug-22	3.14	2.21	181.30
						9-Nov-22	4.02	3.09	180.41
						5-Apr-23	1.32	0.39	183.11
						3-Aug-23	1.82	0.89	182.62
						20-Nov-23	3.28	2.35	181.16

Table 6
Monitoring Well Details and Water Levels

Well I.D.	Ground Elevation (m ASL)	Stick-Up (m)	TOC Elevation (m ASL)	Well Depth Below TOC (m)	Well Depth below ground (m)	Date	Water level (m below TOC)	Water Level below ground (m)	Water Level Elevation (m ASL)
BH21-11	184.3	0.68	184.98	6.99	6.31	10-May-22	1.45	0.77	183.53
						27-Jun-22	1.25	0.57	183.73
						24-Aug-22	1.61	0.93	183.37
						9-Nov-22	1.65	0.97	183.33
						5-Apr-23	1.10	0.42	183.88
						3-Aug-23	1.40	0.72	183.58
						20-Nov-23	1.71	1.03	183.27
BH21-13	183.4	0.82	184.22	7.13	6.31	11-Nov-21	1.37	0.55	182.85
						10-May-22	1.34	0.52	182.88
						27-Jun-22	1.36	0.54	182.86
						24-Aug-22	2.89	2.07	181.33
						9-Nov-22	3.17	2.35	181.05
						5-Apr-23	1.09	0.27	183.13
						3-Aug-23	1.72	0.90	182.50
						23-Oct-23	2.83	2.01	181.40
						20-Nov-23	2.64	1.82	181.58
BH21-14	183.6	0.89	184.49	7.15	6.26	11-Nov-21	1.45	0.56	183.04
						10-May-22	1.56	0.67	182.93
						24-Aug-22	2.44	1.55	182.05
						9-Nov-22	1.59	0.71	182.89
						5-Apr-23	1.12	0.23	183.37
						3-Aug-23	1.61	0.72	182.88
						23-Oct-23	1.97	1.09	182.52
						20-Nov-23	1.55	0.66	182.94
BH21-16	183.4	0.93	184.33	7.20	6.27	10-May-22	1.36	0.43	182.97
						27-Jun-22	1.65	0.72	182.68
						24-Aug-22	2.09	1.16	182.24
						9-Nov-22	2.23	1.30	182.10
						5-Apr-23	2.41	1.48	181.92
						31-May-23	1.84	0.90	182.50
BH22-01	184.3	1.14	185.44	7.12	5.99	25-Mar-22	2.71	1.57	182.73
						12-Apr-22	2.47	1.33	182.97
						27-Jun-22	2.32	1.18	183.12
						24-Aug-22	5.38	4.25	180.06
						9-Nov-22	3.86	2.72	181.58
						5-Apr-23	1.36	0.22	184.08
						3-Aug-23	1.96	0.83	183.48
						20-Nov-23	3.68	2.54	181.76
BH22-02	183.6	0.95	184.55	7.10	6.16	12-Apr-22	2.10	1.15	182.45
						27-Jun-22	1.12	0.17	183.43
						24-Aug-22	2.71	1.76	181.84
						9-Nov-22	2.87	1.92	181.68
						5-Apr-23	2.64	1.69	181.91
						3-Aug-23	2.29	1.34	182.26
						20-Nov-23	2.52	1.57	182.03

Table 6
Monitoring Well Details and Water Levels

Well I.D.	Ground Elevation (m ASL)	Stick-Up (m)	TOC Elevation (m ASL)	Well Depth Below TOC (m)	Well Depth below ground (m)	Date	Water level (m below TOC)	Water Level below ground (m)	Water Level Elevation (m ASL)
BH22-03	184.0	1.01	185.01	7.10	6.10	25-Mar-22	1.16	0.15	183.85
						12-Apr-22	1.29	0.28	183.72
						27-Jun-22	1.88	0.87	183.13
						24-Aug-22	2.56	1.56	182.45
						9-Nov-22	1.53	0.53	183.47
						5-Apr-23	1.27	0.26	183.74
						31-May-23	1.91	0.90	183.10
SM MW-5	183.1	1.34	184.46	7.54	6.20	5-Apr-23	1.43	0.09	183.04
SM MW-7	183.5	1.13	184.65	6.82	5.69	5-Apr-23	2.93	1.80	181.72
SM MW-11	183.2	1.17	184.40	7.10	5.93	5-Apr-23	0.69	-0.49	183.72
SG-101		0.55		0.78	0.22	10-Aug-23	0.53	N/A	
						6-Sep-23	0.00	N/A	
						3-Oct-23	0.00	N/A	
						23-Oct-23	0.00	N/A	
						20-Nov-23	0.54	N/A	
SG-102		0.54		0.78	0.24	10-Aug-23	0.43	N/A	
						6-Sep-23	0.00	N/A	
						3-Oct-23	0.00	N/A	
						23-Oct-23	0.50	N/A	
						20-Nov-23	0.43	N/A	
SG-103		0.56		0.79	0.23	10-Aug-23	0.40	N/A	
						6-Sep-23	0.00	N/A	
						3-Oct-23	0.00	N/A	
						23-Oct-23	0.00	N/A	
						20-Nov-23	0.42	N/A	
SG-104		0.54		0.78	0.24	10-Aug-23	0.43	N/A	
						6-Sep-23	0.00	N/A	
						3-Oct-23	0.00	N/A	
						23-Oct-23	0.51	N/A	
						20-Nov-23	0.45	N/A	

Table 9 - Early Manual Wetland Water Level Measurements

Location ID	Soil Type	Depth May 10, 2022 (m)	Depth May 24, 2022 (m)	Depth July 21, 2022 (m)
SW-1	Silty Clay	0.13	0.07	0.00
SW-2	Silty Clay	0.14	0.00	0.00
SW-3	Silty Clay	N/A	0.14	0.06
SW-4	Silty Clay	0.05	0.03	0.00
SW-5	Silty Clay	0.04	0.00	0.00
SW-6	Silty Clay	0.13	0.30	0.02
SW-7	Silty Clay	0.07	0.12	0.00
SW-8	Silty Clay	N/A	0.13	0.00
SW-9	Silty Clay	N/A	0.03	0.00
SW-10	Silty Clay	N/A	0.02	0.00
SW-11	Silty Clay	0.16	0.08	0.00
SW-12	Silty Clay	0.14	0.06	0.03
SW-13	Silty Clay	0.18	0.05	0.00
SW-14	Silty Clay	0.26	0.29	0.00
SW-15	Silty Clay	0.17	0.27	0.00
SW-16	Silty Clay	0.05	0.00	0.00
SW-17	Silty Clay	0.20	0.05	0.00
SW-18	Silty Clay	0.30	0.18	0.01

TABLE 12a
400 mm USGS Wetland Monthly Water Balance (1981-2010)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	78.2	9.7	45.6	400	9.7	0	31.3	45.6	50.9	Surplus
February	61.3	11.6	48.1	400	11.6	0	31.3	48.1	50.2	Surplus
March	69.7	21.3	68.1	400	21.3	0	8.8	68.1	61.2	Surplus
April	75.4	39.6	40.8	400	39.6	0	0	40.8	53.4	Surplus
May	85.2	71.6	9.3	400	71.6	0	0	9.3	33.7	Surplus
June	82.9	105.8	-27.1	372.9	105.8	0	0	0	18.9	Soil Water Utilization
July	85.9	124.8	-43.2	332.6	121.9	2.9	0	0	11.7	Soil Water Utilization
August	82.4	100.9	-22.6	313.9	97.1	3.8	0	0	7.8	Soil Water Utilization
September	96.8	60.2	31.7	345.6	60.2	0	0	0	6.7	Soil Water Recharge
October	89.3	32.2	52.6	398.2	32.2	0	0	0	5.4	Soil Water Recharge
November	98.5	17.2	76.4	400	17.2	0	0	74.6	42.7	Surplus
December	92	10.9	67.9	400	10.9	0	10.1	67.9	55.9	Surplus
Sum	997.6				599.1				398.5	

TABLE 12b
350 mm USGS Wetland Monthly Water Balance (1981-2010)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	78.2	9.7	45.6	350	9.7	0	31.3	45.6	51	Surplus
February	61.3	11.6	48.1	350	11.6	0	31.3	48.1	50.3	Surplus
March	69.7	21.3	68.1	350	21.3	0	8.8	68.1	61.2	Surplus
April	75.4	39.6	40.8	350	39.6	0	0	40.8	53.4	Surplus
May	85.2	71.6	9.3	350	71.6	0	0	9.3	33.7	Surplus
June	82.9	105.8	-27.1	323	105.8	0	0	0	18.9	Soil Water Utilization
July	85.9	124.8	-43.2	283	121.5	3.3	0	0	11.7	Soil Water Utilization
August	82.4	100.9	-22.6	265	96.5	4.3	0	0	7.8	Soil Water Utilization
September	96.8	60.2	31.7	297	60.2	0	0	0	6.7	Soil Water Recharge
October	89.3	32.2	52.6	349	32.2	0	0	0	5.4	Soil Water Recharge
November	98.5	17.2	76.4	350	17.2	0	0	75.5	43.1	Surplus
December	92	10.9	67.9	350	10.9	0	10.1	67.9	56.2	Surplus
Sum	997.6				598.1				399.4	

TABLE 12c
375 mm USGS Wetland Monthly Water Balance (1981-2010)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	78.2	9.7	45.6	375	9.7	0	31.3	45.6	51	Surplus
February	61.3	11.6	48.1	375	11.6	0	31.3	48.1	50.2	Surplus
March	69.7	21.3	68.1	375	21.3	0	8.8	68.1	61.2	Surplus
April	75.4	39.6	40.8	375	39.6	0	0	40.8	53.4	Surplus
May	85.2	71.6	9.3	375	71.6	0	0	9.3	33.7	Surplus
June	82.9	105.8	-27.1	347.9	105.8	0	0	0	18.9	Soil Water Utilization
July	85.9	124.8	-43.2	307.8	121.7	3.1	0	0	11.7	Soil Water Utilization
August	82.4	100.9	-22.6	289.3	96.8	4	0	0	7.8	Soil Water Utilization
September	96.8	60.2	31.7	321	60.2	0	0	0	6.7	Soil Water Recharge
October	89.3	32.2	52.6	373.7	32.2	0	0	0	5.4	Soil Water Recharge
November	98.5	17.2	76.4	375	17.2	0	0	75	42.9	Surplus
December	92	10.9	67.9	375	10.9	0	10.1	67.9	56	Surplus
Sum	997.6				598.6				398.9	

TABLE 13a
400 mm USGS Wetland Monthly Water Balance (2022)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	62.1	7.9	11.9	400	7.9	0	41.7	11.9	29.8	Surplus
February	99.7	11.2	75.1	400	11.2	0	52.9	75.1	54.4	Surplus
March	59.2	22.9	80.3	400	22.9	0	6.2	80.3	68.9	Surplus
April	53.4	38.4	18.6	400	38.4	0	0	18.6	45.1	Surplus
May	63.7	80.1	-19.5	380.5	80.1	0	0	0	24.4	Soil Water Utilization
June	72.6	104.5	-35.6	346.6	102.8	1.7	0	0	14.2	Soil Water Utilization
July	72.5	122.5	-53.6	300.2	115.3	7.2	0	0	8.9	Soil Water Utilization
August	51	104.7	-56.2	258	90.6	14	0	0	5.2	Soil Water Utilization
September	86	60.2	21.5	279.4	60.2	0	0	0	5.6	Soil Water Recharge
October	107.5	31.2	70.9	350.3	31.2	0	0	0	6	Soil Water Recharge
November	104.9	18.2	81.5	400	18.2	0	0	31.8	21.5	Surplus
December	64.4	11.9	46.7	400	11.9	0	3.3	46.7	34	Surplus
Sum	897				590.7				318	

TABLE 13b
350 mm USGS Wetland Monthly Water Balance (2022)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	62.1	7.9	11.9	350	7.9	0	41.7	11.9	29.9	Surplus
February	99.7	11.2	75.1	350	11.2	0	52.9	75.1	54.4	Surplus
March	59.2	22.9	80.3	350	22.9	0	6.2	80.3	68.9	Surplus
April	53.4	38.4	18.6	350	38.4	0	0	18.6	45.1	Surplus
May	63.7	80.1	-19.5	330.5	80.1	0	0	0	24.4	Soil Water Utilization
June	72.6	104.5	-35.6	296.9	102.5	2	0	0	14.2	Soil Water Utilization
July	72.5	122.5	-53.6	251.4	114.4	8.1	0	0	8.9	Soil Water Utilization
August	51	104.7	-56.2	211	88.8	15.8	0	0	5.2	Soil Water Utilization
September	86	60.2	21.5	232.5	60.2	0	0	0	5.6	Soil Water Recharge
October	107.5	31.2	70.9	303.4	31.2	0	0	0	6	Soil Water Recharge
November	104.9	18.2	81.5	350	18.2	0	0	34.8	23	Surplus
December	64.4	11.9	46.7	350	11.9	0	3.3	46.7	34.7	Surplus
Sum	897				587.7				320.3	

TABLE 13c
375 mm USGS Wetland Monthly Water Balance (2022)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	62.1	7.9	11.9	375	7.9	0	41.7	11.9	29.9	Surplus
February	99.7	11.2	75.1	375	11.2	0	52.9	75.1	54.4	Surplus
March	59.2	22.9	80.3	375	22.9	0	6.2	80.3	68.9	Surplus
April	53.4	38.4	18.6	375	38.4	0	0	18.6	45.1	Surplus
May	63.7	80.1	-19.5	355.5	80.1	0	0	0	24.4	Soil Water Utilization
June	72.6	104.5	-35.6	321.7	102.7	1.9	0	0	14.2	Soil Water Utilization
July	72.5	122.5	-53.6	275.7	114.9	7.6	0	0	8.9	Soil Water Utilization
August	51	104.7	-56.2	234.4	89.8	14.9	0	0	5.2	Soil Water Utilization
September	86	60.2	21.5	255.9	60.2	0	0	0	5.6	Soil Water Recharge
October	107.5	31.2	70.9	326.8	31.2	0	0	0	6	Soil Water Recharge
November	104.9	18.2	81.5	375	18.2	0	0	33.2	22.2	Surplus
December	64.4	11.9	46.7	375	11.9	0	3.3	46.7	34.3	Surplus
Sum	897				589.4				319.1	

TABLE 14a
400 mm USGS Wetland Monthly Water Balance (2023)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	86.8	12.4	67.2	400	12.4	0	7.2	67.2	52.5	Surplus
February	68.6	13.3	50	400	13.3	0	10.3	50	51.9	Surplus
March	109.8	22.1	89.3	400	22.1	0	4	89.3	74.2	Surplus
April	98.1	42.9	54.3	400	42.9	0	0	54.3	66.8	Surplus
May	34.6	64	-31.2	368.8	64	0	0	0	32.7	Soil Water Utilization
June	74.4	102.6	-31.9	339.4	100.1	2.5	0	0	19.2	Soil Water Utilization
July	163	122.5	32.4	371.7	122.5	0	0	0	15.9	Soil Water Recharge
August	138.7	91.9	39.9	400	91.9	0	0	11.6	16.6	Surplus
September	30.1	63.3	-34.7	365.3	63.3	0	0	0	6.3	Soil Water Utilization
October	62.9	36.5	23.3	388.6	36.5	0	0	0	5.6	Soil Water Recharge
November	53.6	16.5	34.5	400	16.5	0	0	23	15.4	Surplus
December	110.3	14.4	90.3	400	14.4	0	0	90.3	57	Surplus
Sum	1030.9				599.9				414.1	

TABLE 14b
350 mm USGS Wetland Monthly Water Balance (2023)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	86.8	12.4	67.2	350	12.4	0	7.2	67.2	52.9	Surplus
February	68.6	13.3	50	350	13.3	0	10.3	50	52.1	Surplus
March	109.8	22.1	89.3	350	22.1	0	4	89.3	74.3	Surplus
April	98.1	42.9	54.3	350	42.9	0	0	54.3	66.9	Surplus
May	34.6	64	-31.2	318.8	64	0	0	0	32.7	Soil Water Utilization
June	74.4	102.6	-31.9	289.7	99.8	2.8	0	0	19.2	Soil Water Utilization
July	163	122.5	32.4	322.1	122.5	0	0	0	15.9	Soil Water Recharge
August	138.7	91.9	39.9	350	91.9	0	0	12	16.8	Surplus
September	30.1	63.3	-34.7	315.3	63.3	0	0	0	6.4	Soil Water Utilization
October	62.9	36.5	23.3	338.6	36.5	0	0	0	5.6	Soil Water Recharge
November	53.6	16.5	34.5	350	16.5	0	0	23	15.4	Surplus
December	110.3	14.4	90.3	350	14.4	0	0	90.3	57.1	Surplus
Sum	1030.9				599.6				415.3	

TABLE 14c
375 mm USGS Wetland Monthly Water Balance (2023)

Date	P	PET	P-PET	Soil Moisture	AET	PET-AET	Snow Storage	Surplus	ROtotal	Comments
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	
January	86.8	12.4	67.2	375	12.4	0	7.2	67.2	52.7	Surplus
February	68.6	13.3	50	375	13.3	0	10.3	50	52	Surplus
March	109.8	22.1	89.3	375	22.1	0	4	89.3	74.2	Surplus
April	98.1	42.9	54.3	375	42.9	0	0	54.3	66.8	Surplus
May	34.6	64	-31.2	343.8	64	0	0	0	32.7	Soil Water Utilization
June	74.4	102.6	-31.9	314.6	100	2.7	0	0	19.2	Soil Water Utilization
July	163	122.5	32.4	346.9	122.5	0	0	0	15.9	Soil Water Recharge
August	138.7	91.9	39.9	375	91.9	0	0	11.8	16.7	Surplus
September	30.1	63.3	-34.7	340.3	63.3	0	0	0	6.4	Soil Water Utilization
October	62.9	36.5	23.3	363.6	36.5	0	0	0	5.6	Soil Water Recharge
November	53.6	16.5	34.5	375	16.5	0	0	23	15.4	Surplus
December	110.3	14.4	90.3	375	14.4	0	0	90.3	57.1	Surplus
Sum	1030.9				599.8				414.7	

Appendix A

Terms of Reference



Terra-Dynamics Consulting Inc.

432 Niagara Street, Unit 2 St. Catharines, ON L2M 4W3

August 2, 2022

Niagara Peninsula Conservation Authority
250 Thorold Road West, 3rd Floor
Welland, ON L3C 3W2

Re: Updated Water Balance Terms of Reference, Residential Subdivision, 436 Quaker Road, Welland, and Lot 228 /Part Lot 174, Thorold, ON

1.0 Introduction and Background Information

Terra-Dynamics Consulting Inc. respectfully submits this updated Terms of Reference (ToFR) responding to comments provided by the Niagara Peninsula Conservation Authority on the ToFR submitted April 13, 2022. This ToFR is to complete a Site, and wetland feature-based, water balance assessment for the proposed Primont Homes Welland/Thorold Residential Subdivisions. It is our understanding the Site is approximately 64 hectares in size within the City of Welland and the Town of Thorold, and includes 436 Quaker Road in Welland, and Lot 228 and Part Lot 174, Town of Thorold.

The Ministry of Natural Resources and Forestry (MNRF) have mapped approximately 17 hectares of provincially significant wetland at the Site associated with the Niagara Street Cataract Road Woodlot Wetland Complex (MNRF, 2009) including:

1. 5.2 hectares of swamp along Quaker Road and First Avenue in the southeast corner of the Site,
2. 8.2 hectares of swamp in the northern portion of the Site, and
3. 3.6 hectares of marsh in the northeast corner of the Site along Cataract Road.

This scope of work is based upon our experience with the NPCA, and Niagara Region, requiring water balances and our experience studying Niagara's physical environment. Our current understanding of the study requirements are detailed below after a review of information provided by Walter Fedy including a geotechnical investigation report (DS Consultants, 2021), a Conceptual Wetland Restoration Plan (GEI Consultants, 2022) and discussions with GEI Consultants biologists.

2.0 Water Balance Scope of Work

A water balance assessment, both Site and feature-based wetland, will be completed to:

1. Ensure no negative impacts to the natural heritage system;
2. Inform stormwater management design at the Site in such a manner that pre-development water balance conditions are maintained for all wetlands in the Natural Heritage System Designation. A detailed water balance will be required as part of a stormwater management plan submission; and
3. PSW Wetlands be conserved, with the successful matching of pre- and post-development water balances, as best as practical.

Our water balance will address these requirements and be completed following the Conservation Authority Guidelines for Hydrogeological Assessments (see attached Table 1, Conservation Ontario, 2013) and include (i) a description of pre-development conditions, (ii) impact assessment and (iii) recommended mitigation measures for a subdivision on municipal servicing.

The feature-based wetland water balance assessment will evaluate the pre-development hydrologic regime of the Provincially significant wetland areas on-site associated with the Niagara Street Cataract Road Woodlot Wetland Complex (MNRF, 2009).

2.2.1 Field Investigation

Wetland hydroperiod characterization from hydrologic field monitoring includes a year of monitoring at the following locations (Figure 1):

- a) eighteen (18) wetland monitoring staff gauges with datalogging pressure transducers (water level loggers);
- b) datalogging pressure transducers (water level loggers) installed in four (4) on-site shallow monitoring wells (BH21-1, BH21-3, BH21-13 and BH21-14) constructed by DS Consultants (2021) corresponding with the three primary MNRF wetland polygons; and
- c) installation of a barometric pressure data logger to correct for barometric pressure changes on water levels.

Groundwater levels will also be manually measured at the existing on-Site ten (10) monitoring wells in the spring, summer and fall seasons.

Hydraulic conductivity testing will be completed of the four monitoring wells with datalogging pressure transducers installed adjacent the wetlands and compared to hydraulic conductivities calculated from grain-size analyses completed during the geotechnical analyses.

2.2.2 Water Balance/Wetland Modelling

The water balance assessment will use existing long-term water balance modelling by NPCA (AquaResource Inc. and Niagara Peninsula Conservation Authority (NPCA), 2009). This modelling was completed at an hourly interval over a fifteen-year period (1991-2005) providing baseline pre-development water balance values. This approach exceeds the minimum requirements for a “low risk” water balance (Figure 2). Results will be refined using information obtained during the geotechnical investigation and our own field investigations to further refine the hydrogeological characterization.

A water balance model will be completed for the wetland using the United States Geological Survey (USGS) Thornthwaite Monthly Water Balance (McCabe and Markstrom, 2007). The model provides:

- i. A number of adjustable parameters for calibration of pre-development conditions to Niagara Peninsula Conservation Authority (NPCA) water balance modelling (AquaResource Inc. and NPCA, 2009); and

- ii. A monthly water balance, as this is commonly sufficient detail for assessing wetland hydrologic function during summer months on low permeability soils.

Pre- and post-development wetland catchments will be determined, mapped and used for the wetland water balance analyses.

2.2.4 Wetland Risk Evaluation

Since early 2021, NPCA has been requiring water balances conform to the guidelines (2012), monitoring protocols (2016) and risk evaluations (2017) developed by the Toronto Region Conservation Authority (TRCA). This work program will exceed the requirements for “low risk” evaluation as specified by the TRCA and include a risk evaluation (Figure 2, 2017).

2.2.5 Mitigation

The post-development water balance will consider the proposed storm drainage plan and recommendations provided for the Stormwater Management Plan to improve post-development water management completing the water balance requirement for a “mitigation plan” (Figure 2, TRCA, 2017). It is expected that a mitigation plan can be developed to avoid any requirements for new continuous water balance modelling.

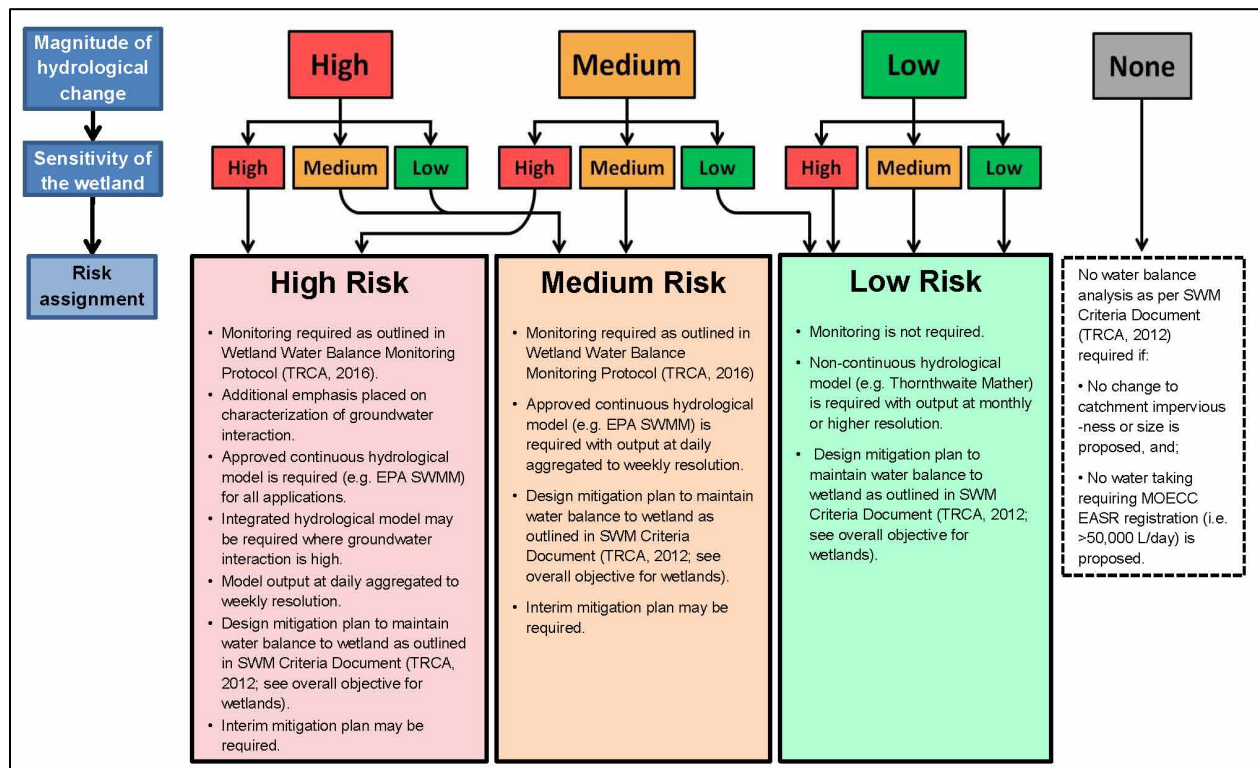


Figure 2 – Wetland Risk Evaluation Decision Tree (TRCA, 2017)

We trust this information is sufficient for your present needs. Thank you for the opportunity to submit this proposed Terms of Reference. Please do not hesitate to contact us if you have any questions.

Yours truly,

TERRA-DYNAMICS CONSULTING INC.



Jayme D. Campbell, P. Eng.
Senior Water Resources Engineer

cc. Eric Salembier, WalterFedy

Attachments

Figure 1 – Monitoring Locations

Table 1 – Hydrogeological Assessment Check List intended to Support Development Applications

7.0 References

AquaResource Inc. and Niagara Peninsula Conservation Authority (NPCA), 2009. Water Availability Study for the Central Welland River, Big Forks Creek, and Beaverdams Shriners Creeks Watershed Plan Areas, Niagara Peninsula Source Protection Area.

Conservation Ontario, 2013. Hydrogeological Assessment Submissions, Conservation Authority Guidelines for Development Applications.

DS Consultants Ltd., 2022. Report on Preliminary Geotechnical Investigation, Quaker Road and First Avenue, Welland, Ontario. Prepared for Primont Homes.

GEI Consultants, 2022. Conceptual Wetland Restoration Plan for removal of unevaluated wetlands on lands owned by Primont Homes within the City of Welland and City of Thorold, Ontario. Prepared for Ian MacPherson, Primont Homes.

McCabe, G.J., and Markstrom, S.L., 2007. A monthly water-balance model driven by a graphical user interface. U.S. Geological Survey Open-File report 2007-1008, 6p.

Ministry of Natural Resources and Forestry (MNRF), 2009. Niagara Street – Cataract Road Wetland Complex, Wetland Evaluation Edition 3rd.

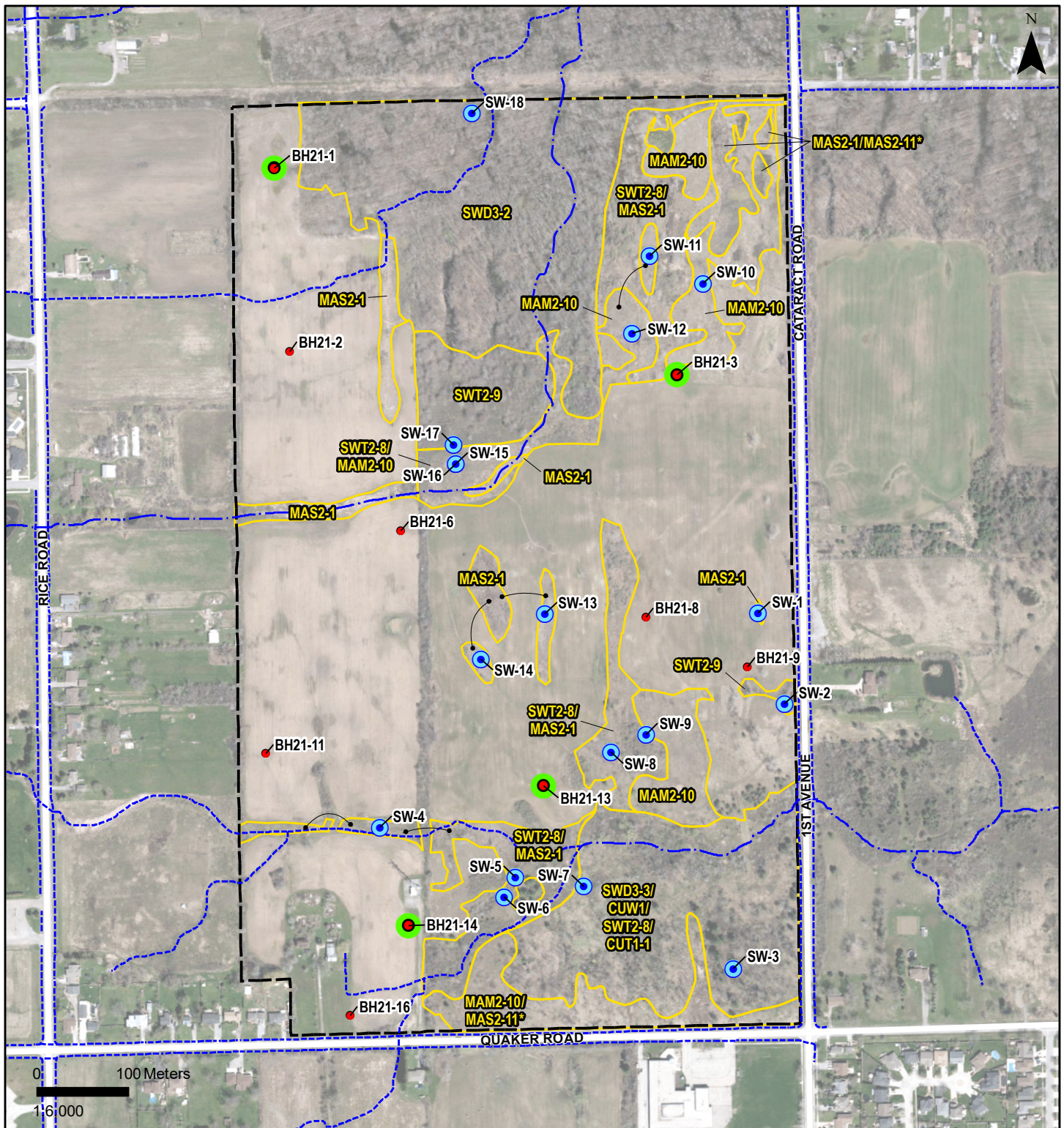
Niagara Peninsula Conservation Authority, 2022. RE: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference. E-mail from Nicholas Godfrey (Watershed Planner) to Jayme Campbell (Senior Water Resource Engineer).

Niagara Peninsula Conservation Authority and AquaResource Inc., 2010. Niagara Peninsula Tier 1 Water Budget and Water Quantity Stress Assessment Final Report, Niagara Peninsula Source Protection Area.

Toronto and Region Conservation Authority (TRCA), 2017. Wetland Water Balance Risk Evaluation.

Toronto and Region Conservation Authority (TRCA), 2016. Wetland Water Balance Monitoring Protocol.

Toronto and Region Conservation Authority (TRCA), 2012. Water Balance Guidelines for the Protection of Natural Features.



- Subject Lands
- Monitoring Well
- Monitoring Well and Datalogger
- ELC Wetland
- Wetland Monitoring Location
- Watercourse (NPCA)
- Ephemeral
- Intermittent or Ephemeral

ELC Code	ELC Name
CUT1-1	Sumac Cultural Thicket
CUW1	Mineral Cultural Woodland
MAM2-10	Forb Mineral Meadow Marsh
MAS2-1	Cattail Mineral Shallow Marsh
MAS2-11*	Southern Arrow-wood Mineral Thicket Swamp
SWD3-2	Silver Maple Mineral Deciduous Swamp
SWD3-3	Swamp Maple Mineral Deciduous Swamp
SWT2-8	Silky Dogwood Mineral Thicket Swamp
SWT2-9	Gray Dogwood Mineral Thicket Swamp

Monitoring Locations

Water Balance, 436 Quaker Rd, Welland
and Lot 228/Lot 174, Thorold, ON
Primont Homes



Terra-Dynamics Consulting Inc.

Figure 1

Table 1: Hydrogeological Assessment Check List intended to Support Development Applications

Groundwater Assessment	Master Environmental Servicing Plan or Equivalent	Environmental Assessment (EA)	Site Plan Commercial, Institutional, or Industrial	Subdivision or Condominium Development		Single lot Residential	Dewatering
				Municipal Servicing	Private Servicing		
1. EXISTING CONDITIONS:							
Introduction and background	☐	☐	☐	☐	☐	☐	☐
Site location and description	☐	☐	☐	☐	☐	☐	☐
Description of: - Topography & Drainage - Physiography - Geology & Soils	☐	☐	☐	☐	☐	☐	☐
Test pits/Boreholes	☐	☐	☐	☐	☐	GNR	☐
Monitoring Wells	☐	☐	☐	☐	☐	GNR	☐
Private Well Survey	☐	☐	☐	☐	☐	GNR	☐
Hydrostratigraphy/Hydrogeology: - Aquifer properties - Groundwater Levels - Groundwater flow direction	☐	☐	☐	☐	☐	☐	☐
Description of surface water features and functions	☐	☐	☐	☐	☐	☐	☐
Water Taking Permit details	GNR	GNR	GNR	GNR	GNR	GNR	☐
Water Quality	☐	☐	☐	☐	☐	GNR	☐
D-5-5 (Water Supply)	GNR	GNR	GNR	GNR	☐	GNR	GNR

Groundwater Assessment	Master Environmental Servicing Plan or Equivalent	Environmental Assessment (EA)	Site Plan Commercial, Institutional, or Industrial	Subdivision or Condominium Development		Single lot Residential	Dewatering
				Municipal Servicing	Private Servicing		
2. IMPACT ASSESSMENT:							
Groundwater Levels	☐	☐	☐	☐	☐	GNR	☐
Pumping Tests*	☐	☐	GNR	GNR	☐	GNR	☐
Groundwater Discharge (Baseflow)	☐	☐	☐	☐	☐	GNR	☐
Water Balance	☐	☐	☐	☐	☐	GNR	GNR
Groundwater Quality	☐	☐	☐	☐	☐	GNR	☐
D-5-4 (Onsite Sewage Systems)	GNR	GNR	GNR	GNR	☐	GNR	GNR
3. MITIGATION MEASURES:							
Maintenance of Infiltration/Recharge	☐	☐	☐	☐	☐	GNR	GNR
Maintenance Groundwater Quality	☐	☐	☐	☐	☐	GNR	☐
Monitoring Program	☐	☐	☐	☐	☐	GNR	☐
Contingency Plans**	GNR	GNR	GNR	☐	☐	GNR	☐

NOTES: This table outlines the type of planning application and associated requirements most commonly required by Conservation Authorities in the review of Hydrogeological Assessments. This table is not a complete list of all types of applications dealt with by each Conservation Authority nor is the checklist appropriate for every development situation. Individual Conservation Authorities should be consulted with for specific requirements.

☐ - Recommended

GNR – Generally Not Required

* Where development is municipally serviced, these tests will be necessary on a case by case basis (sensitive aquifer/ aquatic considerations).

**May be scoped, Contingency Plans will not be needed in most cases.

jcampbell@terra-dynamics.com

From: Taran Lennard <tlennard@npca.ca>
Sent: August 9, 2022 12:46 PM
To: jcampbell@terra-dynamics.com
Cc: 'Eric Salembier'
Subject: RE: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference

Hi Jayme,

The previous comments have been addressed to the satisfaction of NPCA. Staff do not offer further comment on the ToR for the Water Balance.

Thank you.

Taran Lennard
Watershed Planner

Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor | Welland, ON L3C 3W2
Tel: 905-788-3135 | extension 277
email: tlennard@npca.ca

[NPCA Watershed Explorer](#)

Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is open by appointment only with limited staff, please refer to the [Staff Directory](#) and reach out to the staff member you wish to speak or meet with directly.

Updates regarding NPCA operations and activities can be found at [Get Involved NPCA Portal](#), or on social media at facebook.com/NPCAOntario & twitter.com/NPCA_Ontario.

For more information on Permits, Planning and Forestry please go to the Permits & Planning webpage at <https://npca.ca/administration/permits>.

For mapping on features regulated by the NPCA please go to our GIS webpage at <https://gis-npca-camaps.opendata.arcgis.com/> and utilize our Watershed Explorer App or GIS viewer.

To send NPCA staff information regarding a potential violation of Ontario Regulation 155/06 please go to the NPCA Enforcement and Compliance webpage at <https://npca.ca/administration/enforcement-compliance>

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: Tuesday, August 2, 2022 3:27 PM
To: Taran Lennard <tlennard@npca.ca>
Cc: Sarah Mastroianni <smastroianni@npca.ca>; 'Eric Salembier' <esalembier@walterfedy.com>
Subject: RE: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference

Good afternoon Taran,

Please find attached the updated water balance Terms of Reference with the additional information requested by NPCA.

Jayme D. Campbell, P.Eng.

Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
<https://terra-dynamics.com/>

Common sense solutions to environmental challenges

From: Nicholas Godfrey <ngodfrey@npca.ca>
Sent: May 25, 2022 1:07 PM
To: jcampbell@terra-dynamics.com
Cc: Taran Lennard <tlennard@npca.ca>
Subject: RE: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference

Good afternoon Jaymee,

Our office has reviewed the Terms of Reference and offers the following comments:

1. The Terms of Reference has identified that 4 wetland monitoring staff gauges and 4 shallow groundwater monitoring wells (BH21-1, BH21-3, BH21-13 and BH21-14) will be established and/or instrumented with datalogging pressure transducers within the study area. Please provide a figure which identifies the proposed monitoring locations.
2. The Terms of Reference has identified that 10 existing monitoring wells will be manually monitored in spring, summer, and fall, please include the location of these wells on a figure.
3. The Terms of Reference does not specify the intended duration of monitoring. Please identify the duration of monitoring.
4. The Terms of Reference does not discuss catchments of the wetlands present within the study area. Pre and post development catchments must be clearly identified and documented in the report and within a figure.

Please let me know if you have any questions.

Best,

Nicholas Godfrey, M.A.
Watershed Planner
Niagara Peninsula Conservation Authority (NPCA)
250 Thorold Road West, 3rd Floor, Welland, ON, L3C 3W2
905-788-3135, ext. 278
ngodfrey@npca.ca
www.npca.ca

Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is currently closed with limited staff, please refer to the [Staff Directory](#) and reach out to the staff member you wish to speak or meet with directly. Our Conservation Areas are currently open, but may have modified amenities and/or regulations.

Updates regarding NPCA operations and activities can be found at [Get Involved NPCA Portal](#), or on social media at [NPCA's Facebook Page](#) & [NPCA's Twitter page](#).

From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>
Sent: April 19, 2022 10:31 AM

To: 'Eric Salembier' <esalembier@walterfedy.com>

Cc: Sarah Mastroianni <smastroianni@npca.ca>; Nicholas Godfrey <ngodfrey@npca.ca>

Subject: FW: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference

Good morning Eric,

Would you be able to answer Sarah's question?

Thank you.

Jayne D. Campbell, P.Eng.

Senior Water Resource Engineer

Terra-Dynamics Consulting Inc.

432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3

Phone: 289-407-0915

<https://terra-dynamics.com/>

Common sense solutions to environmental challenges

From: Sarah Mastroianni <smastroianni@npca.ca>

Sent: April 19, 2022 10:23 AM

To: Nicholas Godfrey <ngodfrey@npca.ca>

Cc: jcampbell@terra-dynamics.com

Subject: FW: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference

Hi Nick,

As discussed, please take the lead on this one for the NPCA.

Jayne, I don't actually see a file number internally for this one (and Jessica is no longer here to ask), did this one have a municipal preconsultation meeting that you know of?

Thanks.

Sarah Mastroianni

Manager, Planning and Development

Niagara Peninsula Conservation Authority (NPCA)

250 Thorold Road West, 3rd Floor | Welland, ON L3C 3W2

Tel: 905-788-3135 | extension 249

smastroianni@npca.ca

www.npca.ca

[NPCA Watershed Explorer](#)

Due to the COVID-19 pandemic, the NPCA has taken measures to protect staff and public while providing continuity of services. The NPCA main office is open by appointment only with limited staff, please refer to the [Staff Directory](#) and reach out to the staff member you wish to speak or meet with directly.

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From: jcampbell@terra-dynamics.com <jcampbell@terra-dynamics.com>

Sent: Wednesday, April 13, 2022 1:23 PM

To: 'Lampman, Cara' <Cara.Lampman@niagararegion.ca>; Adam.Boudens@niagararegion.ca; Sarah Mastroianni <smastroianni@npca.ca>

Cc: 'Eric Salembier' <esalembier@walterfedy.com>

Subject: Primont Homes Welland/Thorold Hydrogeological Water Balance Terms of Reference

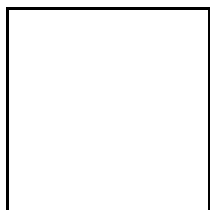
Good afternoon Sarah, Cara and Adam,

Please find attached a proposed hydrogeology water balance terms of reference regarding Primont Homes Welland/Thorold Residential Subdivisions for your review and comment.

If you have any questions regarding the attached please feel free to contact me directly.

Jayne D. Campbell, P.Eng.
Senior Water Resource Engineer
Terra-Dynamics Consulting Inc.
432 Niagara Street, Unit 2, St. Catharines, Ontario L2M 4W3
Phone: 289-407-0915
<https://terra-dynamics.com/>

Common sense solutions to environmental challenges



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www.avast.com

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Appendix B

Borehole and Monitoring Well Logs

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765685 E 641199

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-29-2021

REF. NO.: 21-339-300

ENCL NO.: 2

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT CONTENT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m		STRENGTH (kPa)				W _p	W	W _L			GR	SA	SI	CL
183.5	TOPSOIL: 300 mm		1	SS	5		20	40	60	80	100								
183.2	SILTY SAND: disturbed/reworked, trace organics, brown, moist, loose						20	40	60	80	100								
182.7	SILTY CLAY: trace sand, fine sand seams, brown, very moist to moist, very stiff to firm		2	SS	13		20	40	60	80	100								
1							20	40	60	80	100								
2			3	SS	20		20	40	60	80	100								
3							20	40	60	80	100								
4			4	SS	17		20	40	60	80	100								
5							20	40	60	80	100								
6			5	SS	14		20	40	60	80	100								
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99							20	40	60	80	100								
100							20	40	60	80	100								

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES

+ 3, X 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site
 CLIENT: Primont Homes
 PROJECT LOCATION: Welland, Ontario
 DATUM: Geodetic
 BOREHOLE LOCATION: See Drawing 1 N 4765487 E 641216

DRILLING DATA

Method: Solid Stem Augers
 Diameter: 150 mm
 Date: Oct-29-2021

REF. NO.: 21-339-300

ENCL NO.: 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT			POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20 40 60 80 100	20 40 60 80 100	W _P W W _L	WATER CONTENT (%)	10 20 30	GR SA SI CL							
184.1	TOPSOIL: 300 mm						184													
0.0 183.8	SILTY SAND: disturbed/reworked, trace organics, brown, moist, loose		1	SS	4		183.5													
0.3 183.3							183.4													
0.8	SILTY CLAY: fine sand seams, brown, moist to very moist, very stiff to firm		2	SS	16		183													
1																				
2			3	SS	21		182													
3	very moist below 2.3m		4	SS	9		181													
4																				
5	grey below 3m		5	SS	8		180													
6																				
7	firm below 4.6m		6	SS	4		179													
8				VANE																
9																				
10	silt layers, trace gravel		7	SS	6		178													
11																				
12				VANE			177													
13	END OF BOREHOLE																			
14	Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgl): Nov. 11, 2021 0.7 May 10, 2022 0.68 June 27, 2022 0.54																			

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765461 E 641631

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 4

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		POCKET PEN (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)				
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		W _p		W		W _L				GR	SA	SI	CL	
182.4								20	40	60	80	100										
0.0	TOPSOIL: 350 mm		1	SS	4																	
182.0																						
0.4	CLAYEY SILT: disturbed/reworked, trace organics, brown, moist, firm																					
181.5			2	SS	14																	
0.9	SILTY CLAY: trace sand, silt seams/layers, brown, moist to very moist, very stiff to firm																					
			3	SS	18																	
	grey, very moist below 2.3m		4	SS	17																	
			5	SS	11																	
	wet, firm below 4.6m		6	SS	7																	
				VANE																		
			7	SS	4																	
				VANE																		
175.1																						
7.3	END OF BOREHOLE																					
	Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgl): Nov. 11, 2021 0.35 May 10, 2022 0.52																					

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, × 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765324 E 641710

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 5

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				W _P W W _L								
								○ UNCONFINED + FIELD VANE 												

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

REF. NO.: 21-339-300

Date: Oct-27-2021

ENCL NO.: 6

BOREHOLE LOCATION: See Drawing 1 N 4765353 E 641503

[illegible]

GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ $\epsilon = 3\%$ Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765297 E 641336

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 7

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, X 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site
 CLIENT: Primont Homes
 PROJECT LOCATION: Welland, Ontario
 DATUM: Geodetic
 BOREHOLE LOCATION: See Drawing 1 N 4765120 E 641247

DRILLING DATA
 Method: Solid Stem Augers
 Diameter: 150 mm
 Date: Oct-28-2021
 REF. NO.: 21-339-300
 ENCL NO.: 8

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				W _p	W	W _L			
184.2	TOPSOIL: 300 mm							20	40	60	80	100					GR SA SI CL
183.9	CLAYEY SILT: disturbed/reworked, trace organics, brown, moist, soft		1	SS	3		184										
183.3	SILTY CLAY: trace sand, silt seams/layers, brown, moist to very moist, very stiff to firm		2	SS	15		183										
182			3	SS	24		182								225		
181	grey, very moist, stiff below 3m		4	SS	16		181								225		
180			5	SS	9		180								75		
179	firm below 4.6m		6	SS	7		179										
178.2				VANE			178										
177.5	SILT: some sand, brown, wet, compact		7	SS	28		178										
177.5	END OF BOREHOLE																
177.5	Notes: 1. Borehole wet at 6m depth during drilling.																

GROUNDWATER ELEVATIONS
 Measurement 1st 2nd 3rd 4th

GRAPH NOTES
 + 3, × 3: Numbers refer to Sensitivity
 ○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

REF. NO.: 21-339-300

Date: Oct-27-2021

ENCL NO.: 9

BOREHOLE LOCATION: See Drawing 1 N 4765201 E 641601

GRAPH NOTES + 3, $\times 3$: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

REF. NO.: 21-339-300

Date: Oct-27-2021

ENCL NO.: 10

BOREHOLE LOCATION: See Drawing 1 N 4765147 E 641707

GRAPH NOTES + 3, $\times 3$: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765113 E 641466

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 11

[illegible]

GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ $\epsilon = 3\%$ Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765056 E 641193

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 12

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN. (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							WATER CONTENT (%)		GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765024 E 641312

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 13

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		W _p	W	W _L			
183.8	TOPSOIL: 300 mm							20 40 60 80 100							GR SA SI CL
183.5	SILTY SAND: disturbed/reworked, trace topsoil, brown, moist, loose		1	SS	5			20 40 60 80 100							
183.0	SILTY CLAY: trace sand, brown, moist to very moist, very stiff to firm		2	SS	16		183								
182.0			3	SS	26		182								
181.0	stiff below 2.3m		4	SS	14		181								
180.0	grey, wet, firm below 3m		5	SS	6		180								
179.0			6	SS	6		179								
178.0			7	SS	7		178								
177.0							177								
176.5	END OF BOREHOLE														
7.3	Notes: 1. Borehole wet below 3m depth during drilling.														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, × 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765022 E 641489

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 14

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		POCKET PEN (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		WATER CONTENT (%)		W _P	W	W _L	GR			SA	SI	CL	
								○ UNCONFINED	+ FIELD VANE & Sensitivity	● QUICK TRIAXIAL	× LAB VANE										
183.4	TOPSOIL: 300 mm																				
0.0 183.1	CLAYEY SILT: disturbed/reworked, trace topsoil, brown, moist, firm		1	SS	7																
0.3																					
182.6	SILTY CLAY: trace sand, brown, moist to very moist, very stiff to soft		2	SS	15																
0.8																					
	stiff below 2.3m		3	SS	20																
	grey, wet, firm below 3m		4	SS	12																
			5	SS	5																
				VANE																	
			6	SS	6																
				VANE																	
	soft																				
			7	SS	3																
176.7	END OF BOREHOLE																				
6.7	Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbg): Nov. 11, 2021 0.55 May 10, 2022 0.52 June 27, 2022 0.54																				

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

BOREHOLE LOCATION: See Drawing 1 N 4764872 E 641346

GRAPH NOTES + 3, $\times 3$: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4764896 E 641312

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 16

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							WATER CONTENT (%)			GR	SA	SI	CL
												20			40	60	80				
184.1								FIELD VANE & Sensitivity													
0.0								UNCONFINED +													
183.8								QUICK TRIAXIAL × LAB VANE													
0.3	TOPSOIL: 300 mm		1	SS	5		184														
183.3	CLAYEY SILT: disturbed/reworked, trace topsoil, brown, wet, firm																				
0.8	SILTY CLAY: trace sand, trace gravel, brown, moist to very moist, very stiff to soft		2	SS	17		183														
			3	SS	23		182														
			4	SS	17		181														
			5	SS	11		180														
			6	SS	3		179														
				VANE																	
			7	SS	4		178														
				VANE			177														
176.8	END OF BOREHOLE																				
7.3	Notes: 1. Borehole wet below 4.6m during drilling.																				

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, × 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4764776 E 641281

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 17

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)					W _P	W	W _L			GR	SA	SI	CL
												20									
183.4	0.0	TOPSOIL: 600 mm		1	SS	4															
182.8	0.6	CLAYEY SILT: disturbed/reworked, trace topsoil, brown, wet, firm																			
182.4	1.0	SILTY CLAY: trace sand, trace gravel, brown, moist to very moist, very stiff to firm		2	SS	11															
				3	SS	18															
		stiff below 2.3m		4	SS	9															
		grey, firm below 3m		5	SS	5															
					VANE																
				6	SS	5															
					VANE																
				7	SS	6															
176.7	6.7	END OF BOREHOLE																			
Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgl): Nov. 11, 2021 4.43 May 10, 2022 0.54 June 27, 2022 0.72																					

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Additional Geotechnical Investigation

CLIENT: Primont Homes

PROJECT LOCATION: Quaker Road and First Avenue, Welland, ON

DATUM: Geodetic

BOREHOLE LOCATION: See Figure 1 N 4765406.469 E 641715.248

DRILLING DATA

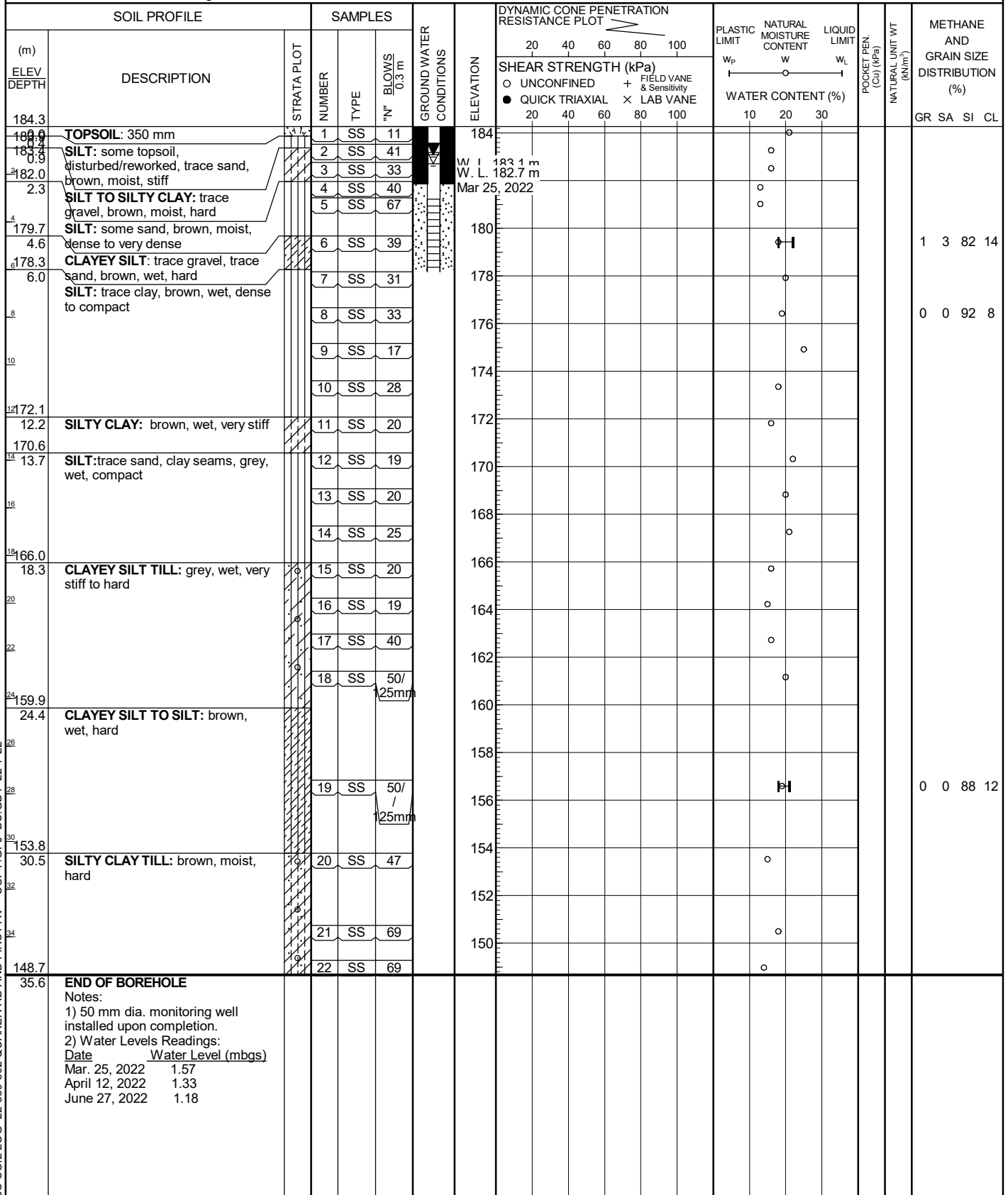
Method: Hollow Stem Auger

Diameter: 200 mm

Date: Mar-08-2022

REF. NO.: 21-339-302

ENCL NO.: 18



GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, X 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Additional Geotechnical Investigation

CLIENT: Primont Homes

PROJECT LOCATION: Quaker Road and First Avenue, Welland, ON

DATUM: Geodetic

BOREHOLE LOCATION: See Figure 1 N 4764772.797 E 641331.348

DRILLING DATA

Method: Hollow Stem Auger

Diameter: 200 mm

Date: Mar-02-2022

REF. NO.: 21-339-302

ENCL NO.: 19

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		SHEAR STRENGTH (kPa)		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		POCKET PEN. (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			20	40	60	80	100	W _p	W	W _L				
183.6	TOPSOIL: 400 mm		1	SS	3		183.4 m												
182.7	SILTY CLAY: disturbed/reworked, brown, moist, soft		2	SS	17		182.7												
182.4	SILTY CLAY: with silt seams, trace gravel, brown, moist to wet, very stiff to firm		3	SS	20														
182.1			4	SS	12														
181.8			5	SS	9														
181.5	layer of silt, grey, wet, loose		6	SS	4														
181.2			VANE																
180.9			7	SS	4														
176.0			8	SS	8														
175.7	SILT: some sand, with clay seams/layers, brown, wet, loose		9	SS	4														
175.4			10	SS	5														
175.1			11	SS	8														
169.9			12	SS	15														
169.6	SILTY CLAY: trace to some gravel, reddish brown, moist, very stiff to hard		13	SS	16														
169.3			14	SS	23														
169.0			15	SS	31														
163.8			16	SS	54														
163.5	CLAYEY SILT TO SILT: trace sand, some clay, brown, moist, hard		17	SS	55														
160.7			18	SS	37														
160.4	CLAYEY SILT TILL: brown, moist, hard to very stiff		19	SS	43														
160.1			20	SS	46														
159.8			21	SS	25														
159.5			22	SS	18														
159.2			23	SS	28														
158.9			24	SS	25														
158.6			25	SS	39														
148.0			26	SS	33														
148.0	END OF BOREHOLE																		
148.0	Notes: 1) 50 mm dia. monitoring well installed at 6.10 mbgs upon completion. 2) Water Levels Readings:																		
148.0	Date Water Level (mbgs)																		
148.0	Mar. 25, 2022 Not Accessible																		
148.0	April 12, 2022 1.15																		
148.0	June 27, 2022 0.17																		

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 22-339-302 QUAKER RD AND FIRST AV - COPY.GPJ DS.GDT 22-7-22

PROJECT: Additional Geotechnical Investigation

CLIENT: Primont Homes

PROJECT LOCATION: Quaker Road and First Avenue, Welland, ON

DATUM: Geodetic

BOREHOLE LOCATION: See Figure 1 N 4764874.239 E 641283.907

DRILLING DATA

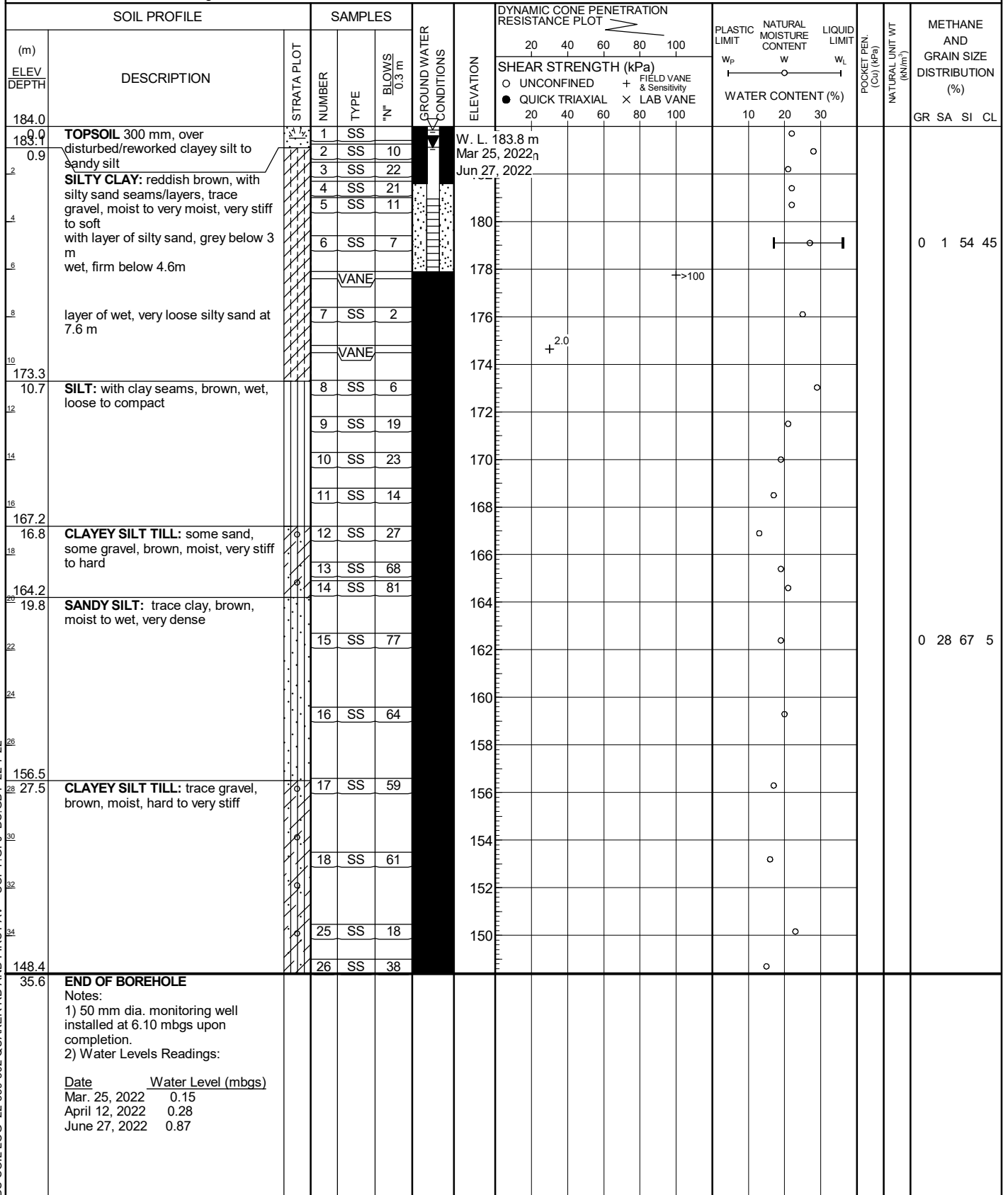
Method: Hollow Stem Auger

Diameter: 200 mm

Date: Mar-03-2022

REF. NO.: 21-339-302

ENCL NO.: 20



GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

Log of Borehole No. 1

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

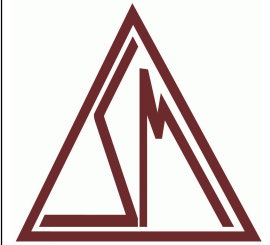
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765186

Client: Primont (Thorold/Welland) Inc.

E: 641731



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content			
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	w%			
												10	20	30	40
Standard Penetration Test															
blows/300mm															
20 40 60 80															

0	ft	m	183.32		Ground Surface										
1					Topsoil	SS	1	3,3,6,8	9		<1.0				
2					Approximately 200 millimetres of topsoil.										
3					Silty Clay/Clayey Silt	SS	2	7,7,9,13	16		>4.5				
4					Brown to reddish brown, some organics in upper levels, firm to very stiff.										
5						SS	3	7,11,16,19	27		>4.5				
6															
7						SS	4	5,7,10,13	17		2.5				
8															
9						SS	5	4,3,5,6	8		1.5				
10					Transition in colour to grey.										
11															
12															
13															
14															
15															
16						SS	6	3,2,4,5	6		<1.0				
17															
18															
19															
20															
21						SS	7	2,2,3,4	5		<1.0				
22															
23															
24															
25															
26															
27						SS	8	1,2,2,4	4		<1.0				
28															
29															
30					Sandy Silt/Silt										
31					Reddish brown, occasional gravel, loose to very dense.	SS	9	6,6,7,8	13						
32															
33															
34															
35															
36						SS	10	6,7,7,6	14						
37															
38															
39															
40															
41						SS	11	3,3,6,7	9						
42															
43															
44															
45															
46						SS	12	4,6,7,10	13						
47															
48															
49															

Drill Method: Hollow Stem Augers

Drill Date: December 07, 2022

Hole Size: 200 Millimetres

Drilling Contractor: Elements Drilling Ltd.

Soil-Mat Engineers & Consultants Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 2

Log of Borehole No. 1

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

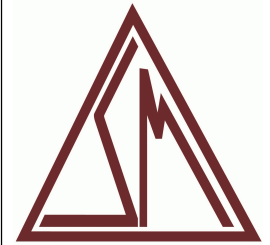
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765186

Client: Primont (Thorold/Welland) Inc.

E: 641731



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE						Moisture Content w%	
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm ²)	U. Wt. (kN/m ³)	10 20 30 40
					Standard Penetration Test blows/300mm							20 40 60 80
50												
51					SS	13	4,6,10,12	16				
52	16											
53												
54												
55												
56	17				SS	14	6,6,8,8	14				
57												
58												
59	18											
60												
61					SS	15	5,7,13,16	20				
62	19											
63												
64												
65	20											
66	162.90				SS	16	9,24,48,50/5"	72				
67			End of Borehole									
68			NOTES: 1. Borehole was advanced using solid stem auger equipment on December 07, 2022 to termination at a depth of 20.4 metres. 2. Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903. 3. Soil samples will be discarded after 3 months unless otherwise directed by our client.									
69	21											
70												
71												
72	22											
73												
74												
75	23											
76												
77												
78	24											
79												
80												
81	25											
82												
83												
84	26											
85												
86												
87	27											
88												
89												
90	28											
91												
92												
93	29											
94												
95												
96	30											
97												
98												

Drill Method: Hollow Stem Augers

Drill Date: December 07, 2022

Hole Size: 200 Millimetres

Drilling Contractor: Elements Drilling Ltd.

Soil-Mat Engineers & Consultants Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 2 of 2

Log of Borehole No. 2

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

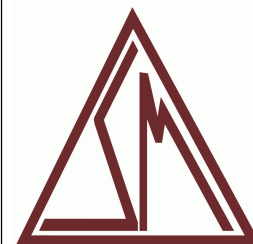
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765226

Client: Primont (Thorold/Welland) Inc.

E: 641680



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content w%						
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)	10	20	30	40			
												Standard Penetration Test blows/300mm				20	40	60
ft	m		Ground Surface															
0	183.26																	
1	182.96		Topsoil Approximately 300 millimetres of topsoil.		SS	1	2,2,3,5	5		2.0								
2			Silty Clay/Clayey Silt Brown, occasional gravel, firm to very stiff.		SS	2	5,7,11,14	18		>4.5								
3					SS	3	6,11,16,21	27		>4.5								
4					SS	4	4,5,6,7	11		1.0								
5	180.83		Transition in colour to grey.		SS	5	4,3,4,6	7		1.5								
6			Sandy Silt/Silt Reddish brown, compact.															
7					SS	6	2,3,3,5	6		<1.0								
8																		
9	177.93				SS	7	5,5,6,10	11										
10			End of Borehole															
11					SS	8	4,7,9,9	16										
12	175.04																	
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
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40																		
41																		
42																		
43																		
44																		
45																		
46																		
47																		
48																		
49																		

NOTES:

- Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.
- Borehole was recorded as caved to 6.0 metres and 'Wet' at a depth of 4.8 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 06, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

Soil-Mat Engineers & Consultants Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 3

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

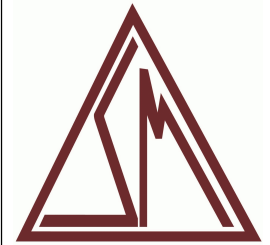
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765364

Client: Primont (Thorold/Welland) Inc.

E: 641633



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content			
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	w%			
												10	20	30	40
Standard Penetration Test															
blows/300mm															
20 40 60 80															
ft	m	183.80	Ground Surface												
0	0		Topsoil		SS	1	3,4,7,5	11		>4.5					
1	1		Approximately 200 millimetres of topsoil.												
2	2		Silty Clay/Clayey Silt		SS	2	5,7,10,12	17		>4.5					
3	3		Brown, occasional gravel, firm to very stiff.												
4	4														
5	5		Sandy Silt/Silt		SS	3	8,11,16,22	27		>4.5					
6	6		Reddish brown, more silt content with depth, trace clay, compact to dense.												
7	7														
8	8				SS	4	22,26,30,44	56							
9	9														
10	10				SS	5	21,23,24,20	47							
11	11														
12	12														
13	13														
14	14														
15	15														
16	16				SS	6	5,6,5,8	11							
17	17														
18	18														
19	19														
20	20														
21	21				SS	7	7,17,22,22	39							
22	22														
23	23														
24	24														
25	25														
26	26				SS	8	13,16,18,23	34							
27	27		End of Borehole												
28	28														
29	29														
30	30														
31	31		NOTES:												
32	32		1. Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.												
33	33														
34	34		2. Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.												
35	35														
36	36														
37	37														
38	38														
39	39														
40	40		3. Soil samples will be discarded after 3 months unless otherwise directed by our client.												
41	41														
42	42														
43	43														
44	44														
45	45														
46	46														
47	47														
48	48														
49	49														

NOTES:

- Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.
- Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 06, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 4

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

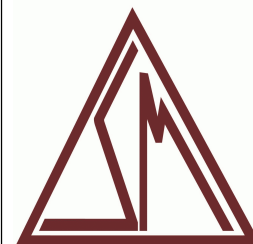
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765208

Client: Primont (Thorold/Welland) Inc.

E: 641522



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content w%				Standard Penetration Test blows/300mm				
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt. (kN/m3)	10	20	30	40	20	40	60	80	
0	183.54		Ground Surface																	
1			Topsoil Approximately 200 millimetres of topsoil.		SS	1	4,5,6,8	11		>4.5										
2					SS	2	5,7,11,16	18		>4.5										
3					SS	3	8,15,19,25	34		>4.5										
4					SS	4	5,6,7,10	13		2.0										
5			Silty Clay/Clayey Silt Brown, firm to hard.																	
6																				
7	180.65		Transition in colour to grey.		SS	5	3,3,4,5	7		<1.0										
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16					SS	6	2,3,4,4	7		<1.0										
17																				
18																				
19																				
20	177.30		Sandy Silt/Silt Reddish brown, trace clay, compact to dense.		SS	7	5,20,22,28	42												
21																				
22																				
23																				
24																				
25																				
26																				
27	175.32				SS	8	6,6,7,7	13												
28			End of Borehole																	
29																				
30																				
31																				
32																				
33																				
34																				
35																				
36																				
37																				
38																				
39																				
40																				
41																				
42																				
43																				
44																				
45																				
46																				
47																				
48																				
49																				

NOTES:

- Borehole was advanced using solid stem auger equipment on December 06, 2022 to termination at a depth of 8.2 metres.
- Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 06, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

Soil-Mat Engineers & Consultants Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 5

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

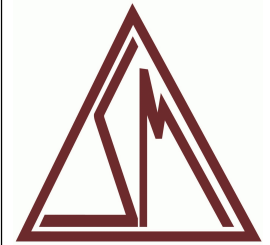
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765091

Client: Primont (Thorold/Welland) Inc.

E: 641718



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content			
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	w%			
												10	20	30	40
												Standard Penetration Test blows/300mm			
20	40	60	80												

0	ft	m	183.12	Ground Surface												
1				Topsoil		SS	1	1,1,1,4	2		>4.5					
2				Approximately 200 millimetres of topsoil.												
3						SS	2	6,8,11,17	19		>4.5					
4		1														
5				Silty Clay/Clayey Silt		SS	3	5,8,11,17	19		>4.5					
6				Brown to reddish brown, firm to very stiff.												
7		2				SS	4	5,6,8,10	14		>4.5					
8																
9						SS	5	3,3,4,4,	7		<1.0					
10		3														
11																
12						SS	6	3,2,3,3	5		<1.0					
13		4	179.01	Transition in colour to grey.												
14																
15		5														
16																
17		6														
18																
19																
20		7	176.42			SS	7	2,2,2,4	4		<1.0					
21				End of Borehole												
22																
23		8		NOTES:												
24				1. Borehole was advanced using solid stem auger equipment on December 07, 2022 to termination at a depth of 6.7 metres.												
25																
26		9		2. Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.												
27																
28		10		3. Soil samples will be discarded after 3 months unless otherwise directed by our client.												
29																
30		11		4. A monitoring well was installed and the following groundwater level readings have been measured:												
31				January 3 2023 : 0.83 metres												
32		12														
33																
34		13														
35																
36		14														
37																
38																
39																
40																
41																
42																
43																
44																
45																
46																
47																
48																
49																

NOTES:

- Borehole was advanced using solid stem auger equipment on December 07, 2022 to termination at a depth of 6.7 metres.
- Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.
- A monitoring well was installed and the following groundwater level readings have been measured:
January 3 2023 : 0.83 metres

Drill Method: Solid Stem Augers

Drill Date: December 07, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

Soil-Mat Engineers & Consultants Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 6

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

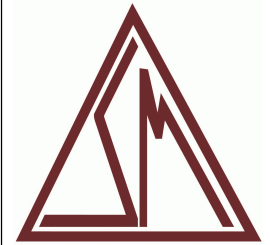
Project: Proposed Residential Development

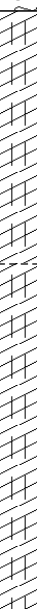
Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765198

Client: Primont (Thorold/Welland) Inc.

E: 641374



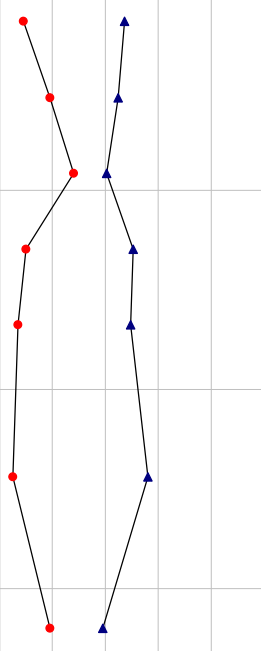
Depth ft m	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content w% ▲ 10 20 30 40 ▲			
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	Standard Penetration Test ● blows/300mm ● 20 40 60 80			
0	183.83		Ground Surface												
1			Topsoil Approximately 200 millimetres of topsoil.	SS	1	2,4,5,7	9		>4.5						
2															
3			Silty Clay/Clayey Silt Brown, firm to very stiff.	SS	2	5,8,11,14	19		>4.5						
4															
5					SS	3	6,9,19,22	28		>4.5					
6															
7	181.09		Transition in colour to grey.	SS	4	4,5,5,6	10		1.0						
8															
9															
10				SS	5	2,3,4,5	7		<1.0						
11															
12															
13															
14															
15															
16				SS	6	2,2,3,5	5		<1.0						
17															
18															
19															
20	177.59														
21			Sandy Silt/Silt Reddish brown, compact.	SS	7	5,7,12,17	19								
22	177.13														
23			End of Borehole												
24															
25															
26															
27															
28															
29															
30															
31															
32															
33															
34															
35															
36															
37															
38															
39															

NOTES:

1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres.

2. Borehole was recorded as 'Wet' at a depth of 5.9 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.

3. Soil samples will be discarded after 3 months unless otherwise directed by our client.



NOTES:

- Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres.
- Borehole was recorded as 'Wet' at a depth of 5.9 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 08, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 7

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

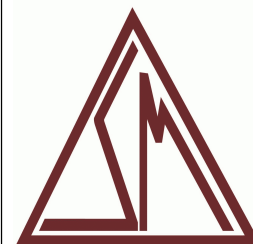
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765042

Client: Primont (Thorold/Welland) Inc.

E: 641421



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE						Moisture Content				
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt.(kN/m3)	w%			
												10	20	30	40
Standard Penetration Test															
● blows/300mm ●															
20 40 60 80															
ft m	183.52		Ground Surface												
0	183.27		Topsoil												
1			Approximately 250 millimetres of topsoil.	SS	1	1,3,5,6	8		>4.5						
2			Silty Clay/Clayey Silt Brown, firm to very stiff.	SS	2	5,7,12,18	19		>4.5						
3	1			SS	3	6,12,14,18	26		>4.5						
4				SS	4	5,6,7,10	13		2.0						
5				SS	5	3,4,4,7	8		2.0						
6	2			SS	6	2,3,4,5	7		<1.0						
7			Transition in colour to grey.												
8			Sandy Silt/Silt Reddish brown, compact.												
9															
10	3														
11															
12															
13	4														
14															
15															
16	5														
17															
18															
19	6														
20															
21															
22	7														
23															
24															
25															
26	8														
27															
28															
29	9														
30															
31															
32															
33	10														
34															
35															
36	1														
37															
38															
39															
NOTES:															
1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres.															
2. Borehole was recorded as caved to 5.9 metres and 'Dry' upon completion and backfilled as per Ontario Regulation 903.															
3. Soil samples will be discarded after 3 months unless otherwise directed by our client.															
4. A monitoring well was installed and the following groundwater level readings have been measured:															
January 3 2023 : 1.6 metres															

Drill Method: Solid Stem Augers

Drill Date: December 08, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 8

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

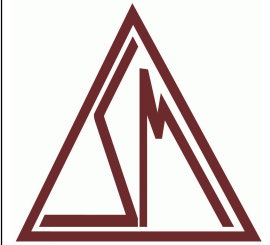
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765199

Client: Primont (Thorold/Welland) Inc.

E: 641192



Depth ft m	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content w% ▲ 10 20 30 40 ▲				
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	Standard Penetration Test ● blows/300mm ● 20 40 60 80				
0	184.94		Ground Surface													
1			Topsoil Approximately 200 millimetres of topsoil.		SS	1	2,3,4,6	7		2.0						
2																
3																
4																
5																
6			Silty Clay/Clayey Silt Brown, occasional gravel, firm to very stiff.		SS	2	4,7,7,12	14		4.0						
7																
8																
9																
10																
11			Transition in colour to grey.													
12																
13																
14																
15																
16			Sandy Silt/Silt Reddish brown, compact.		SS	6	4,4,7,11	11		1.5						
17																
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																
31			End of Borehole													
32																
33																
34																
35																
36																
37																
38																
39																
40																
41																
42																
43																
44																
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48																
49																

NOTES:

- Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 8.2 metres.
- Borehole was recorded as caved to 7.3 metres and 'Wet' at a depth of 6.7 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 08, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 9

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

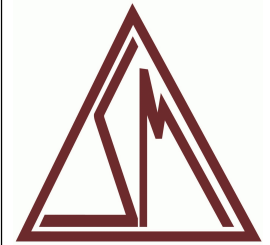
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765253

Client: Primont (Thorold/Welland) Inc.

E: 641229



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content							
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	w%							
												10	20	30	40				
												Standard Penetration Test blows/300mm							
20	40	60	80																
ft	m																		
0	184.05		Ground Surface																
1	183.75		Topsoil Approximately 300 millimetres of topsoil.		SS	1	2,2,4,6	6		4.0									
2			Silty Clay/Clayey Silt Brown, firm to very stiff.		SS	2	6,7,9,11	16		>4.5									
3					SS	3	7,9,11,14	20		>4.5									
4					SS	4	5,9,12,17	21		>4.5									
5					SS	5	4,6,7,8	13		<1.0									
6																			
7	180.40		Transition in colour to grey.																
8	179.94		Sandy Silt/Silt Reddish brown, compact.		SS	6	5,11,13,16	24											
9			End of Borehole NOTES: 1. Borehole was advanced using solid stem auger equipment on December 08, 2022 to termination at a depth of 6.7 metres. 2. Borehole was recorded as caved to 5.4 metres and 'Wet' at a depth of 5.3 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903. 3. Soil samples will be discarded after 3 months unless otherwise directed by our client.																
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21	177.35				SS	7	7,11,14,21	25											
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
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42																			
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45																			
46																			
47																			
48																			
49																			

Drill Method: Solid Stem Augers

Drill Date: December 08, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 10

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

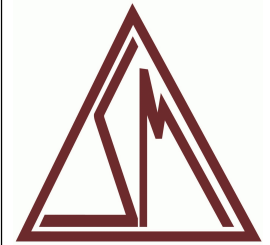
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765588

Client: Primont (Thorold/Welland) Inc.

E: 641174



Depth ft m	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content w% ▲ 10 20 30 40 ▲						
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	Standard Penetration Test ● blows/300mm ● 20 40 60 80						
0	184.23		Ground Surface															
1			Topsoil Approximately 200 millimetres of topsoil.		SS	1	2,1,3,4	4		1.5								
2																		
3				Silty Clay/Clayey Silt Brown, some organics in upper levels, firm to very stiff.		SS	2	4,6,7,11	13		>4.5							
4																		
5						SS	3	5,11,15,18	26		>4.5							
6																		
7					SS	4	5,6,7,9	13		2.5								
8																		
9					SS	5	2,3,4,5	7		1.0								
10	180.73		Transition in colour to grey.															
11																		
12	180.12																	
13			Sandy Silt/Silt Reddish brown, compact to dense.															
14																		
15																		
16						SS	6	6,11,12,14	23									
17																		
18																		
19																		
20																		
21					SS	7	10,16,19,24	35										
22																		
23																		
24																		
25																		
26					SS	8	6,6,9,10	15										
27	176.01																	
28			End of Borehole															
29																		
30																		
31			NOTES:															
32			1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 8.2 metres.															
33																		
34			2. Borehole was recorded as caved to 6.4 metres and 'Wet' at a depth of 5.7 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.															
35																		
36																		
37																		
38																		
39																		
40			3. Soil samples will be discarded after 3 months unless otherwise directed by our client.															
41																		
42																		
43																		
44																		
45																		
46																		
47																		
48																		
49																		

NOTES:

- Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 8.2 metres.
- Borehole was recorded as caved to 6.4 metres and 'Wet' at a depth of 5.7 metres below the existing ground surface upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 09, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 11

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

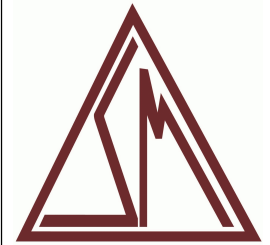
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765518

Client: Primont (Thorold/Welland) Inc.

E: 641270



Depth ft m	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content w%					
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	▲	10 20 30 40		▲		
												Standard Penetration Test blows/300mm					
												●	20 40 60 80		●		
0	183.23		Ground Surface														
1			Topsoil Approximately 200 millimetres of topsoil.		SS	1	2,2,5,5	7		2.0							
2			Silty Clay/Clayey Silt Brown, some organics in upper levels, firm to very stiff.		SS	2	3,4,7,11	11		>4.5							
3					SS	3	4,7,12,16	19		>4.5							
4					SS	4	4,7,8,10	15		2.5							
5	180.64		Transition in colour to grey.		SS	5	3,4,3,7	9		2.0							
6					SS	6	3,3,5,7	8		1.5							
7	176.53		End of Borehole		SS	7	2,3,3,4	6		<1.0							
8			NOTES:														
9			1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 6.7 metres.														
10			2. Borehole was recorded as 'Wet' at a depth of 5.4 metres upon completion and backfilled as per Ontario Regulation 903.														
11			3. Soil samples will be discarded after 3 months unless otherwise directed by our client.														
12			4. A monitoring well was installed and the following groundwater level readings have been measured: January 3 2023 : 0.0 metres														

Drill Method: Solid Stem Augers

Drill Date: December 09, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 12

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

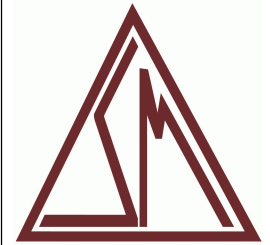
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4765409

Client: Primont (Thorold/Welland) Inc.

E: 641213



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content			
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	w%			
												10	20	30	40
Standard Penetration Test															
blows/300mm															
20 40 60 80															

0	ft	m	184.19		Ground Surface										
1						Topsoil		SS	1	0,2,3,5	5		1.5		
2						Approximately 200 millimetres of topsoil.									
3								SS	2	5,8,10,13	18		>4.5		
4						Silty Clay/Clayey Silt									
5						Brown, firm to very stiff.		SS	3	5,8,12,16	20		>4.5		
6															
7								SS	4	6,10,13,16	23		>4.5		
8															
9								SS	5	4,5,7,7	12		1.5		
10						Transition in colour to grey.									
11															
12															
13															
14															
15															
16															
17								SS	6	3,5,15,19	20		1.5		
18						Sandy Silt/Silt									
19						Reddish brown, compact to dense.									
20															
21															
22								SS	7	12,16,21,25	37				
23															
24															
25															
26															
27								SS	8	12,14,26,28	40				
28						End of Borehole									
29															
30															
31						NOTES:									
32						1. Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 8.2 metres.									
33															
34															
35															
36															
37						2. Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.									
38															
39															
40						3. Soil samples will be discarded after 3 months unless otherwise directed by our client.									
41															
42															
43															
44															
45															
46															
47															
48															
49															

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NOTES:

- Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 8.2 metres.
- Borehole was recorded as open and 'Dry' upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 09, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Log of Borehole No. 13

Project No: SM 220530-G

Project Manager: Ian Shaw, P.Eng.

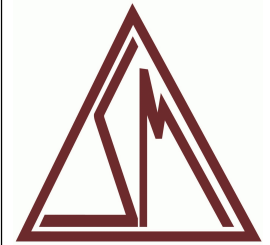
Project: Proposed Residential Development

Borehole Location: See Drawing No. 1

Location: Quaker Road & First Avenue, Welland **UTM Coordinates - N:** 4764871

Client: Primont (Thorold/Welland) Inc.

E: 641196



Depth	Elevation (m)	Symbol	Description	Well Data	SAMPLE							Moisture Content						
					Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U. Wt. (kN/m3)	w%						
												10	20	30	40			
											Standard Penetration Test							
											blows/300mm							
											20	40	60	80				
0	183.94		Ground Surface															
1			Topsoil Approximately 200 millimetres of topsoil.		SS	1	0,2,3,6	5		1.5								
2																		
3						SS	2	5,7,8,11	15		>4.5							
4																		
5						SS	3	7,7,10,15	17		>4.5							
6			Silty Clay/Clayey Silt Brown, firm to very stiff.															
7																		
8																		
9																		
10																		
11																		
12					SS	4	6,12,16,19	28		>4.5								
13																		
14																		
15																		
16																		
17	178.76				SS	5	4,7,8,11	15		3.0								
18																		
19																		
20																		
21																		
22	177.24																	
23					SS	6	3,4,8,8	12		<1								
24																		
25																		
26																		
27																		
28																		
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48																		
49																		

NOTES:

- Borehole was advanced using solid stem auger equipment on December 09, 2022 to termination at a depth of 6.7 metres.
- Borehole was recorded as 'Wet' at a depth of 5.6 metres upon completion and backfilled as per Ontario Regulation 903.
- Soil samples will be discarded after 3 months unless otherwise directed by our client.

Drill Method: Solid Stem Augers

Drill Date: December 09, 2022

Hole Size: 150 Millimetres

Drilling Contractor: Elements Drilling Ltd.

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Datum: Geodetic

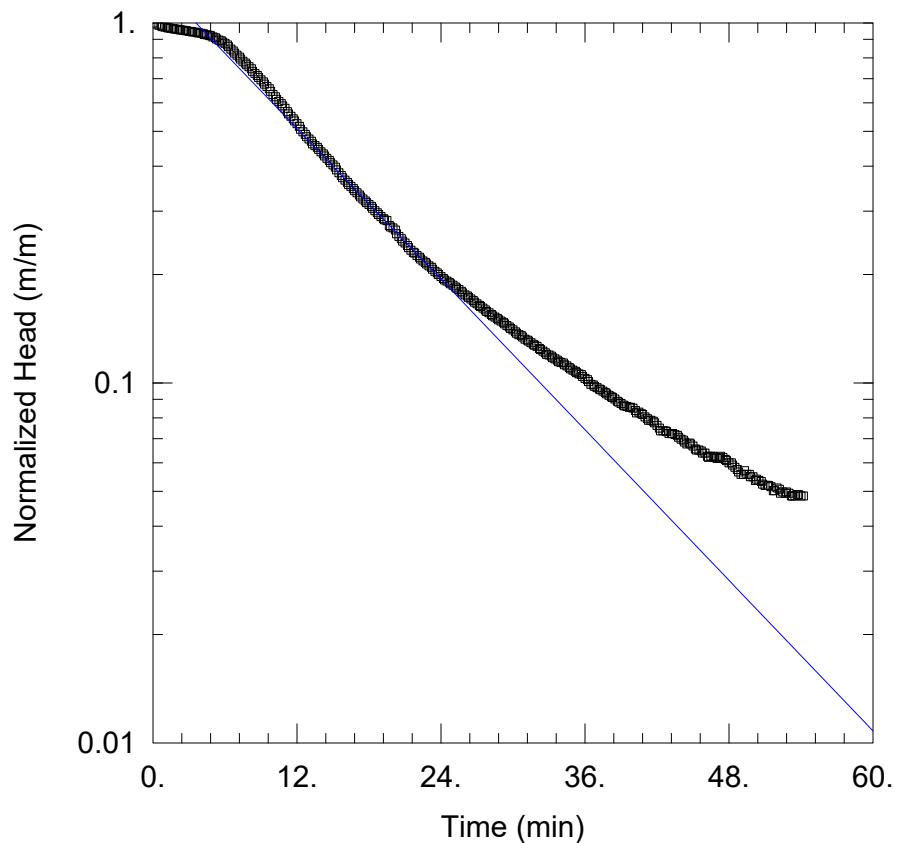
Field Logged by: IC

Checked by: IS

Sheet: 1 of 1

Appendix C

Hydraulic Conductivity Analyses



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_01_new_2023.aqt

Date: 05/16/23

Time: 15:01:11

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-1

Test Date: May 10, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 4.831\text{E-}7$ m/sec

$y_0 = 3.131$ m

AQUIFER DATA

Saturated Thickness: 7.96 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-1)

Initial Displacement: 2.35 m

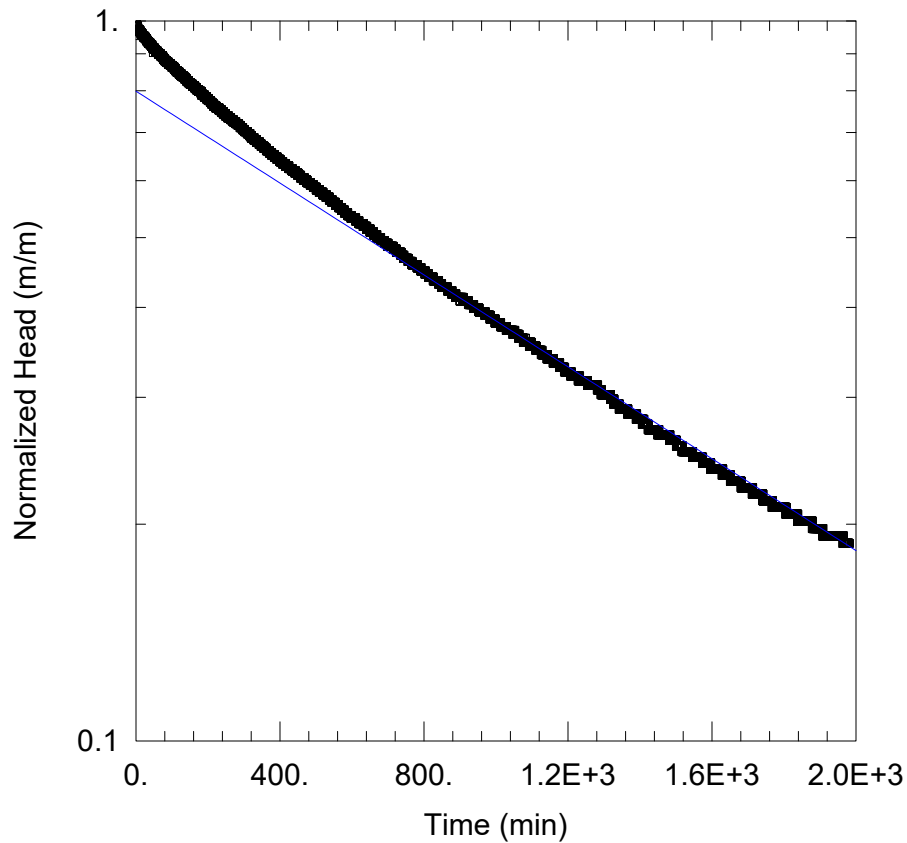
Total Well Penetration Depth: 7.96 m

Casing Radius: 0.0254 m

Static Water Column Height: 7.96 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_02.aqt

Date: 05/16/23

Time: 16:09:23

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-02

Test Date: May 10, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 4.131\text{E-}9$ m/sec

$y_0 = 1.741$ m

AQUIFER DATA

Saturated Thickness: 5.47 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-02)

Initial Displacement: 2.18 m

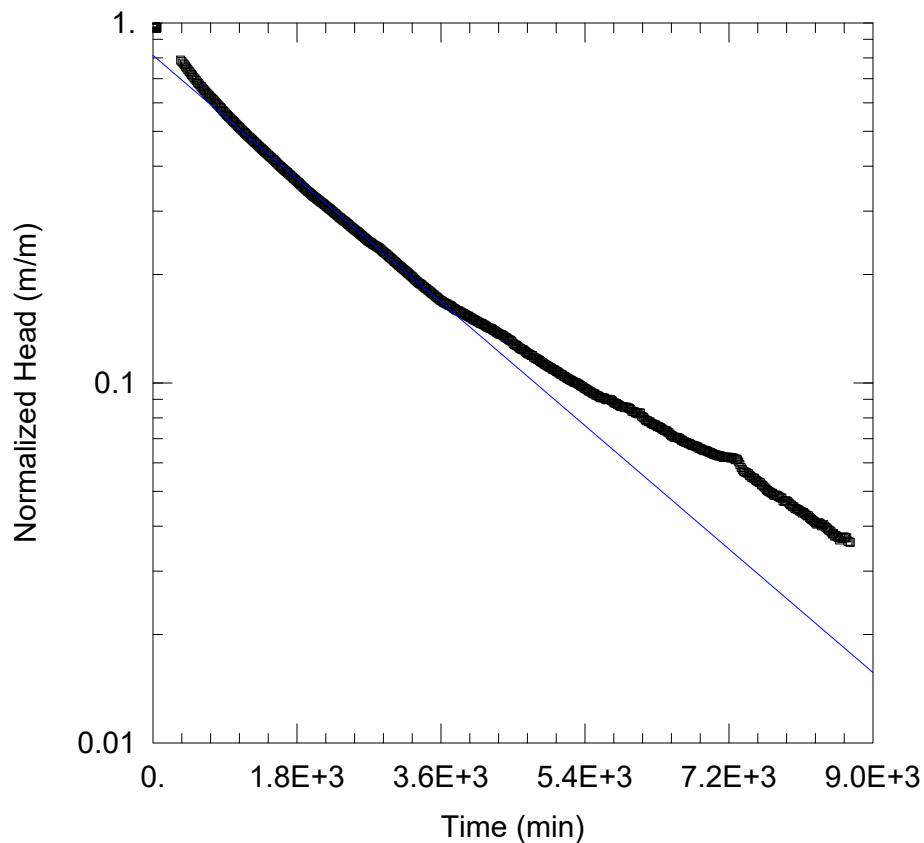
Total Well Penetration Depth: 5.47 m

Casing Radius: 0.0254 m

Static Water Column Height: 5.47 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_3.aqt

Date: 05/08/23

Time: 10:16:51

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-3

Test Date: November 9, 2022

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 2.611E-9$ m/sec

$y_0 = 1.596$ m

AQUIFER DATA

Saturated Thickness: 4.552 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-3)

Initial Displacement: 1.963 m

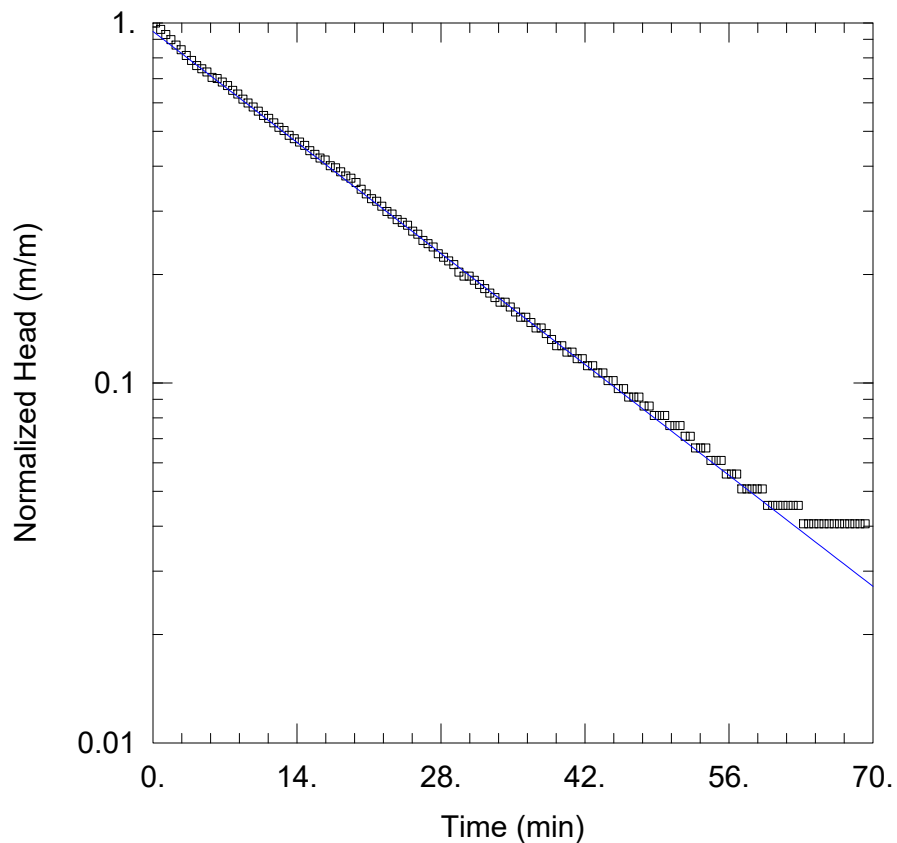
Total Well Penetration Depth: 4.55 m

Casing Radius: 0.0254 m

Static Water Column Height: 4.552 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_06.aqt

Date: 05/16/23

Time: 15:57:15

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-06

Test Date: May 10, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 2.858E-7$ m/sec

$y_0 = 1.866$ m

AQUIFER DATA

Saturated Thickness: 5.54 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-06)

Initial Displacement: 1.97 m

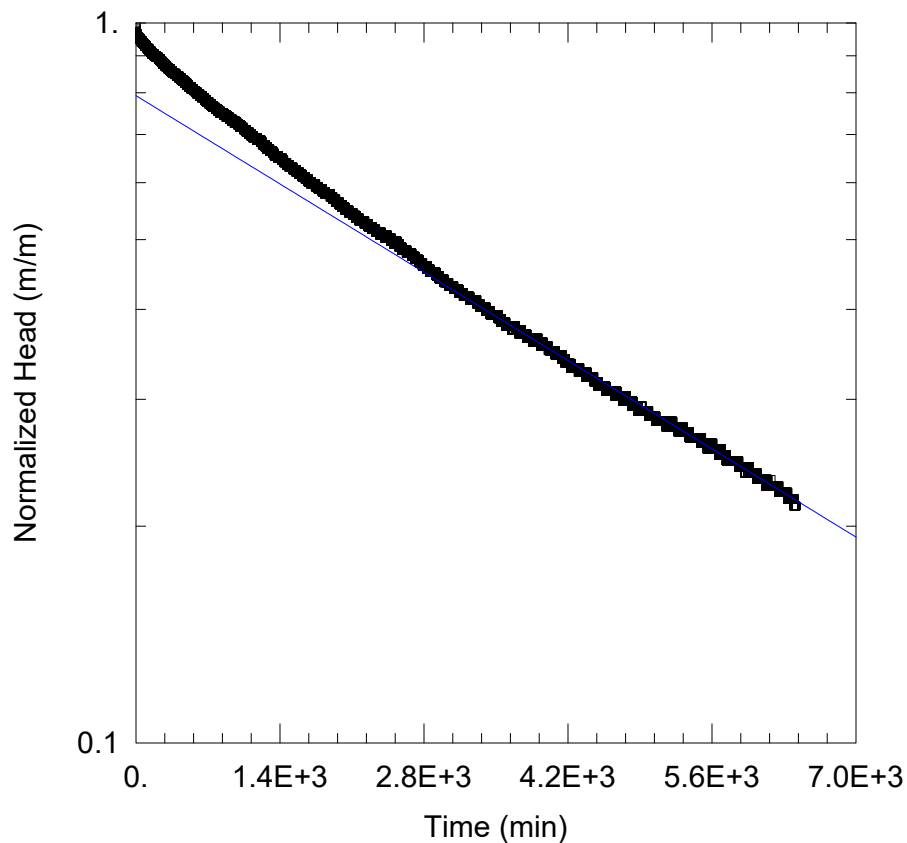
Total Well Penetration Depth: 5.54 m

Casing Radius: 0.0254 m

Static Water Column Height: 5.54 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_11.aqt

Date: 05/16/23

Time: 15:42:38

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-11

Test Date: May 10, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 1.179\text{E-}9$ m/sec

$y_0 = 1.672$ m

AQUIFER DATA

Saturated Thickness: 6.75 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-11)

Initial Displacement: 2.11 m

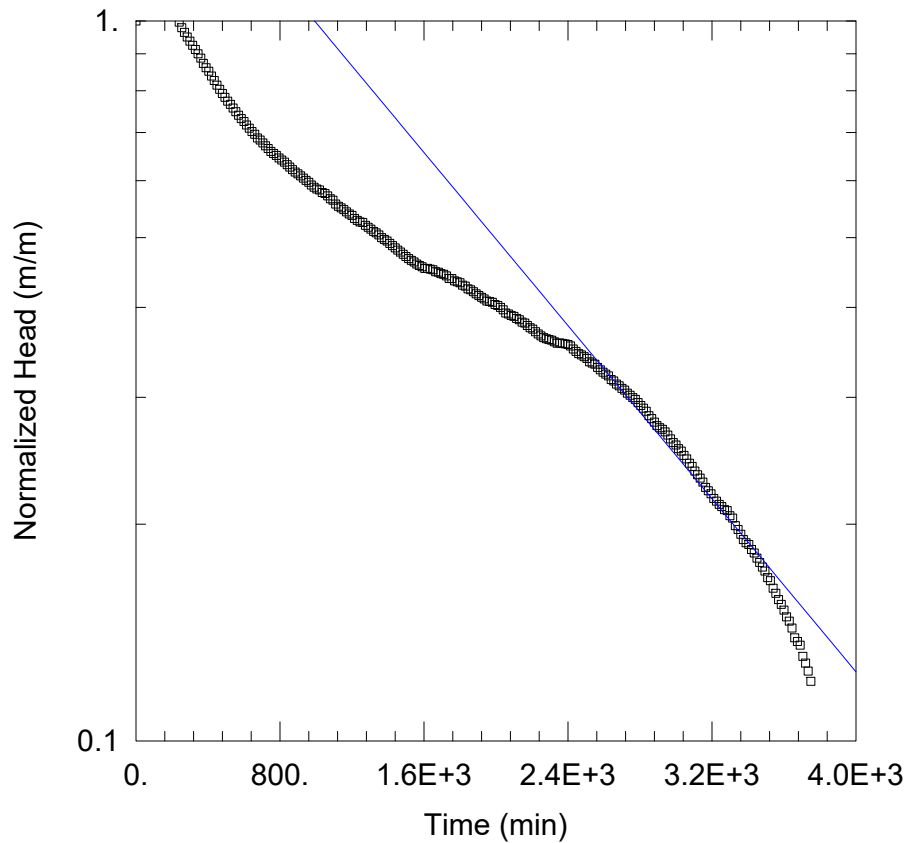
Total Well Penetration Depth: 6.75 m

Casing Radius: 0.0254 m

Static Water Column Height: 6.75 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_13.aqt

Date: 05/08/23

Time: 10:07:41

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-13

Test Date: November 9, 2022

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 3.617E-9$ m/sec

$y_0 = 0.9899$ m

AQUIFER DATA

Saturated Thickness: 3.801 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-13)

Initial Displacement: 0.4983 m

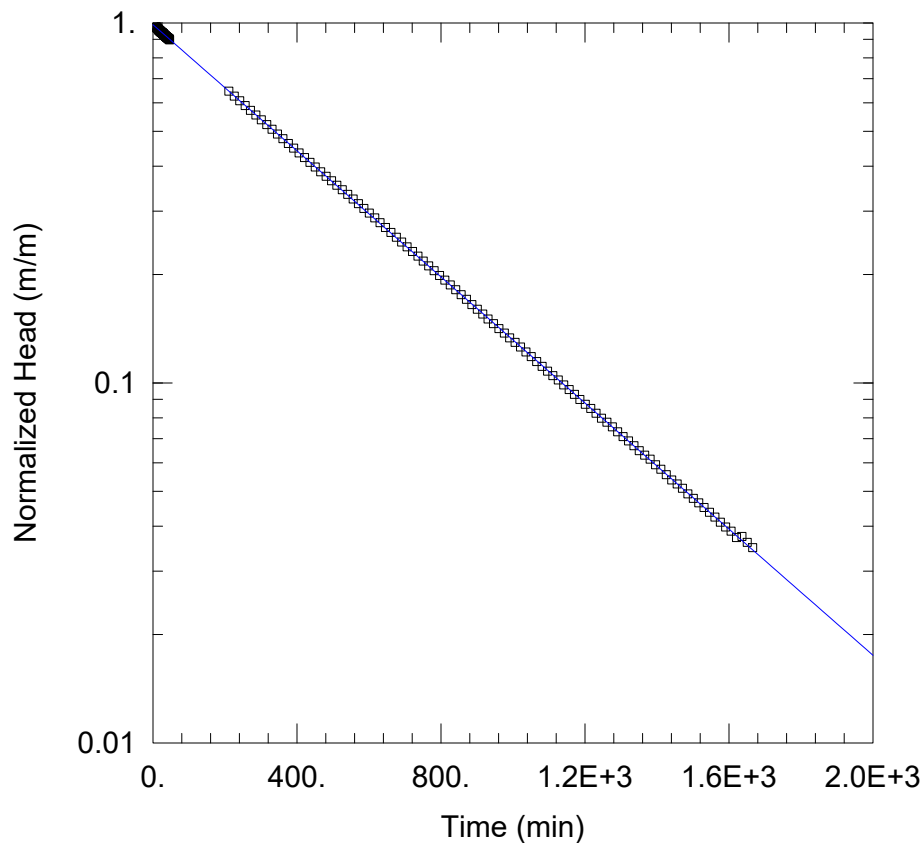
Total Well Penetration Depth: 3.801 m

Casing Radius: 0.0254 m

Static Water Column Height: 3.801 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_14.aqt

Date: 05/08/23

Time: 09:50:10

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-14

Test Date: November 9, 2022

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 1.132E-8$ m/sec

$y_0 = 2.166$ m

AQUIFER DATA

Saturated Thickness: 5.38 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-14)

Initial Displacement: 2.191 m

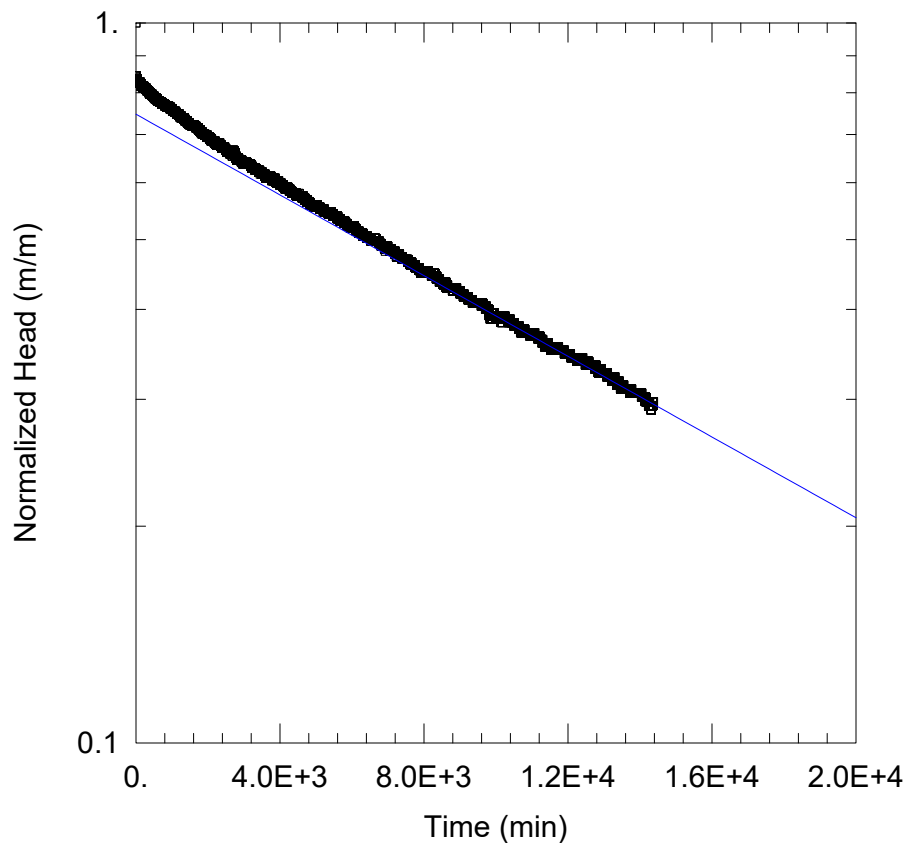
Total Well Penetration Depth: 5.433 m

Casing Radius: 0.0254 m

Static Water Column Height: 5.38 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH21_16.aqt

Date: 05/17/23

Time: 11:24:15

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH21-16

Test Date: May 5, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 3.583E-10$ m/sec

$y_0 = 1.83$ m

AQUIFER DATA

Saturated Thickness: 5.13 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH21-16)

Initial Displacement: 2.45 m

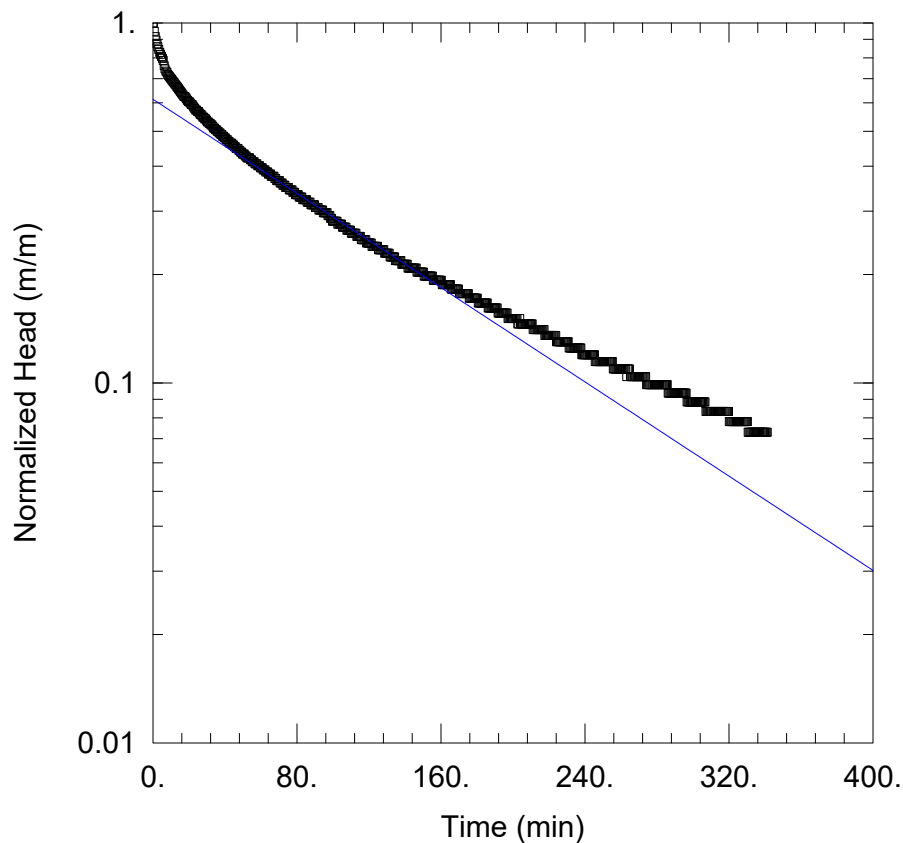
Total Well Penetration Depth: 5.13 m

Casing Radius: 0.0254 m

Static Water Column Height: 5.13 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH22_02.aqt

Date: 05/17/23

Time: 10:41:00

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH22-02

Test Date: May 5, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 4.158E-8$ m/sec

$y_0 = 1.178$ m

AQUIFER DATA

Saturated Thickness: 4.97 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH22-02)

Initial Displacement: 1.92 m

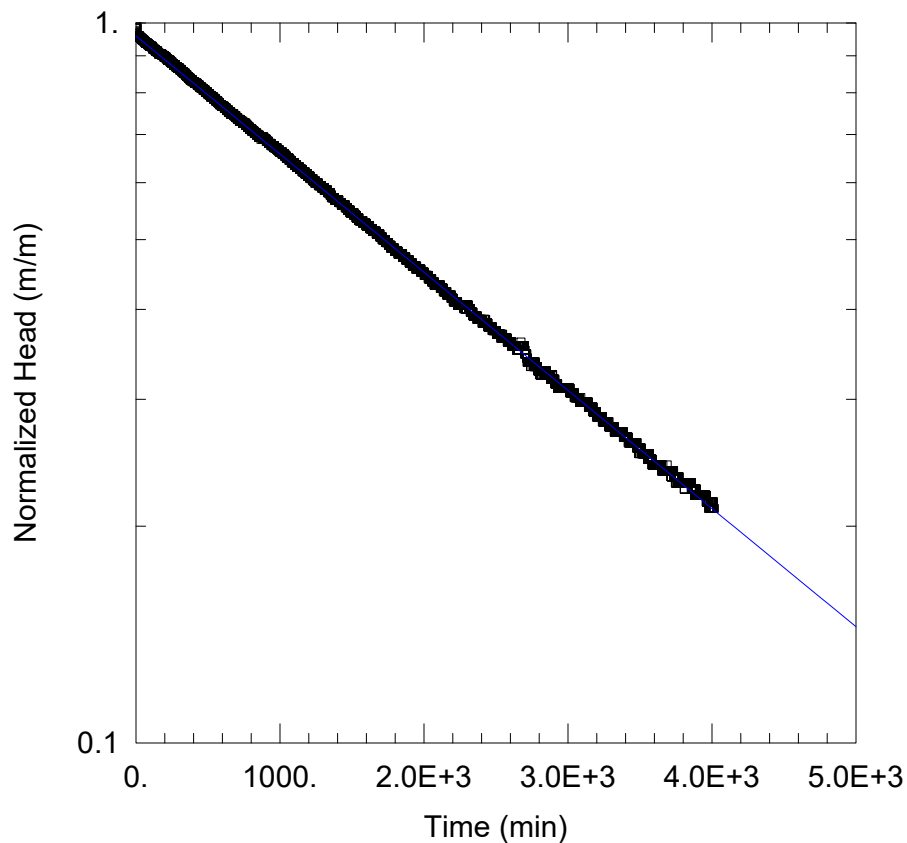
Total Well Penetration Depth: 4.97 m

Casing Radius: 0.0254 m

Static Water Column Height: 4.97 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\BH22_03.aqt

Date: 05/17/23

Time: 10:49:31

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: BH22-03

Test Date: May 5, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 2.151\text{E-}9$ m/sec

$y_0 = 2.129$ m

AQUIFER DATA

Saturated Thickness: 5.84 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH22-03)

Initial Displacement: 2.22 m

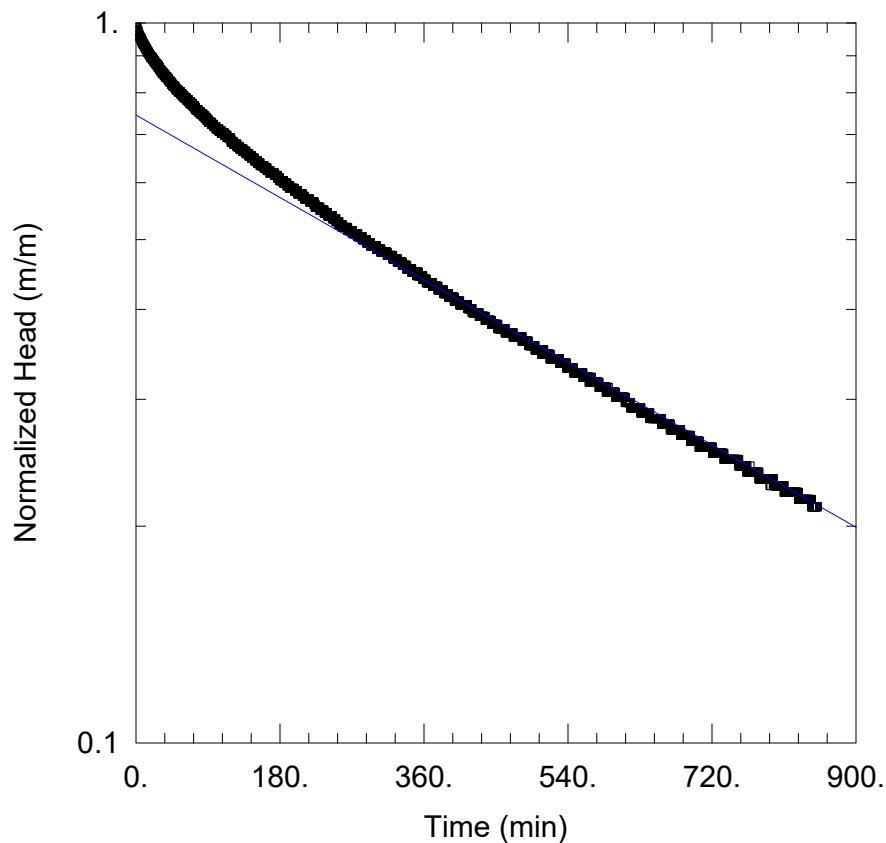
Total Well Penetration Depth: 5.84 m

Casing Radius: 0.0254 m

Static Water Column Height: 5.84 m

Screen Length: 3.05 m

Well Radius: 0.075 m



BAIL-DOWN RECOVERY

Data Set: C:\...\MW11_SM.aqt

Date: 05/17/23

Time: 11:36:55

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.

Client: Primont (Welland/Thorold) Inc.

Location: Welland/Thorold, ON

Test Well: MW-11 SM

Test Date: May 10, 2023

SOLUTION

Aquifer Model: Confined

Solution Method: Bouwer-Rice

$K = 8.132\text{E-}9$ m/sec

$y_0 = 1.424$ m

AQUIFER DATA

Saturated Thickness: 6.31 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (MW-11 SM)

Initial Displacement: 2.02 m

Total Well Penetration Depth: 6.31 m

Casing Radius: 0.0254 m

Static Water Column Height: 6.31 m

Screen Length: 3.05 m

Well Radius: 0.075 m



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-2 SS5 Primont Homes, Welland

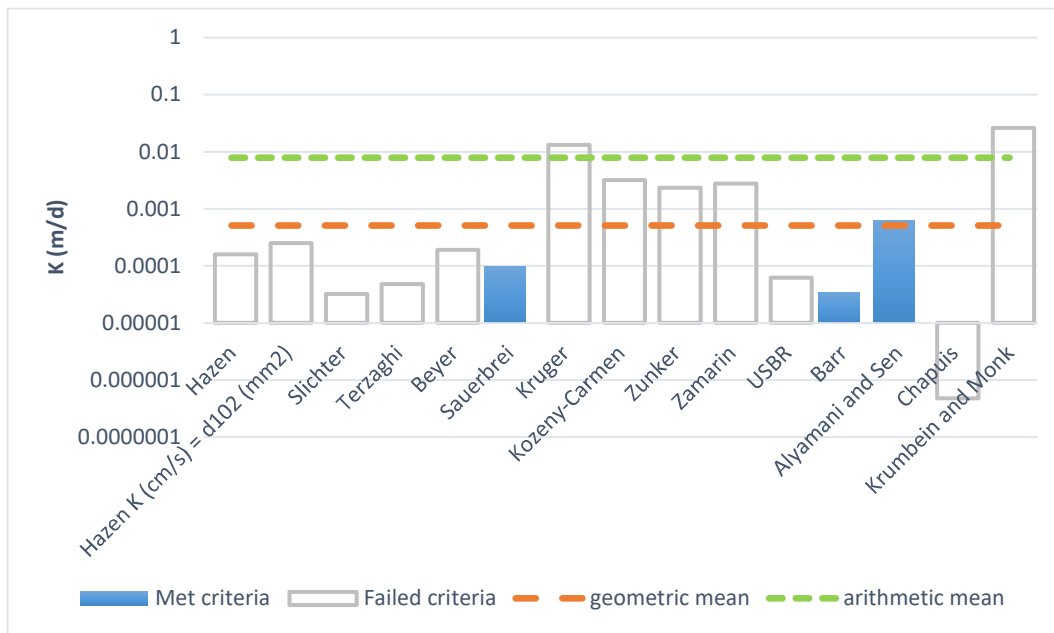
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	2.E-07	2.E-09	0.00	
Hazen K (cm/s) = d_{10} (mm)	3.E-07	3.E-09	0.00	
Slichter	4.E-08	4.E-10	0.00	
Terzaghi	6.E-08	6.E-10	0.00	
Beyer	2.E-07	2.E-09	0.00	
Sauerbrei	1.E-07	1.E-09	0.00	
Kruger	2.E-05	2.E-07	0.01	
Kozeny-Carmen	4.E-06	4.E-08	0.00	
Zunker	3.E-06	3.E-08	0.00	
Zamarin	3.E-06	3.E-08	0.00	
USBR	7.E-08	7.E-10	0.00	
Barr	4.E-08	4.E-10	0.00	
Alayamani and Sen	7.E-07	7.E-09	0.00	
Chapuis	6.E-10	6.E-12	0.00	
Krumbein and Monk	3.E-05	3.E-07	0.03	
Shepherd	4.E-05	4.E-07	0.03	
geometric mean	6.E-07	6.E-09	0.00	
arithmetic mean	9.E-06	9.E-08	0.01	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-3 SS5 Primont Homes, Welland

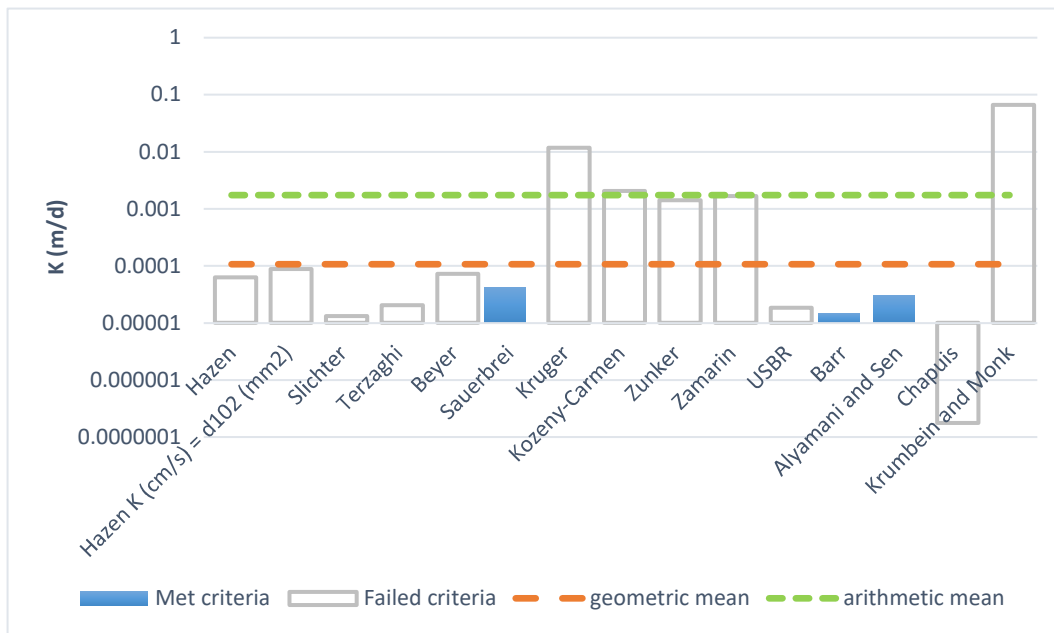
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	7.E-08	7.E-10	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	1.E-07	1.E-09	0.00	
Slichter	2.E-08	2.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	8.E-08	8.E-10	0.00	
Sauerbrei	5.E-08	5.E-10	0.00	
Kruger	1.E-05	1.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	2.E-08	2.E-10	0.00	
Barr	2.E-08	2.E-10	0.00	
Alayamani and Sen	4.E-08	4.E-10	0.00	
Chapuis	2.E-10	2.E-12	0.00	
Krumbein and Monk	8.E-05	8.E-07	0.07	
Shepherd	8.E-06	8.E-08	0.01	
geometric mean	1.E-07	1.E-09	0.00	
arithmetic mean	2.E-06	2.E-08	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-6 SS5 Primont Homes, Welland

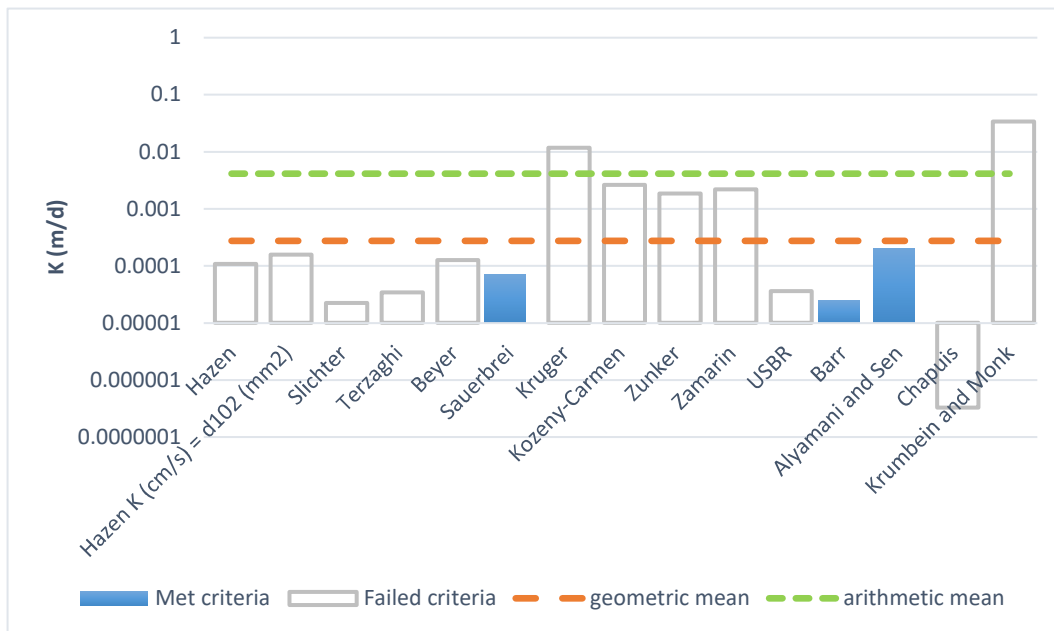
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	1.E-07	1.E-09	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	2.E-07	2.E-09	0.00	
Slichter	3.E-08	3.E-10	0.00	
Terzaghi	4.E-08	4.E-10	0.00	
Beyer	1.E-07	1.E-09	0.00	
Sauerbrei	8.E-08	8.E-10	0.00	
Kruger	1.E-05	1.E-07	0.01	
Kozeny-Carmen	3.E-06	3.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	3.E-06	3.E-08	0.00	
USBR	4.E-08	4.E-10	0.00	
Barr	3.E-08	3.E-10	0.00	
Alaymani and Sen	2.E-07	2.E-09	0.00	
Chapuis	4.E-10	4.E-12	0.00	
Krumbein and Monk	4.E-05	4.E-07	0.03	
Shepherd	2.E-05	2.E-07	0.02	
geometric mean	3.E-07	3.E-09	0.00	
arithmetic mean	5.E-06	5.E-08	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-8 SS5 Primont Homes, Welland

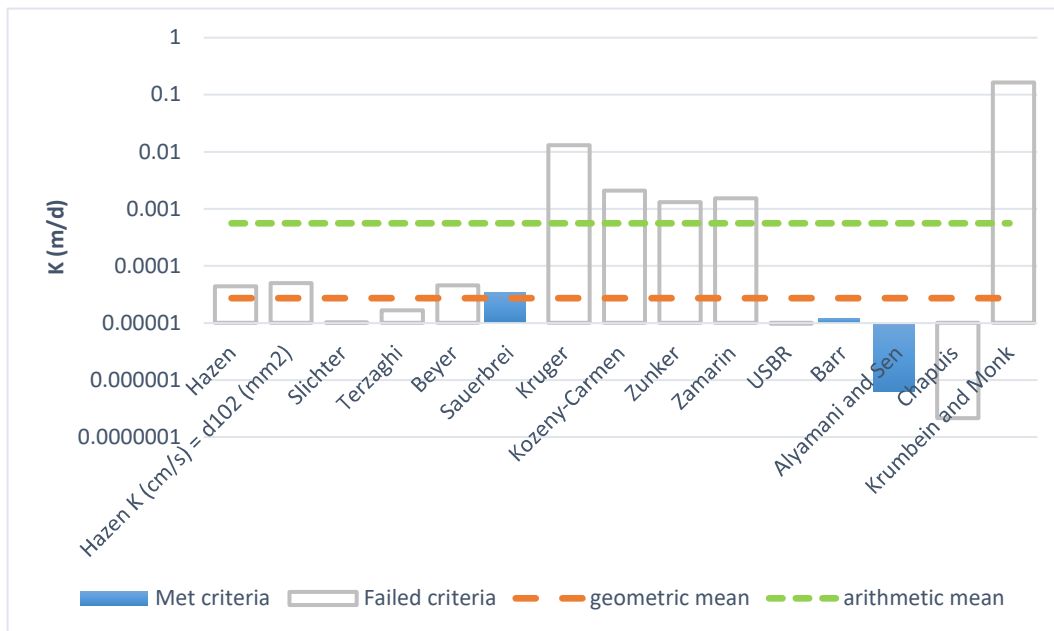
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	5.E-08	5.E-10	0.00	
Hazen K (cm/s) = d_{10}^2 (mm)	6.E-08	6.E-10	0.00	
Slichter	1.E-08	1.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	5.E-08	5.E-10	0.00	
Sauerbrei	4.E-08	4.E-10	0.00	
Kruger	2.E-05	2.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	1.E-08	1.E-10	0.00	
Barr	1.E-08	1.E-10	0.00	
Alaymani and Sen	7.E-10	7.E-12	0.00	
Chapuis	2.E-10	2.E-12	0.00	
Krumbein and Monk	2.E-04	2.E-06	0.16	
Shepherd	3.E-06	3.E-08	0.00	
geometric mean	3.E-08	3.E-10	0.00	
arithmetic mean	6.E-07	6.E-09	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-9 SS5 Primont Homes, Welland

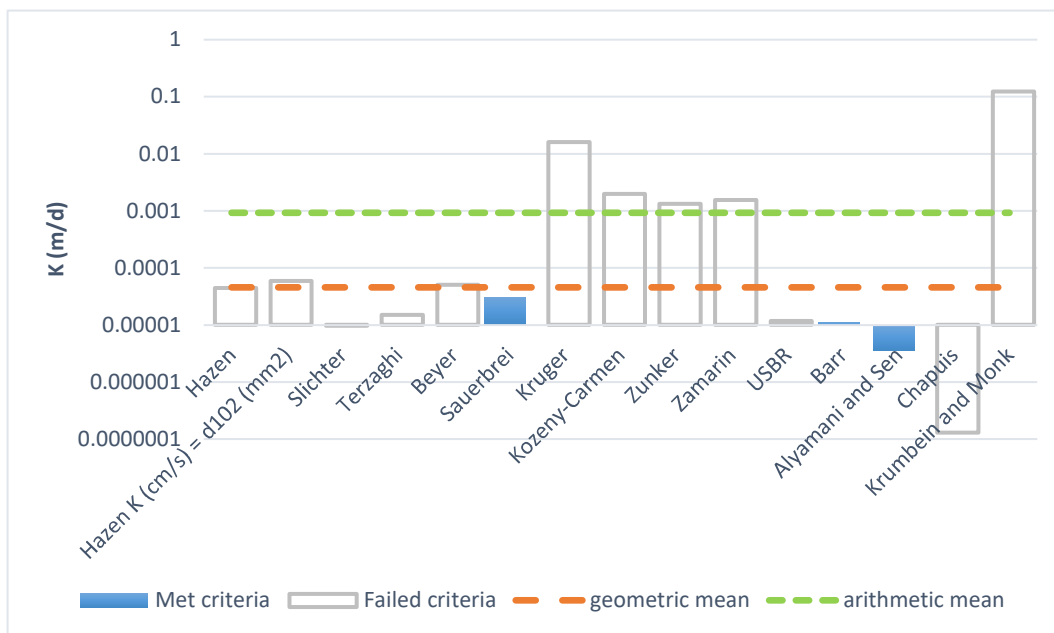
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	5.E-08	5.E-10	0.00	
Hazen K (cm/s) = d_{10}^2 (mm)	7.E-08	7.E-10	0.00	
Slichter	1.E-08	1.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	6.E-08	6.E-10	0.00	
Sauerbrei	4.E-08	4.E-10	0.00	
Kruger	2.E-05	2.E-07	0.02	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	1.E-08	1.E-10	0.00	
Barr	1.E-08	1.E-10	0.00	
Alaymani and Sen	4.E-09	4.E-11	0.00	
Chapuis	1.E-10	1.E-12	0.00	
Krumbein and Monk	1.E-04	1.E-06	0.12	
Shepherd	4.E-06	4.E-08	0.00	
geometric mean	5.E-08	5.E-10	0.00	
arithmetic mean	1.E-06	1.E-08	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-11 SS5 Primont Homes, Welland

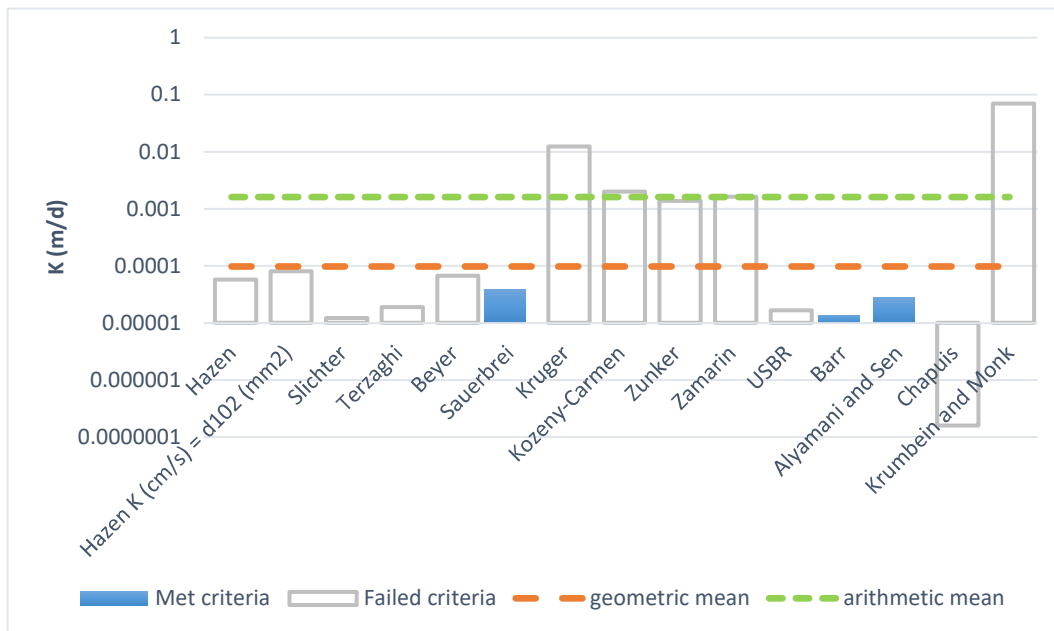
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	7.E-08	7.E-10	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	9.E-08	9.E-10	0.00	
Slichter	1.E-08	1.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	8.E-08	8.E-10	0.00	
Sauerbrei	4.E-08	4.E-10	0.00	
Kruger	1.E-05	1.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	2.E-08	2.E-10	0.00	
Barr	2.E-08	2.E-10	0.00	
Alaymani and Sen	3.E-08	3.E-10	0.00	
Chapuis	2.E-10	2.E-12	0.00	
Krumbein and Monk	8.E-05	8.E-07	0.07	
Shepherd	7.E-06	7.E-08	0.01	
geometric mean	1.E-07	1.E-09	0.00	
arithmetic mean	2.E-06	2.E-08	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-13 SS5 Primont Homes, Welland

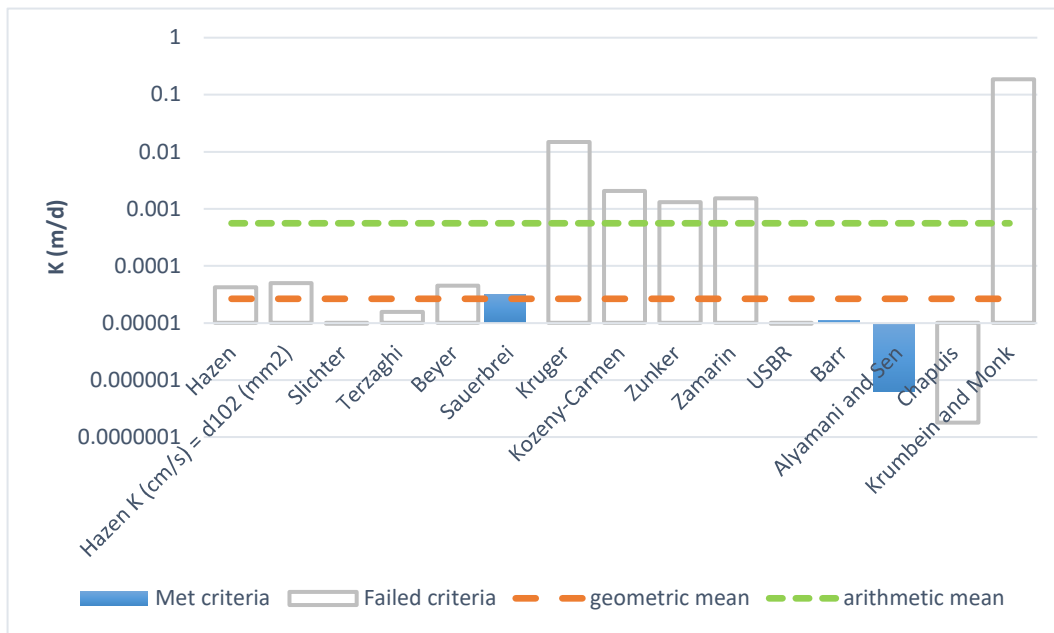
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	5.E-08	5.E-10	0.00	
Hazen K (cm/s) = d_{10}^2 (mm)	6.E-08	6.E-10	0.00	
Slichter	1.E-08	1.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	5.E-08	5.E-10	0.00	
Sauerbrei	4.E-08	4.E-10	0.00	
Kruger	2.E-05	2.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	1.E-08	1.E-10	0.00	
Barr	1.E-08	1.E-10	0.00	
Alaymani and Sen	7.E-10	7.E-12	0.00	
Chapuis	2.E-10	2.E-12	0.00	
Krumbein and Monk	2.E-04	2.E-06	0.19	
Shepherd	3.E-06	3.E-08	0.00	
geometric mean	3.E-08	3.E-10	0.00	
arithmetic mean	6.E-07	6.E-09	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-14 SS5 Primont Homes, Welland

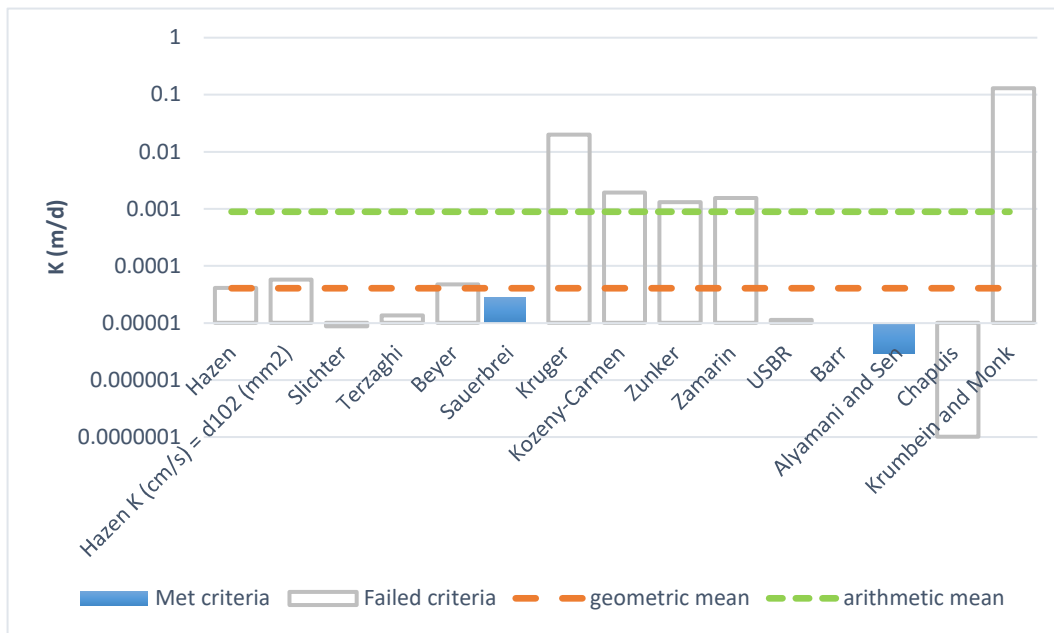
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	5.E-08	5.E-10	0.00	
Hazen K (cm/s) = d_{10}^2 (mm)	7.E-08	7.E-10	0.00	
Slichter	1.E-08	1.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	5.E-08	5.E-10	0.00	
Sauerbrei	3.E-08	3.E-10	0.00	
Kruger	2.E-05	2.E-07	0.02	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	1.E-08	1.E-10	0.00	
Barr	1.E-08	1.E-10	0.00	
Alayamani and Sen	3.E-09	3.E-11	0.00	
Chapuis	1.E-10	1.E-12	0.00	
Krumbein and Monk	2.E-04	2.E-06	0.13	
Shepherd	4.E-06	4.E-08	0.00	
geometric mean	5.E-08	5.E-10	0.00	
arithmetic mean	1.E-06	1.E-08	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH21-16 SS5 Primont Homes, Welland

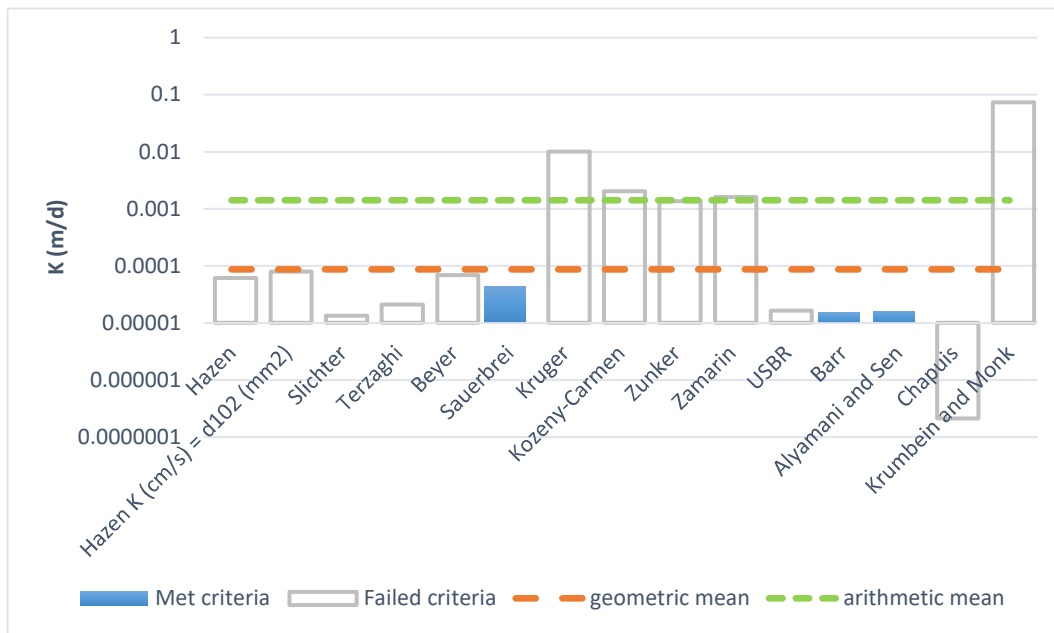
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	7.E-08	7.E-10	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	9.E-08	9.E-10	0.00	
Slichter	2.E-08	2.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	8.E-08	8.E-10	0.00	
Sauerbrei	5.E-08	5.E-10	0.00	
Kruger	1.E-05	1.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	2.E-08	2.E-10	0.00	
Barr	2.E-08	2.E-10	0.00	
Alaymani and Sen	2.E-08	2.E-10	0.00	
Chapuis	2.E-10	2.E-12	0.00	
Krumbein and Monk	8.E-05	8.E-07	0.07	
Shepherd	7.E-06	7.E-08	0.01	
geometric mean	1.E-07	1.E-09	0.00	
arithmetic mean	2.E-06	2.E-08	0.00	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH22-1 SS6 Primont Homes, Welland

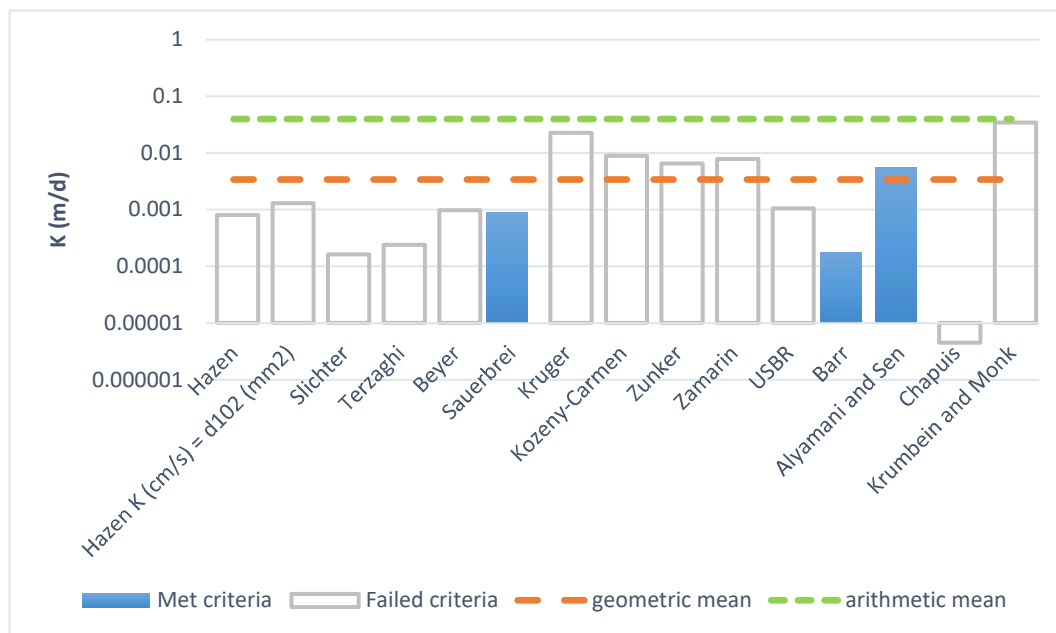
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	9.E-07	9.E-09	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	1.E-06	1.E-08	0.00	
Slichter	2.E-07	2.E-09	0.00	
Terzaghi	3.E-07	3.E-09	0.00	
Beyer	1.E-06	1.E-08	0.00	
Sauerbrei	1.E-06	1.E-08	0.00	
Kruger	3.E-05	3.E-07	0.02	
Kozeny-Carmen	1.E-05	1.E-07	0.01	
Zunker	8.E-06	8.E-08	0.01	
Zamarin	9.E-06	9.E-08	0.01	
USBR	1.E-06	1.E-08	0.00	
Barr	2.E-07	2.E-09	0.00	
Alyamani and Sen	6.E-06	6.E-08	0.01	
Chapuis	5.E-09	5.E-11	0.00	
Krumbein and Monk	4.E-05	4.E-07	0.03	
Shepherd	2.E-04	2.E-06	0.15	
geometric mean	4.E-06	4.E-08	0.00	
arithmetic mean	5.E-05	5.E-07	0.04	



K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH22-2 SS6 Primont Homes, Welland

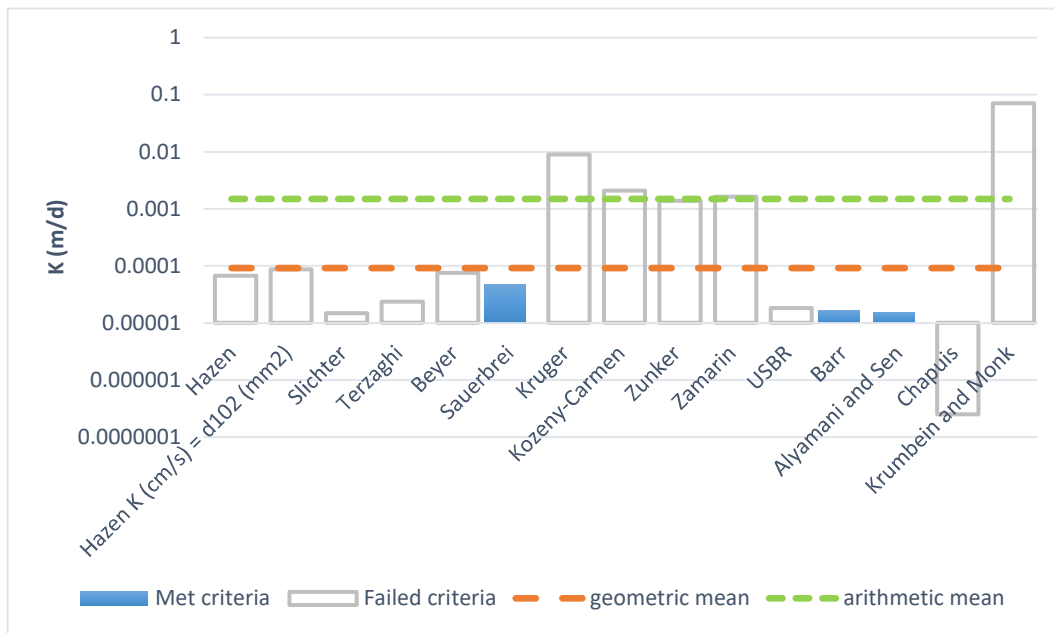
Mass Sample (g):

100

T (oC)

20

Poorly sorted clay with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	8.E-08	8.E-10	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	1.E-07	1.E-09	0.00	
Slichter	2.E-08	2.E-10	0.00	
Terzaghi	3.E-08	3.E-10	0.00	
Beyer	9.E-08	9.E-10	0.00	
Sauerbrei	6.E-08	6.E-10	0.00	
Kruger	1.E-05	1.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	2.E-08	2.E-10	0.00	
Barr	2.E-08	2.E-10	0.00	
Alaymani and Sen	2.E-08	2.E-10	0.00	
Chapuis	3.E-10	3.E-12	0.00	
Krumbein and Monk	8.E-05	8.E-07	0.07	
Shepherd	7.E-06	7.E-08	0.01	
geometric mean	1.E-07	1.E-09	0.00	
arithmetic mean	2.E-06	2.E-08	0.00	



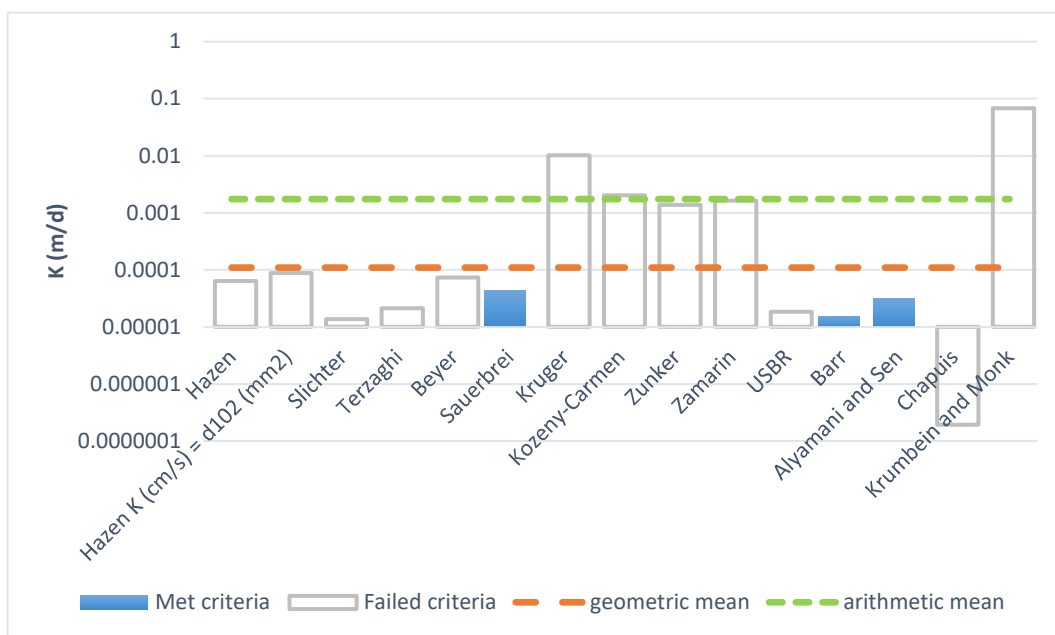
K from Grain Size Analysis Report

Date: 26-Apr-23

Sample Name: BH22-3 SS6 Primont Homes, Welland

Mass Sample (g): 100 T (oC) 20

Poorly sorted clay with fines

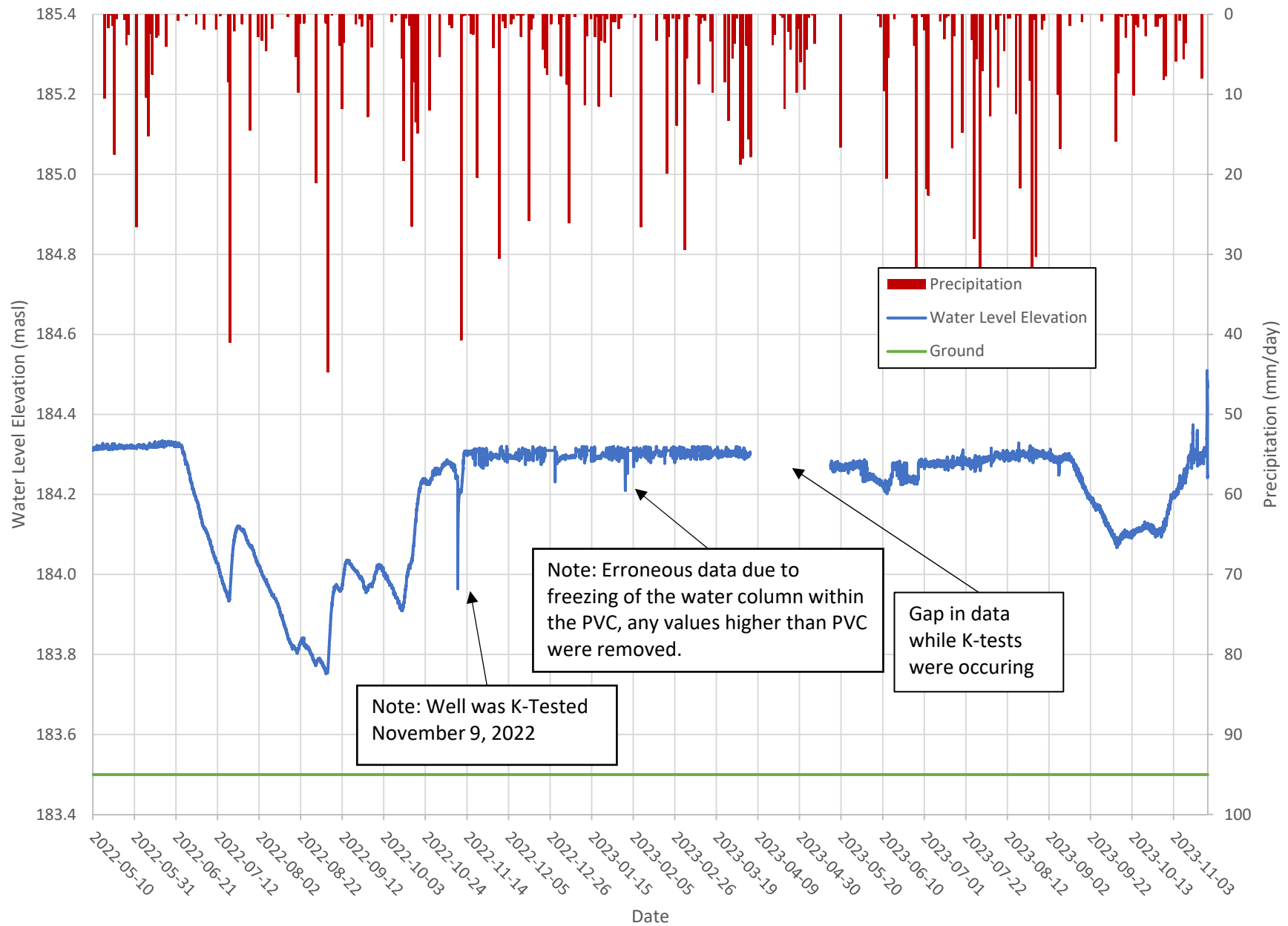


Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	7.E-08	7.E-10	0.00	
Hazen K (cm/s) = d ₁₀ (mm)	1.E-07	1.E-09	0.00	
Slichter	2.E-08	2.E-10	0.00	
Terzaghi	2.E-08	2.E-10	0.00	
Beyer	8.E-08	8.E-10	0.00	
Sauerbrei	5.E-08	5.E-10	0.00	
Kruger	1.E-05	1.E-07	0.01	
Kozeny-Carmen	2.E-06	2.E-08	0.00	
Zunker	2.E-06	2.E-08	0.00	
Zamarin	2.E-06	2.E-08	0.00	
USBR	2.E-08	2.E-10	0.00	
Barr	2.E-08	2.E-10	0.00	
Alaymani and Sen	4.E-08	4.E-10	0.00	
Chapuis	2.E-10	2.E-12	0.00	
Krumbein and Monk	8.E-05	8.E-07	0.07	
Shepherd	8.E-06	8.E-08	0.01	
geometric mean	1.E-07	1.E-09	0.00	
arithmetic mean	2.E-06	2.E-08	0.00	

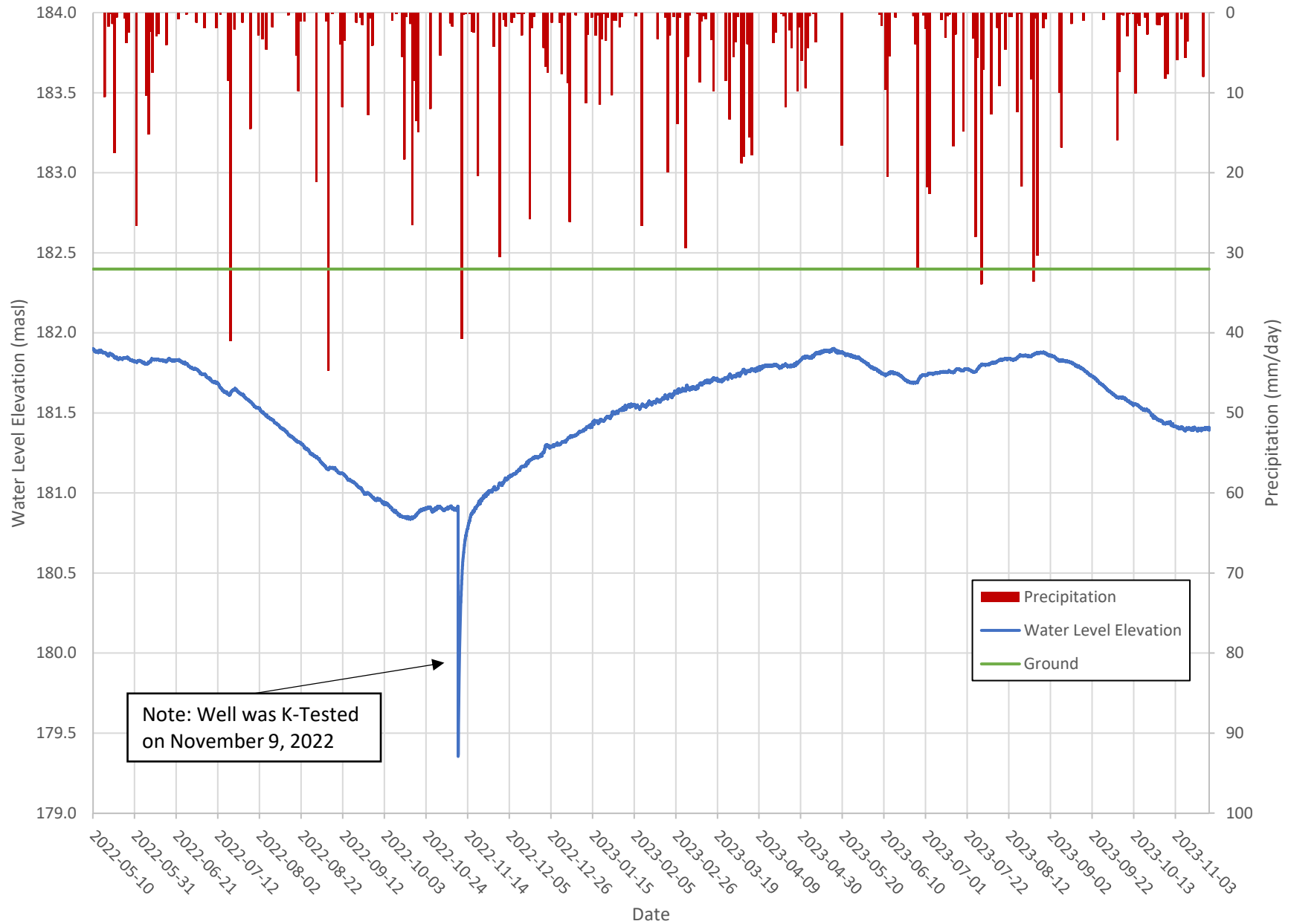
Appendix D

Groundwater Datalogger Charts

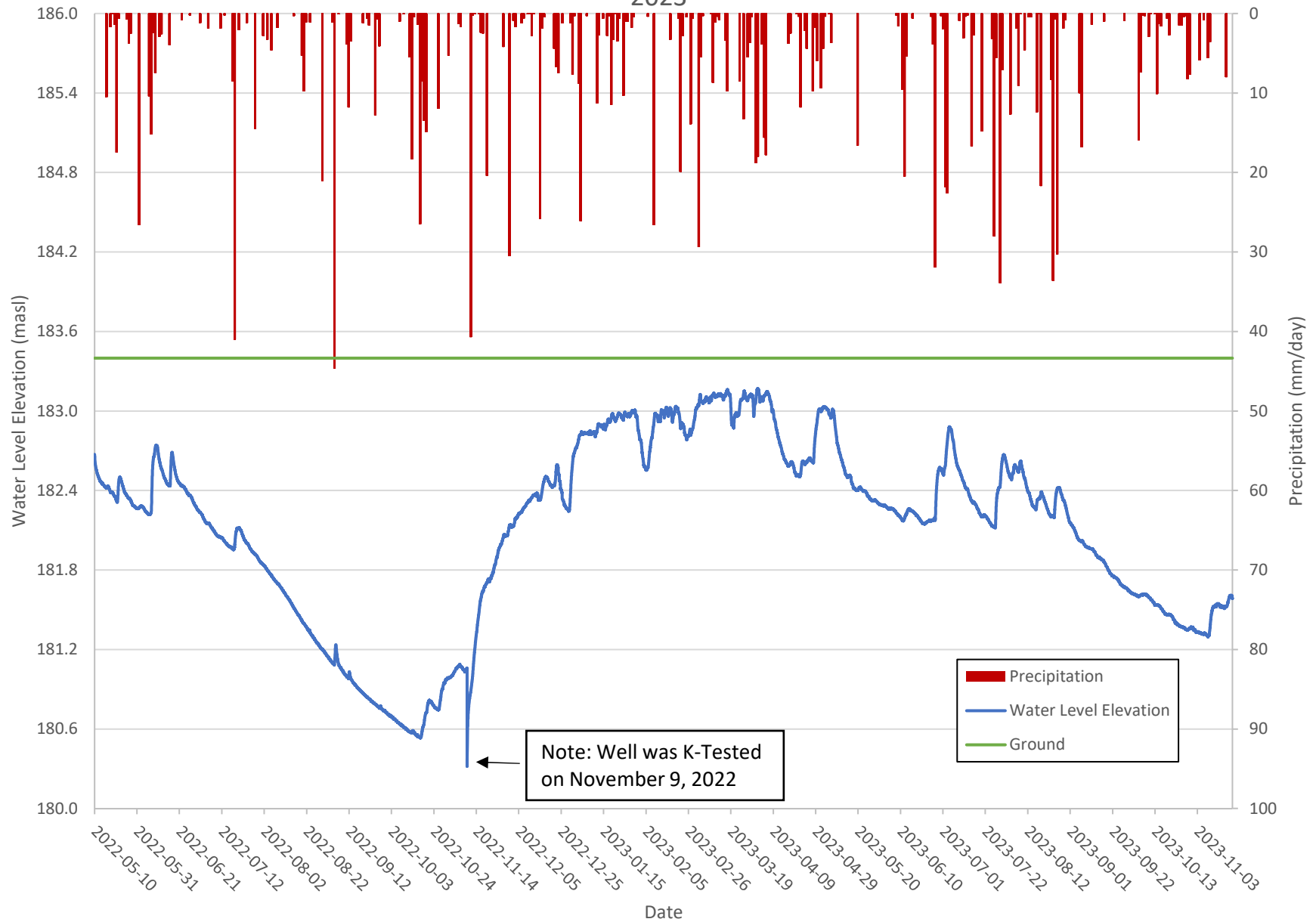
Primont BH21-01 Water Level Elevation vs. Precipitation from May 10, 2022 to November 17, 2023



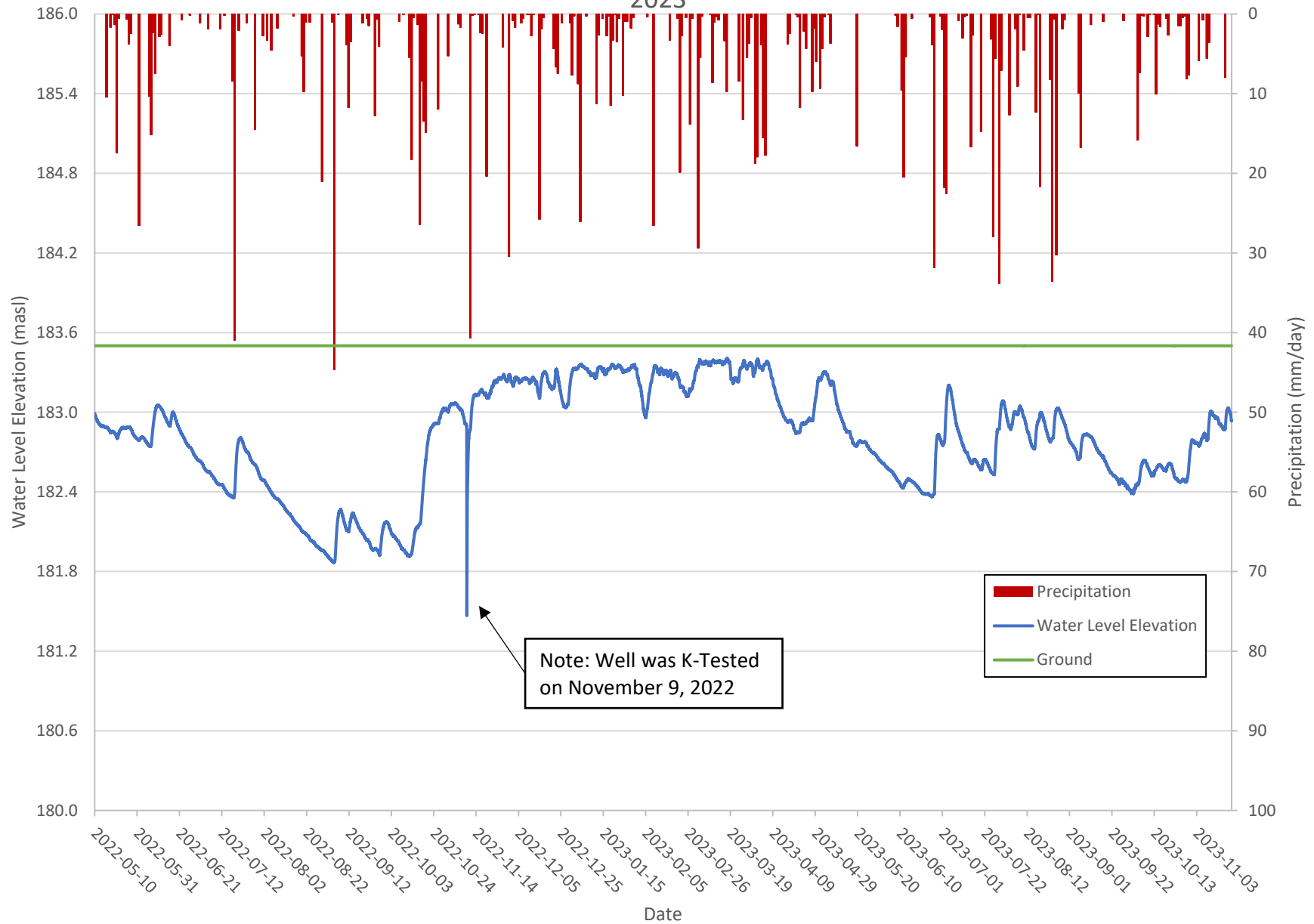
Primont BH21-03 Water Level Elevation vs. Precipitation from May 10,2022 to November 17, 2023



Primont BH21-13 Water Level Elevation vs. Precipitation from May 10, 2022 to November 17, 2023



Primont BH21-14 Water Level Elevation vs. Precipitation from May 10, 2022 to November 17, 2023



Appendix E

Wetland Monitoring

Primont Site Visit April 5, 2023

SW-1

- Top Dp-> Water=32.5cm
- Depth at DP=28.5cm
- Temp=8.6 Cond=208



SW-2

- Top Dp-> Water=60.3cm
- Depth at DP=4cm (small pool)
- Temp=11.25 Cond=455us



SW-3

- Top Dp-> Water=49.5cm
- Depth at DP=18.5cm
- Temp=10.5 Cond=305us



SW-4

- Top Dp-> Water=59.5cm
- Depth at DP=5.5cm
- Temp=9.5 Cond=98us



SW-5

- Top Dp-> Water=60.2cm
- Depth at DP=8.5cm
- Temp=11.9 Cond=64us



SW-6

- Top Dp-> Water=30.5m
- Depth at DP=31.5cm
- Temp=9.5 Cond=58us



SW-7

- Top Dp-> Water=52.4cm
- Depth at DP=16cm
- Temp=10.2 Cond=310us



SW-8

- Top Dp-> Water=37cm
- Depth at DP=19.5cm
- Temp=7.3 Cond=120us



SW-9

- Top Dp-> Water=54.4cm
- Depth at DP=8cm
- Temp=10.3 Cond=132us



SW-10

- Top Dp-> Water=53.2cm
- Depth at DP= 7.9cm
- Temp=7.7 Cond=125



SW-11

- Top Dp-> Water= 48.8cm
- Depth at DP=10.5cm
- Temp=7.8 Cond=264us



SW-12

- Top Dp-> Water=50.3cm
- Depth at DP=10.4cm
- Temp=7.5 Cond=154us



SW-13

- Top Dp-> Water=53.5m
- Depth at DP=8.5cm
- Temp=7.5 Cond=82us0



SW-14

- Top Dp-> Water=39.5cm
- Depth at DP=27.2cm
- Temp= 8.6 Cond=80us



SW-15

- Top Dp-> Water=36.5cm
- Depth at DP=25cm
- Temp=9.3 Cond=77us



SW-16

- Top Dp-> Water=62cm
- Depth at DP=7cm
- Temp= 8.5 Cond=153us



SW-17

- Top Dp-> Water=58cm
- Depth at DP=7.5cm
- Temp= 7.8 Cond=6us

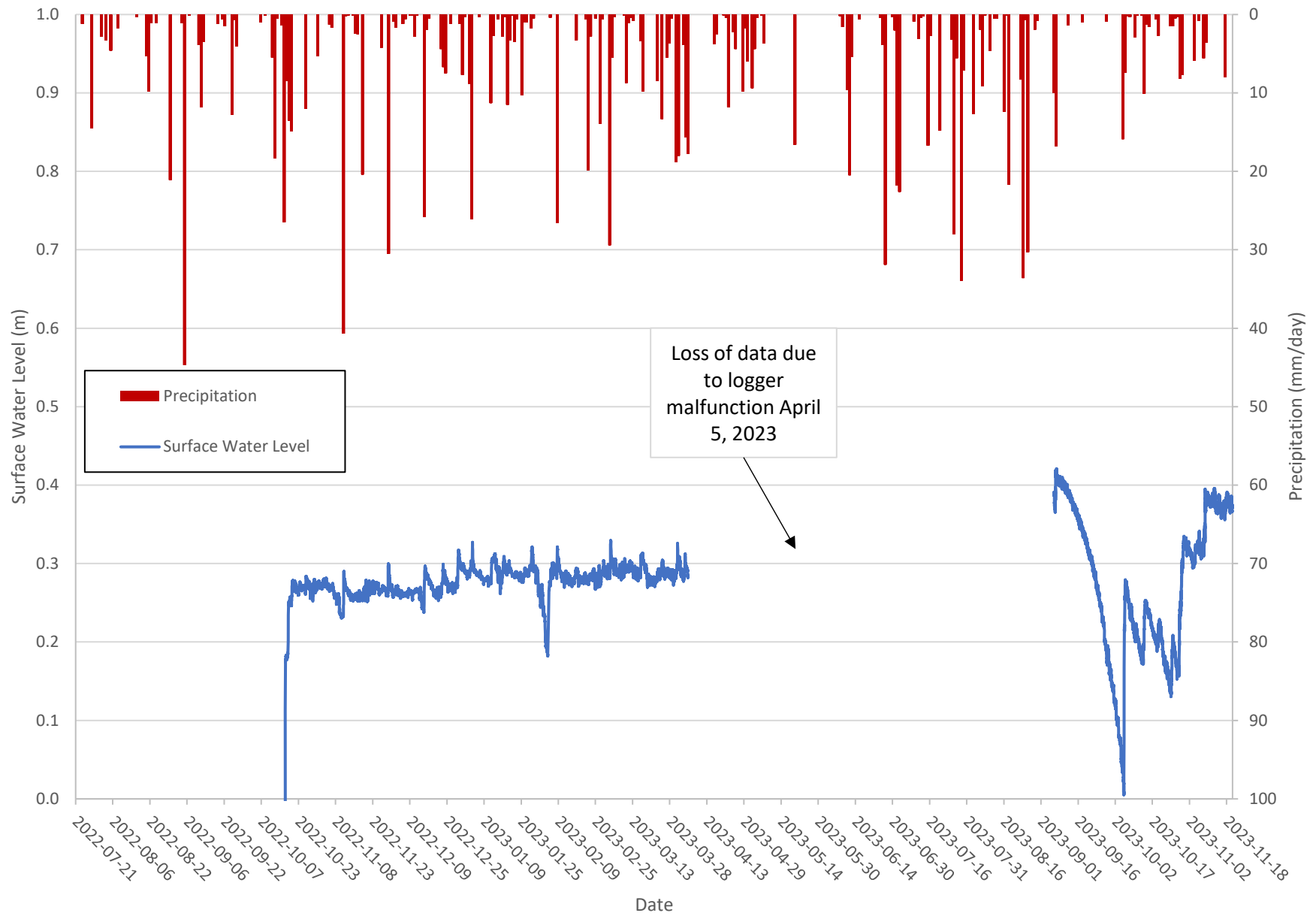


SW-18

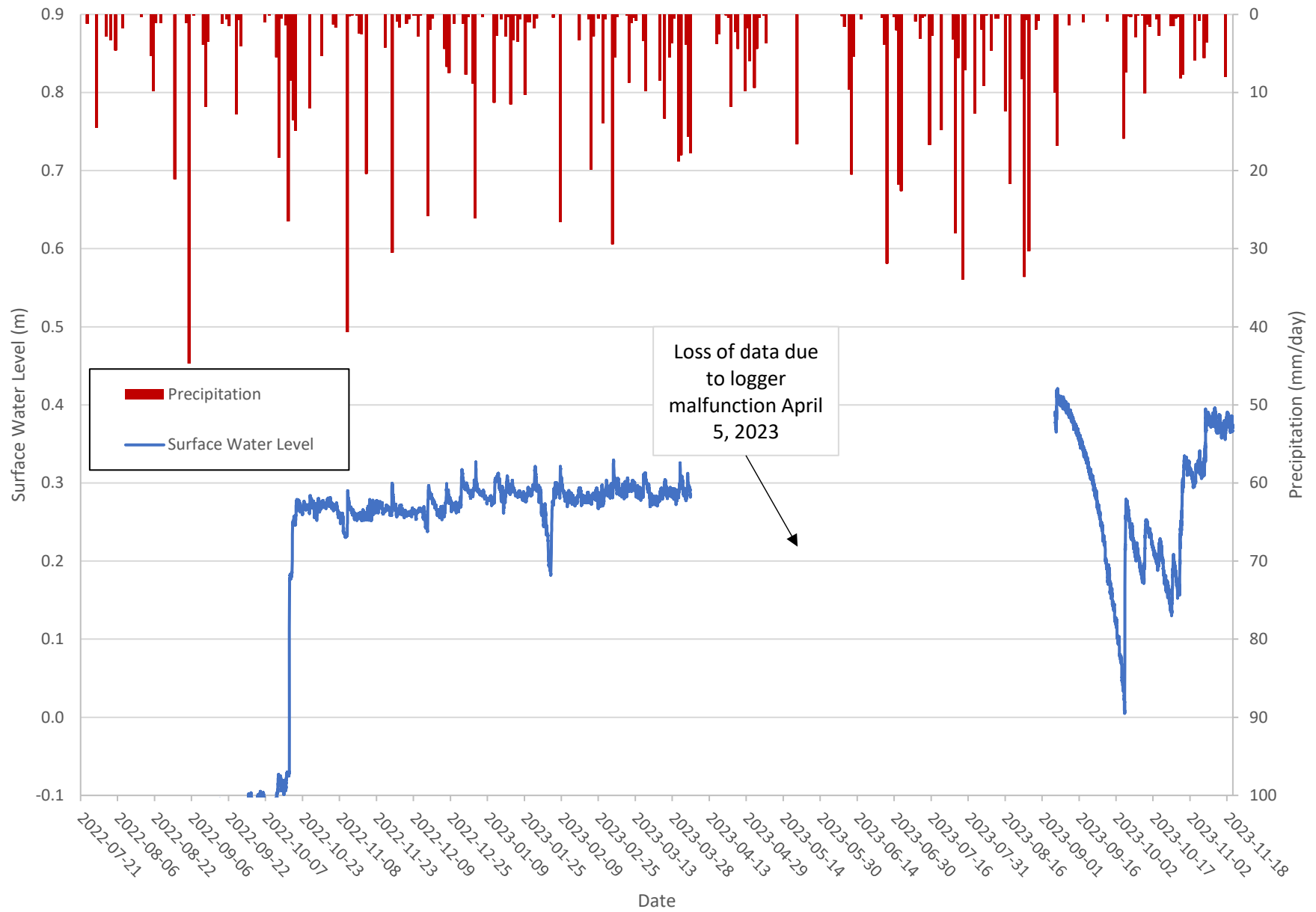
- Top Dp-> Water=36.3cm
- Depth at DP=21.6cm
- Temp= 7.3 Cond=46us



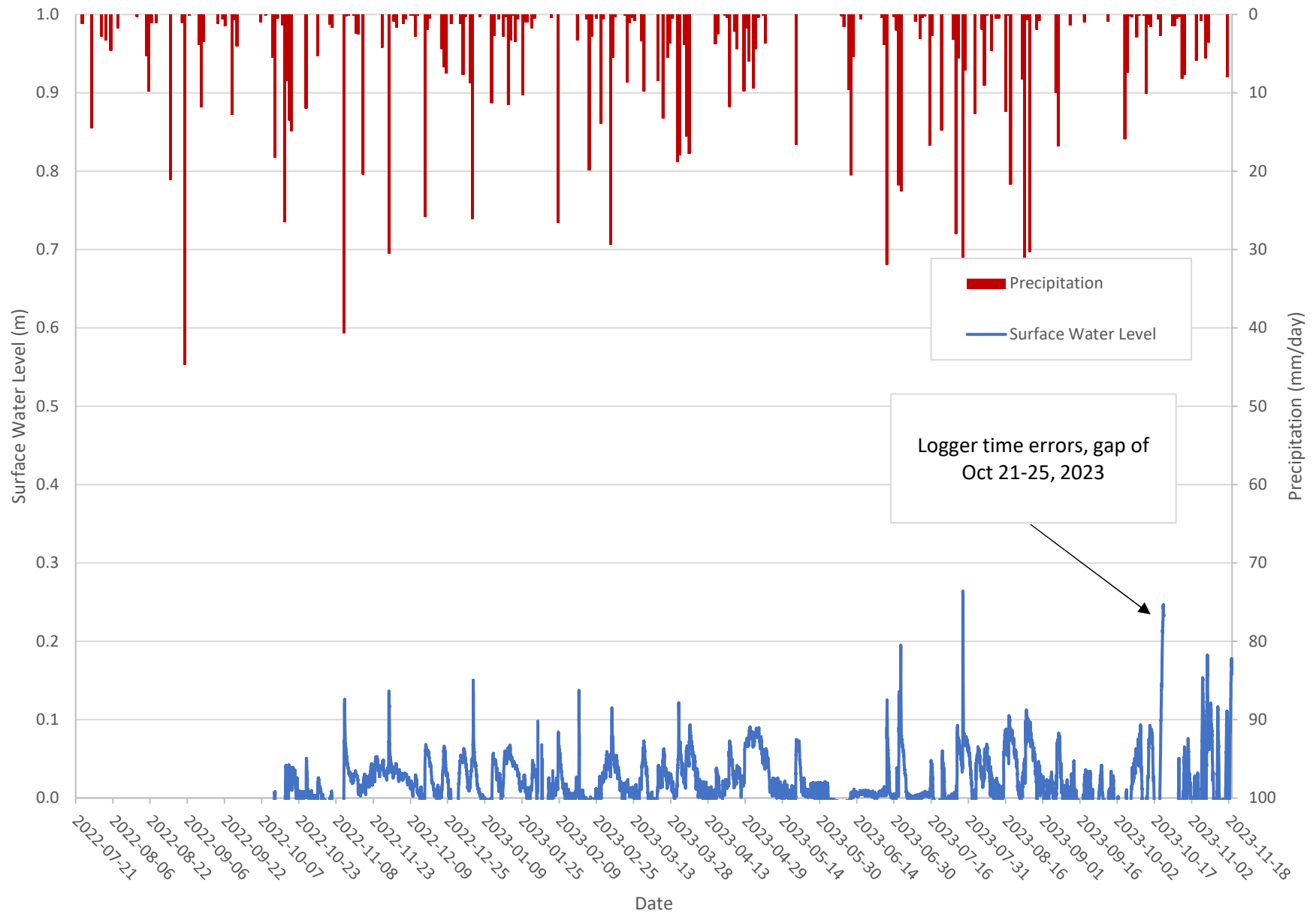
Primont SW-1 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



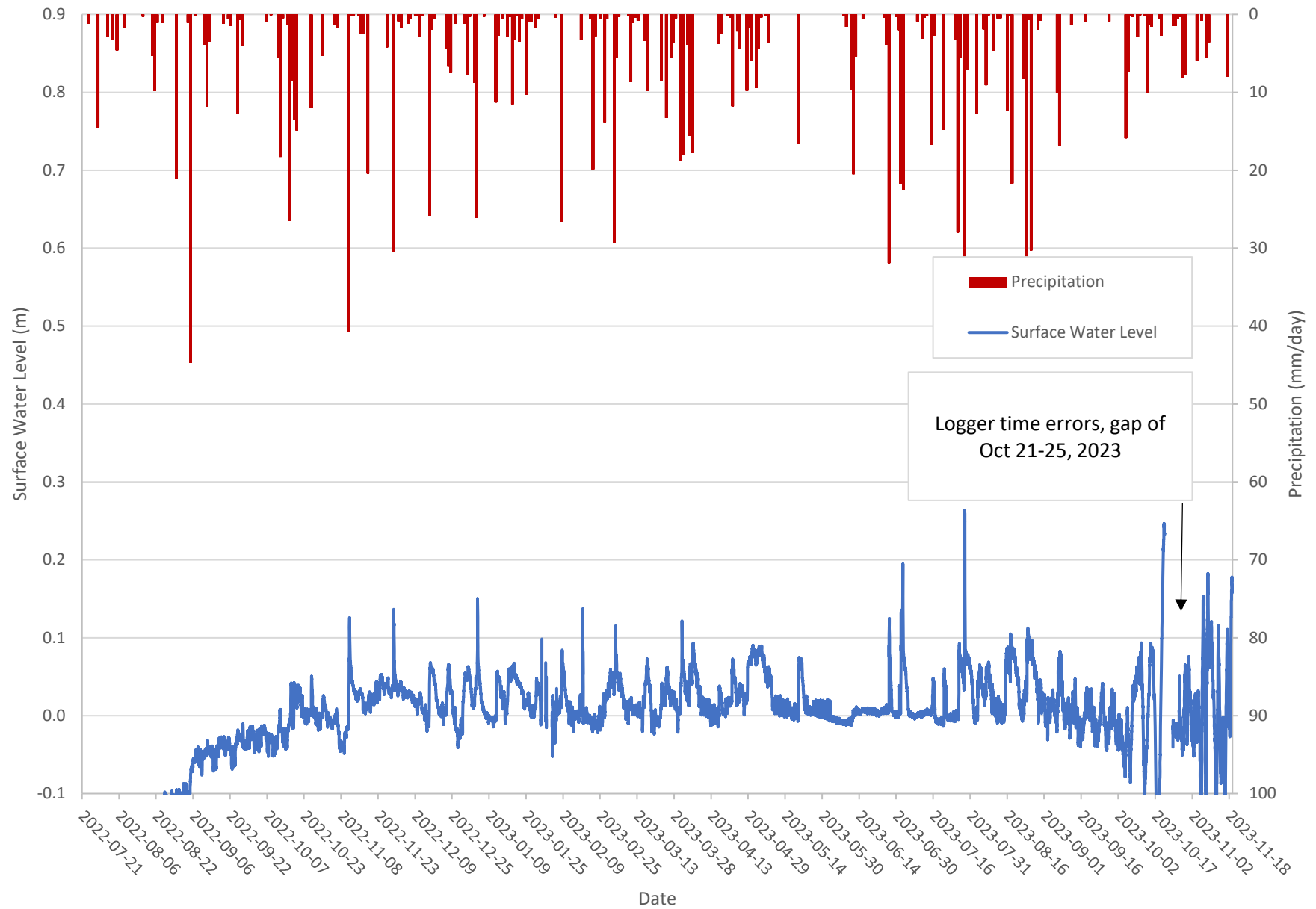
Primont SW-1 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



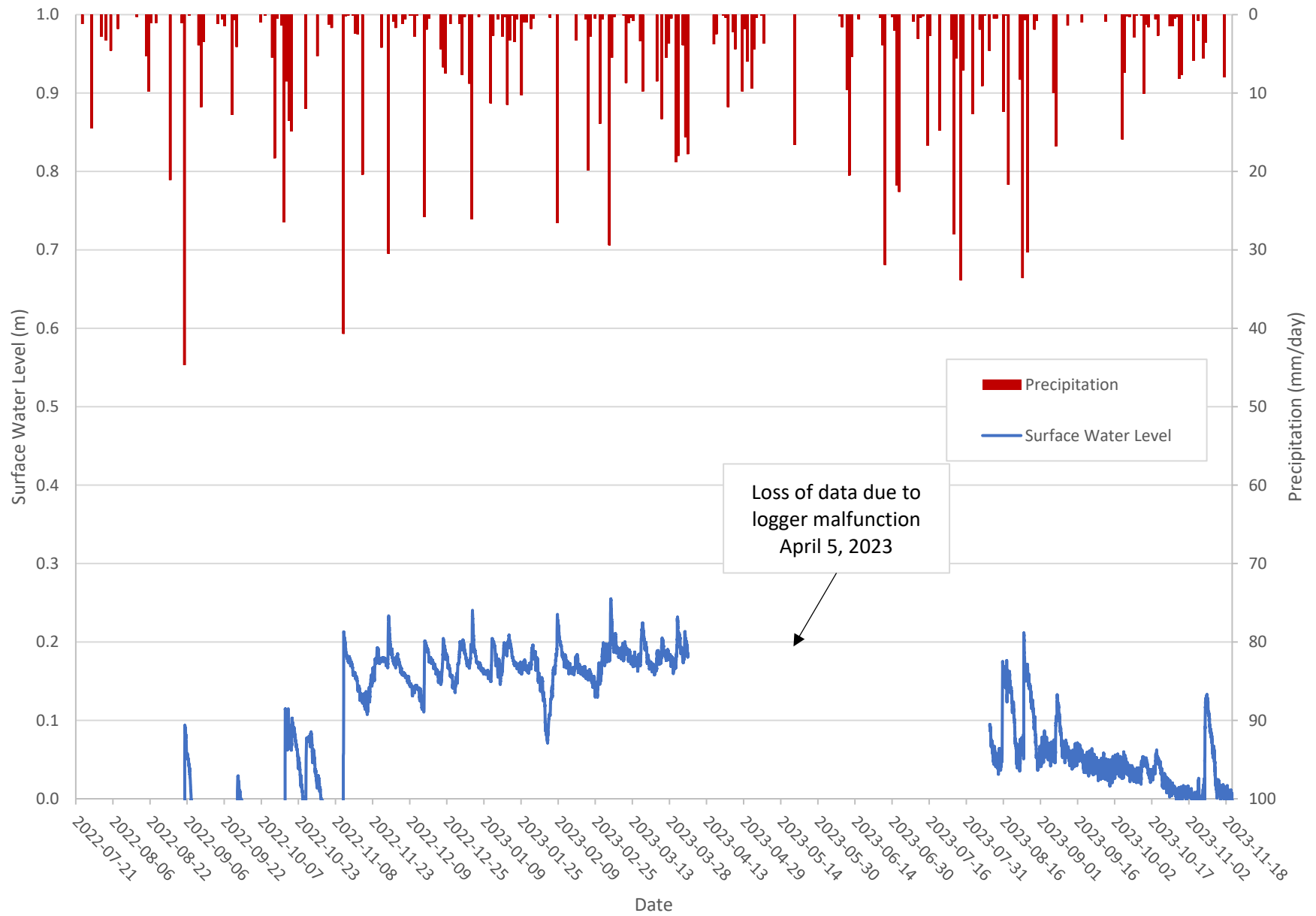
Primont SW-2 Surface Water Level vs. Precipitation from August 10 to November 20, 2023



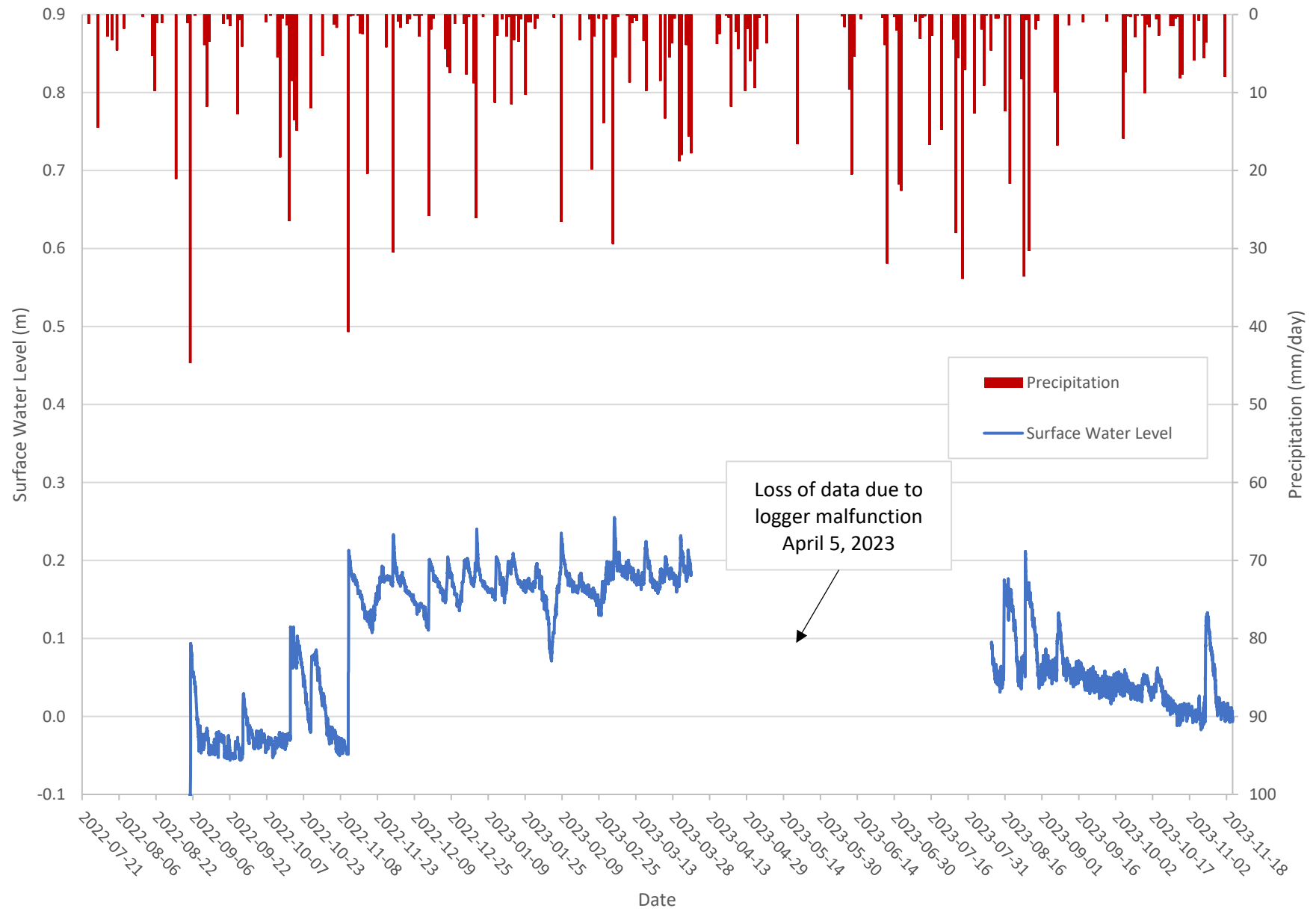
Primont SW-2 Surface Water Level vs. Precipitation from August 10 to November 20, 2023



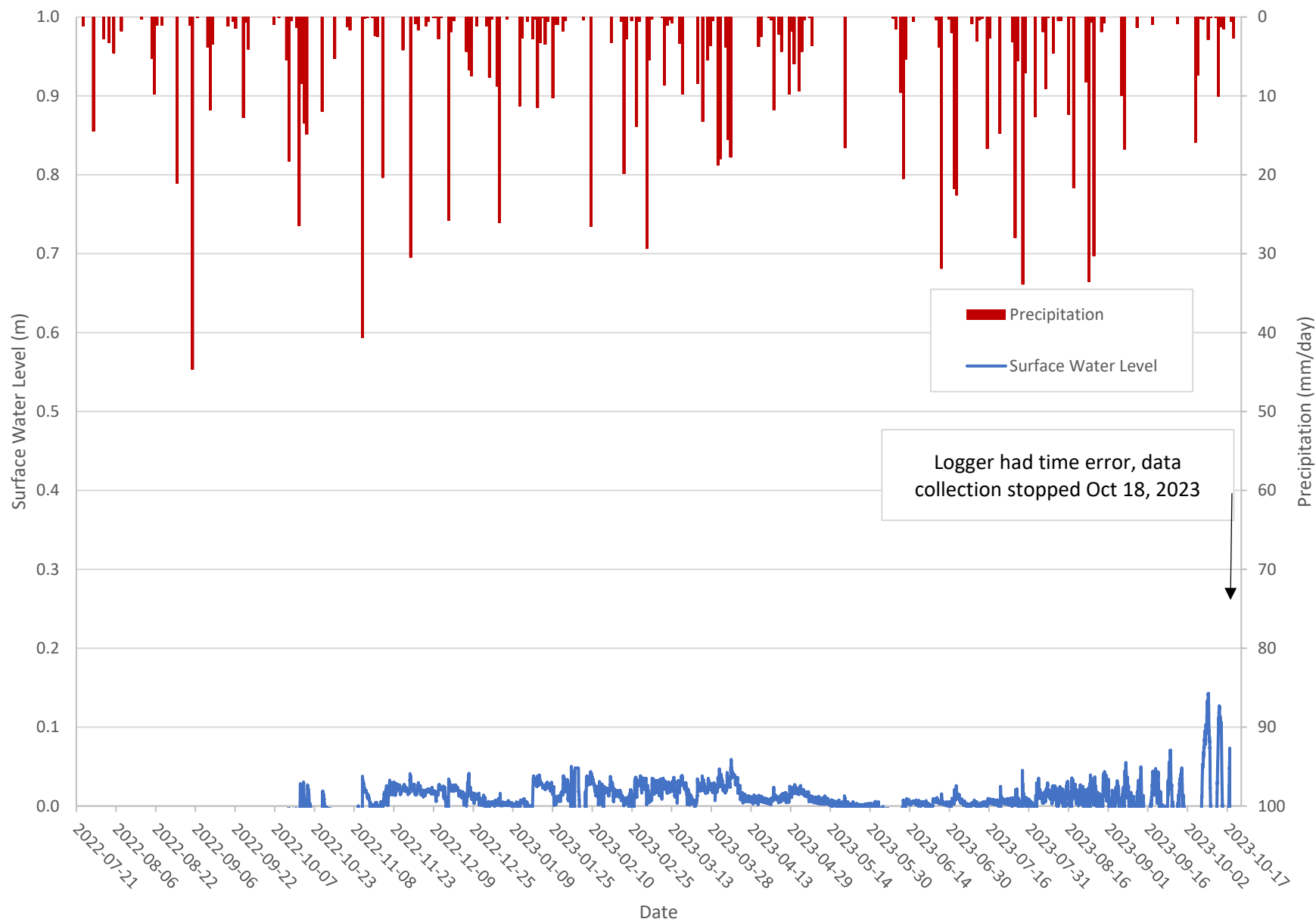
Primont SW-3 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



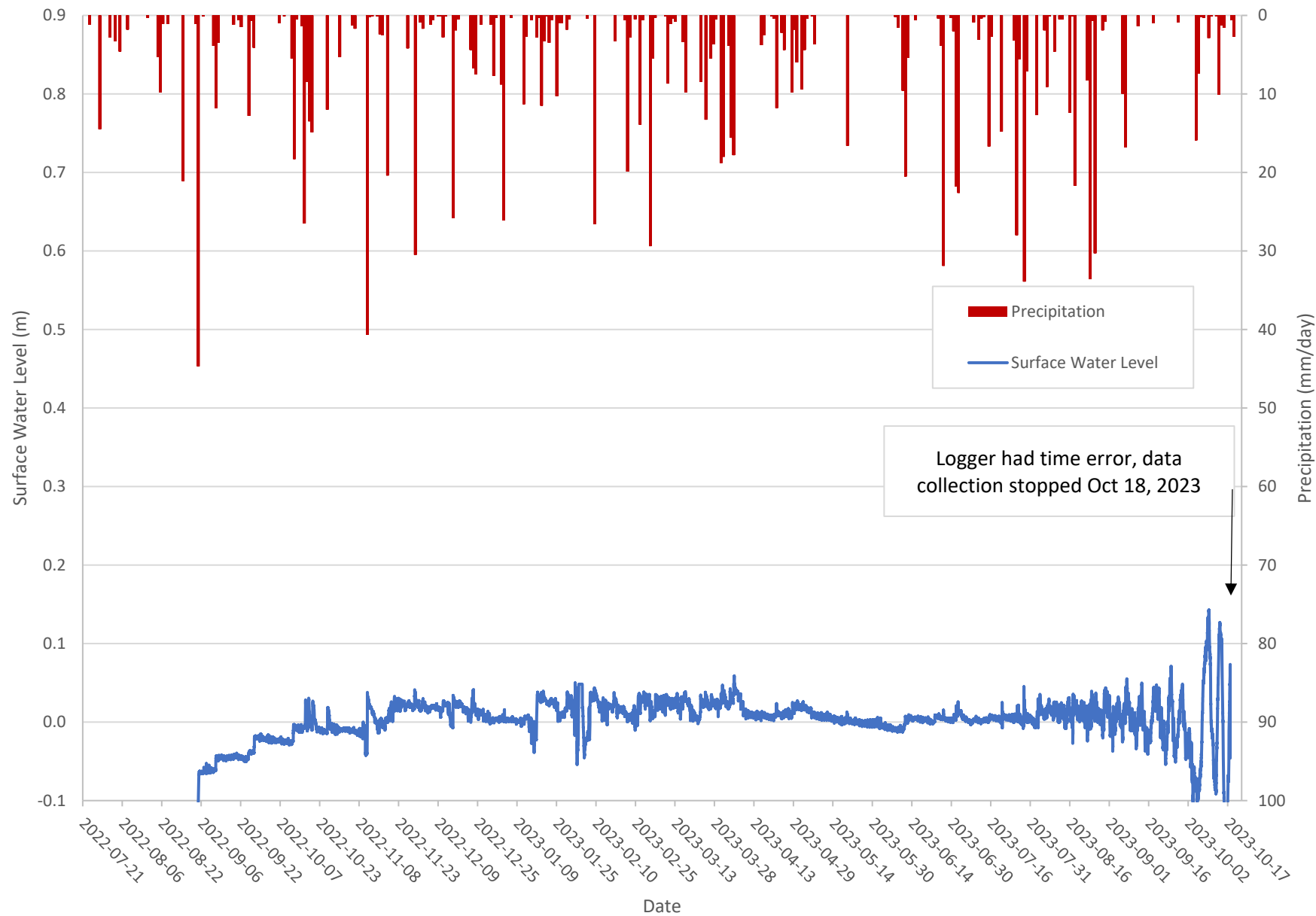
Primont SW-3 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



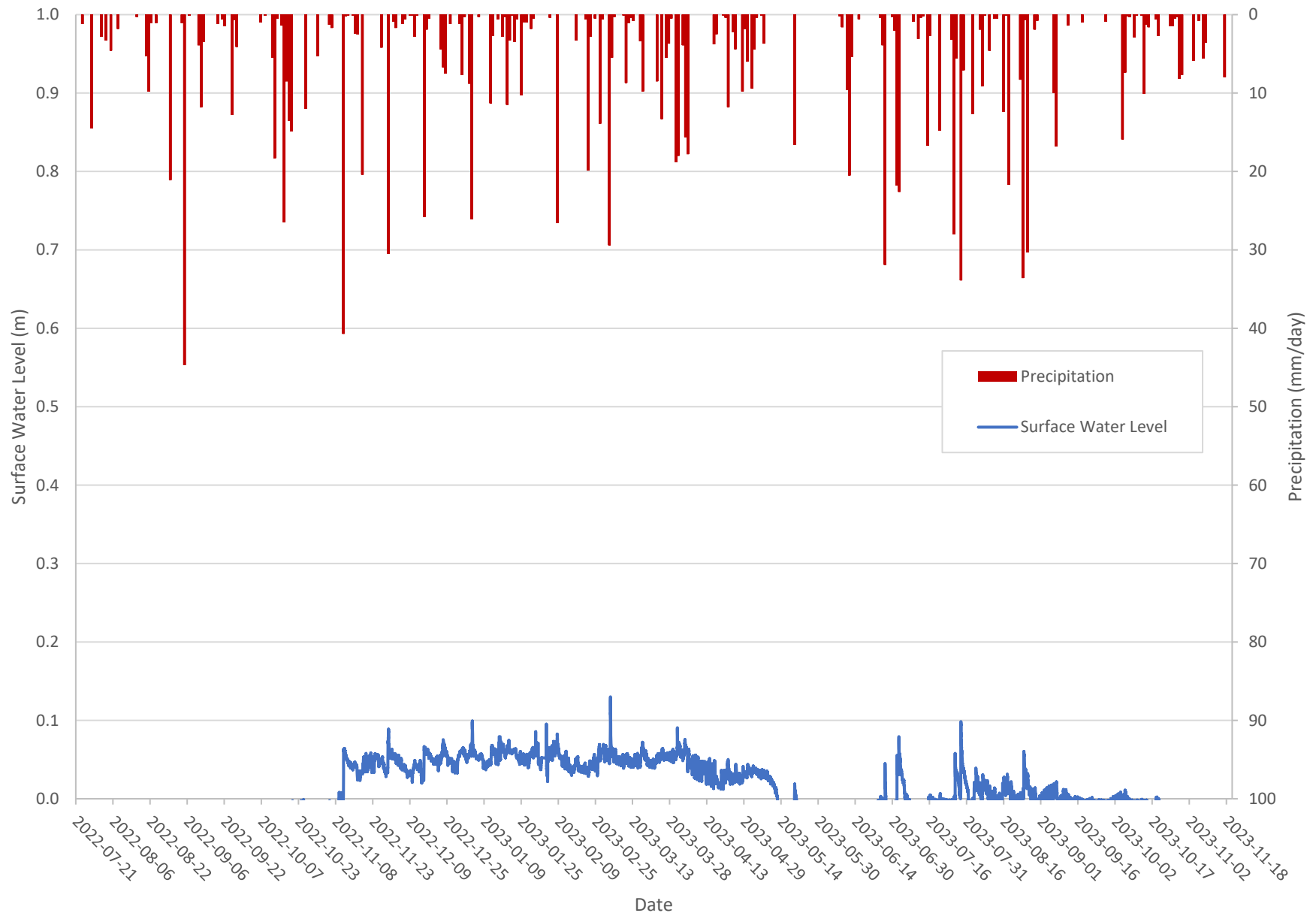
Primont SW-4 Surface Water Level vs. Precipitation from July 21, 2022 to October 18, 2023



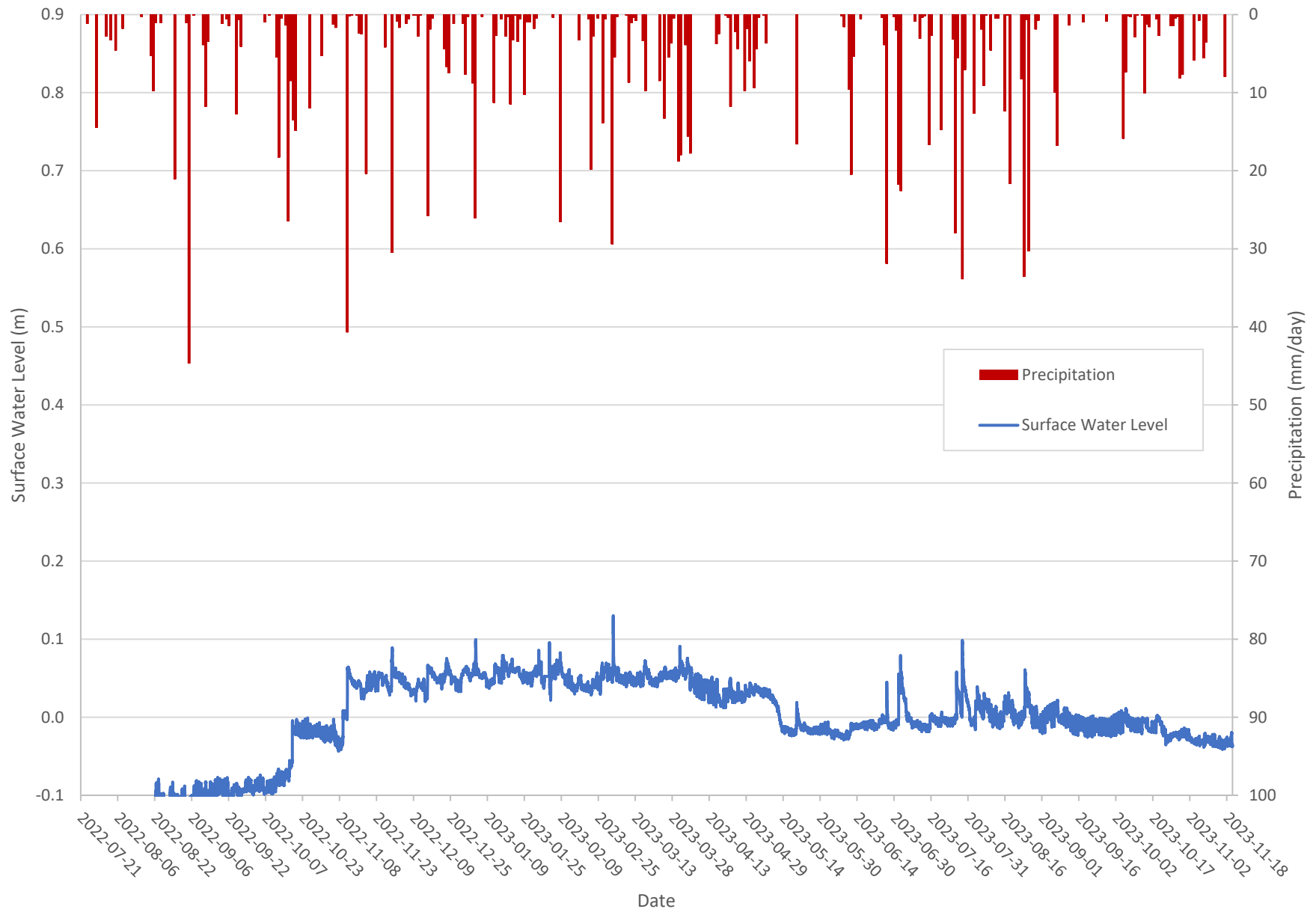
Primont SW-4 Surface Water Level vs. Precipitation from July 21, 2022 to October 18, 2023



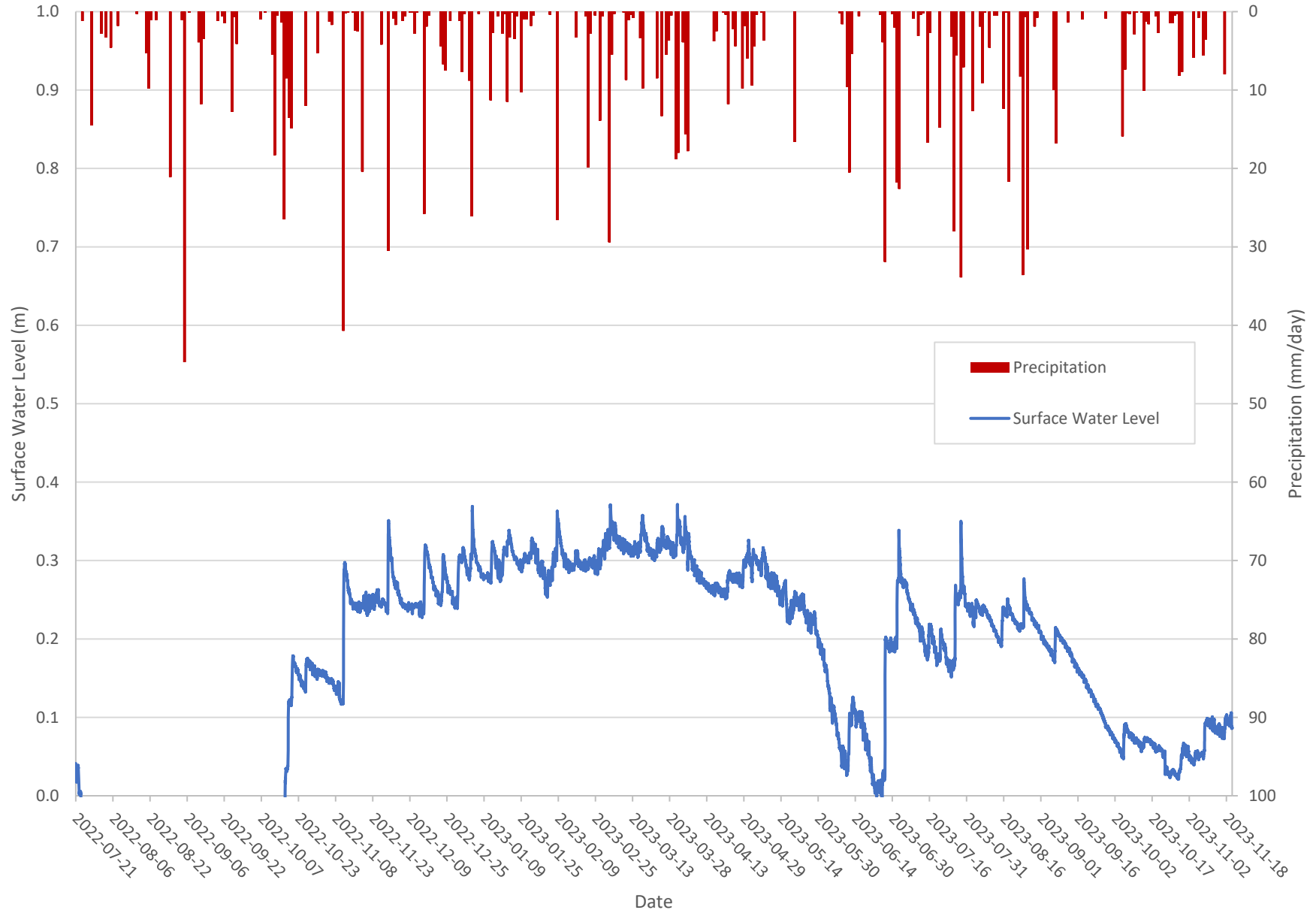
Primont SW-5 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



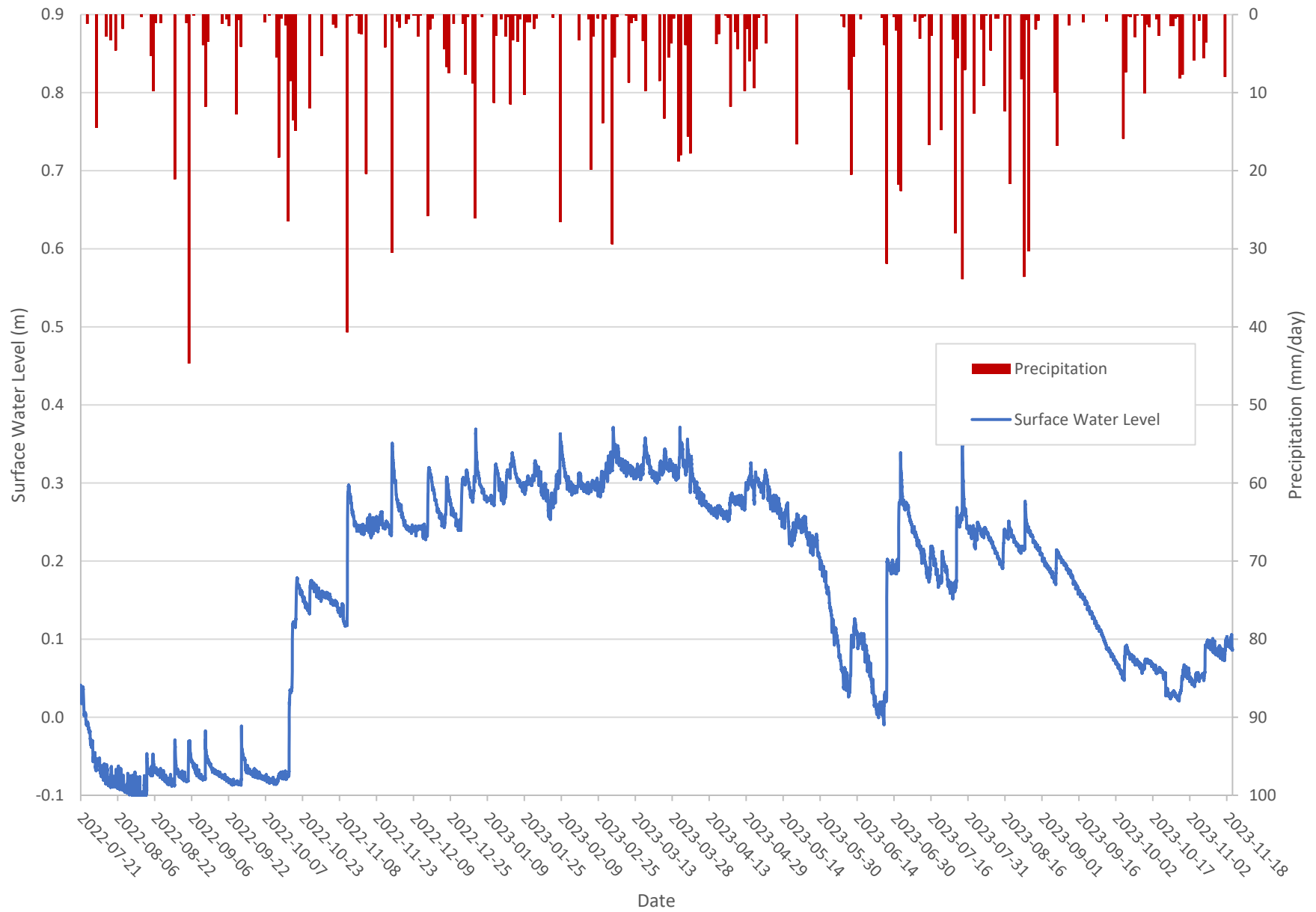
Primont SW-5 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



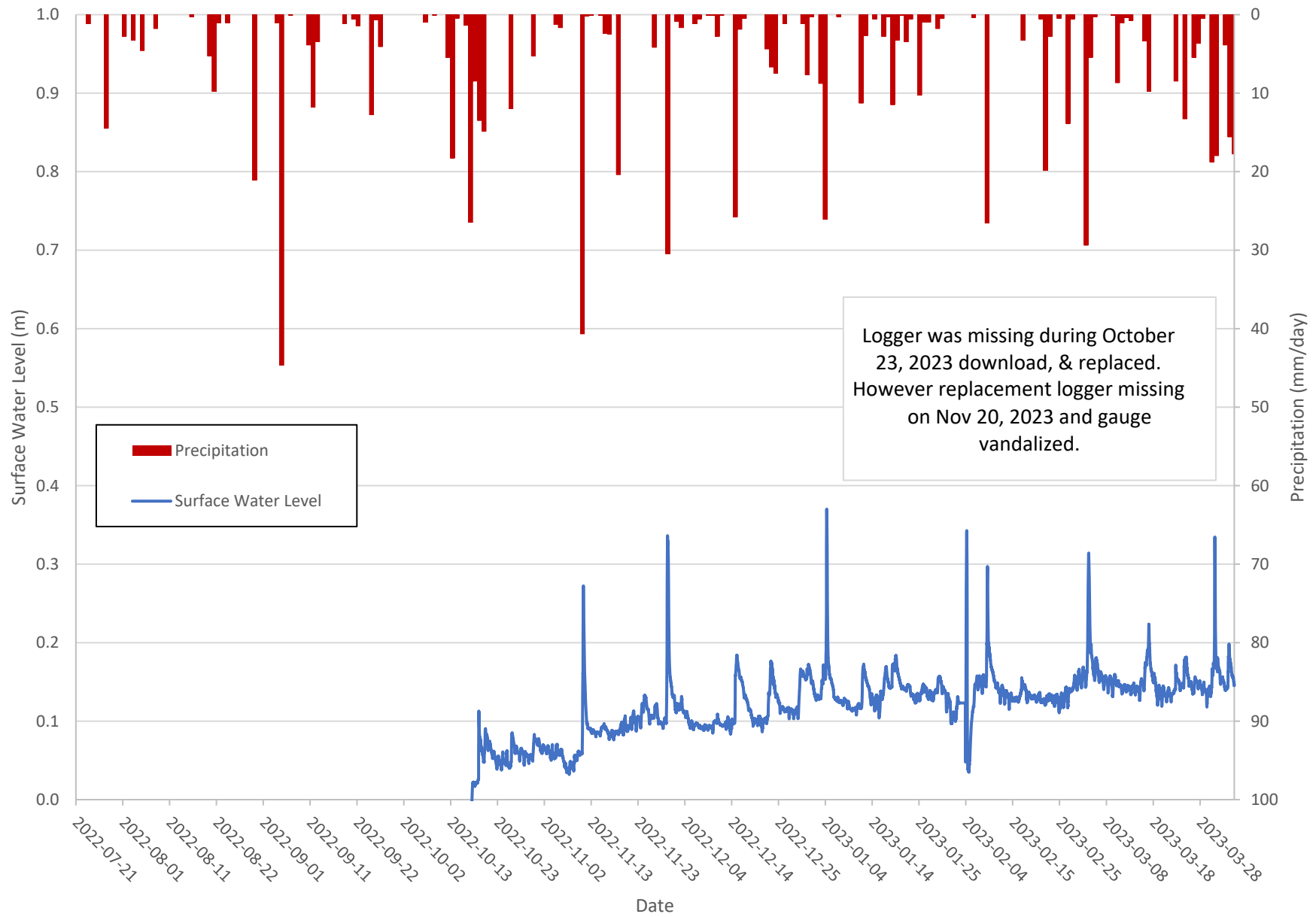
Primont SW-6 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



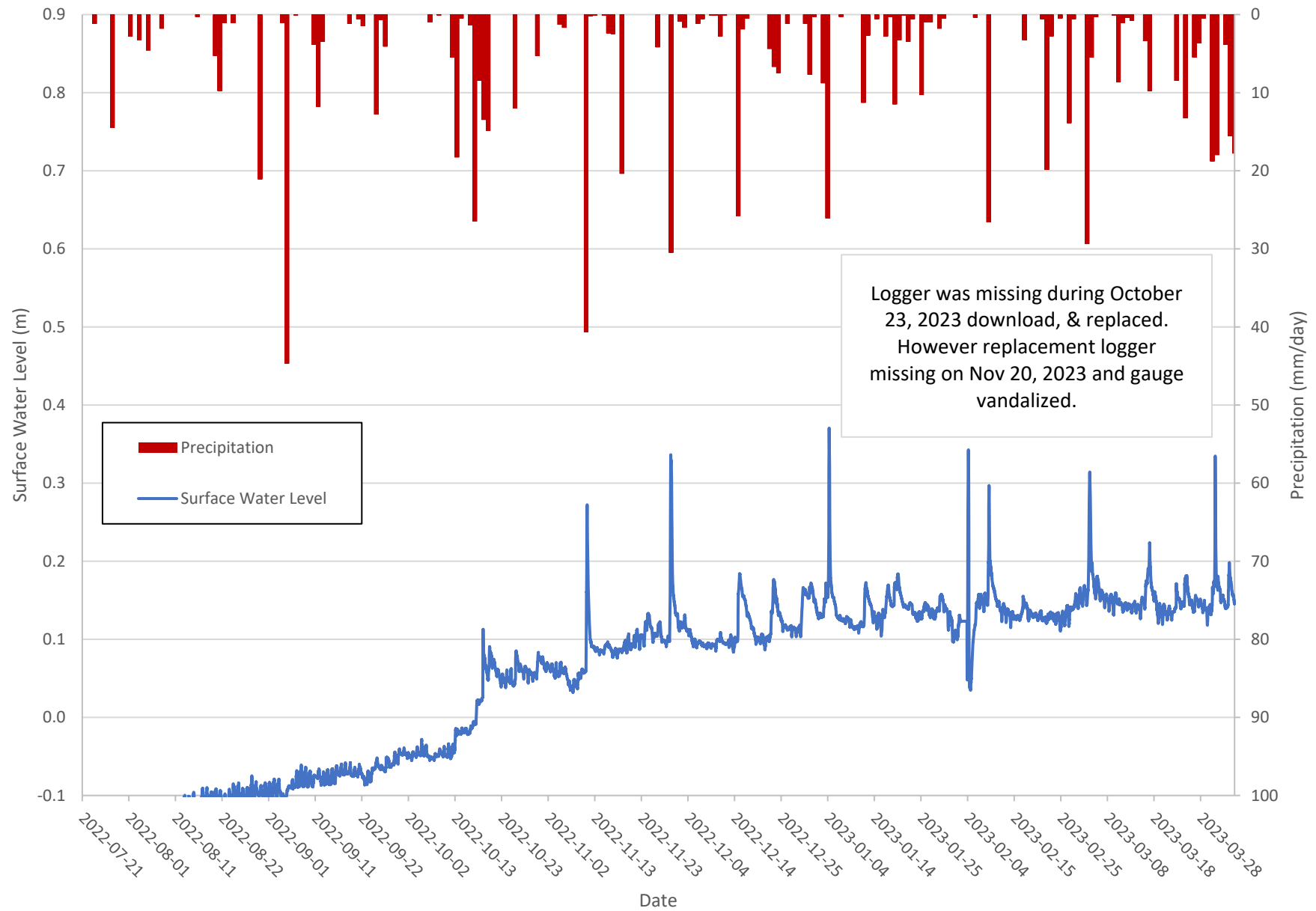
Primont SW-6 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



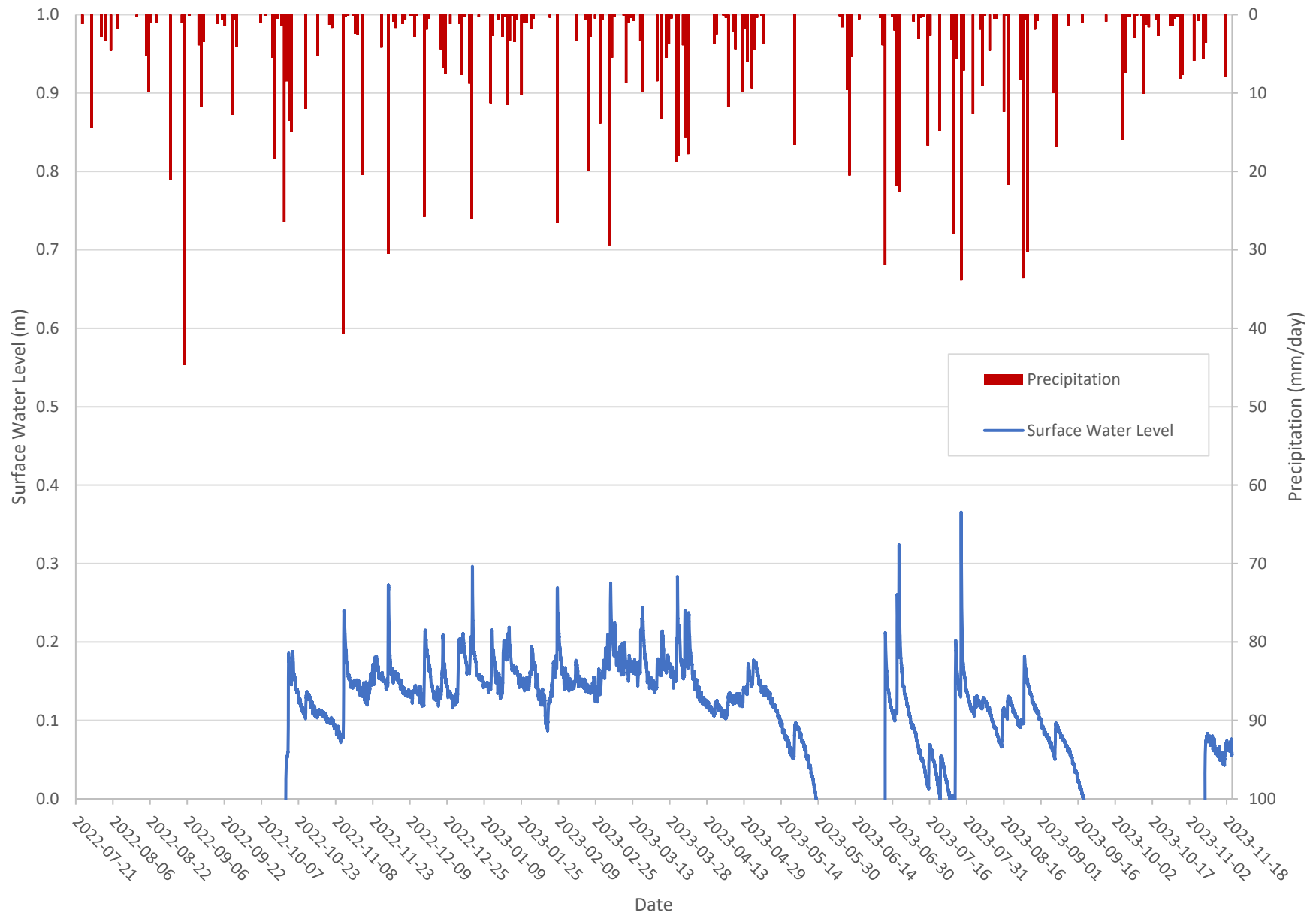
Primont SW-7 Surface Water Level vs. Precipitation from July 21, 2022 to April 5, 2023



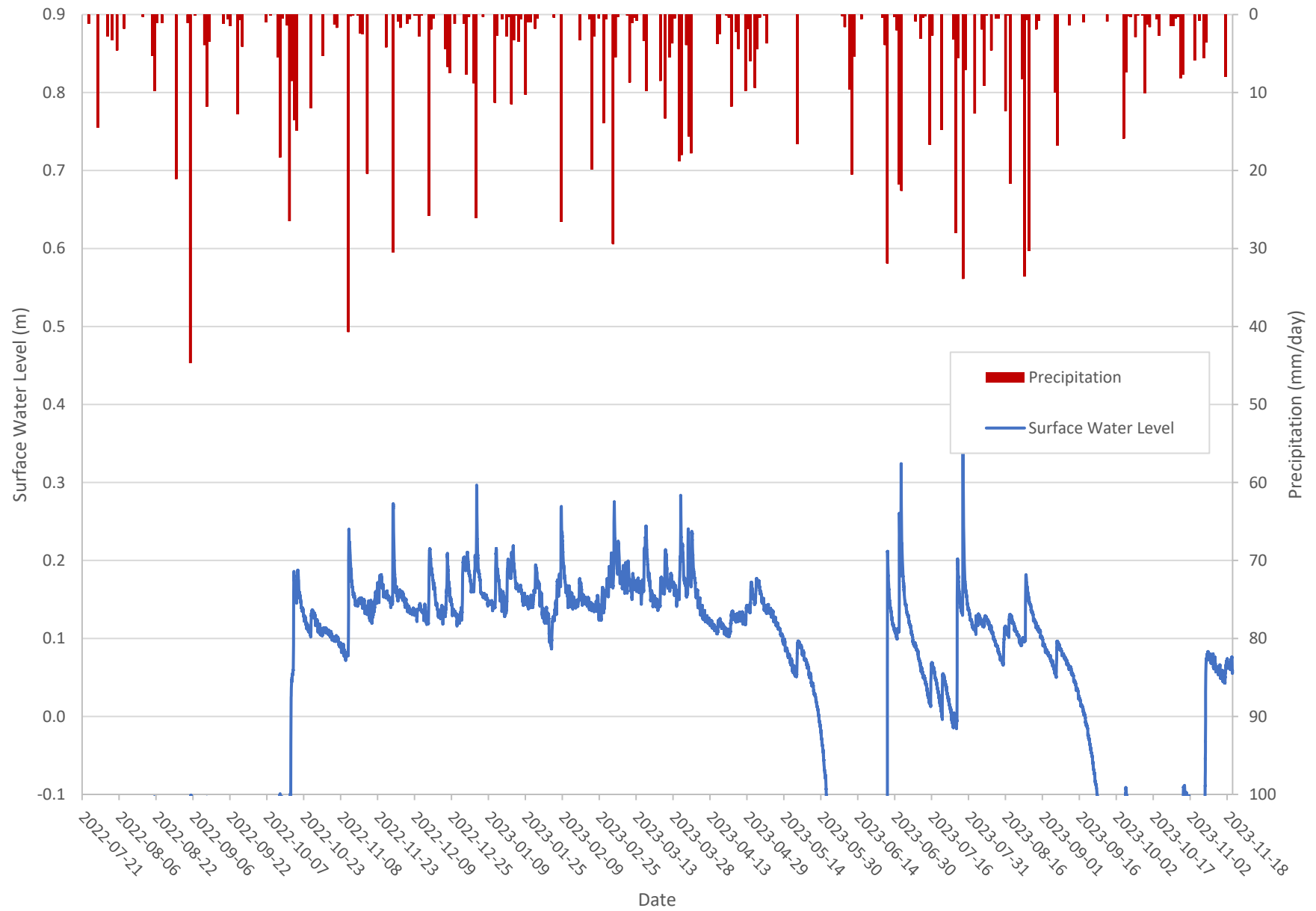
Primont SW-7 Surface Water Level vs. Precipitation from July 21, 2022 to April 5, 2023



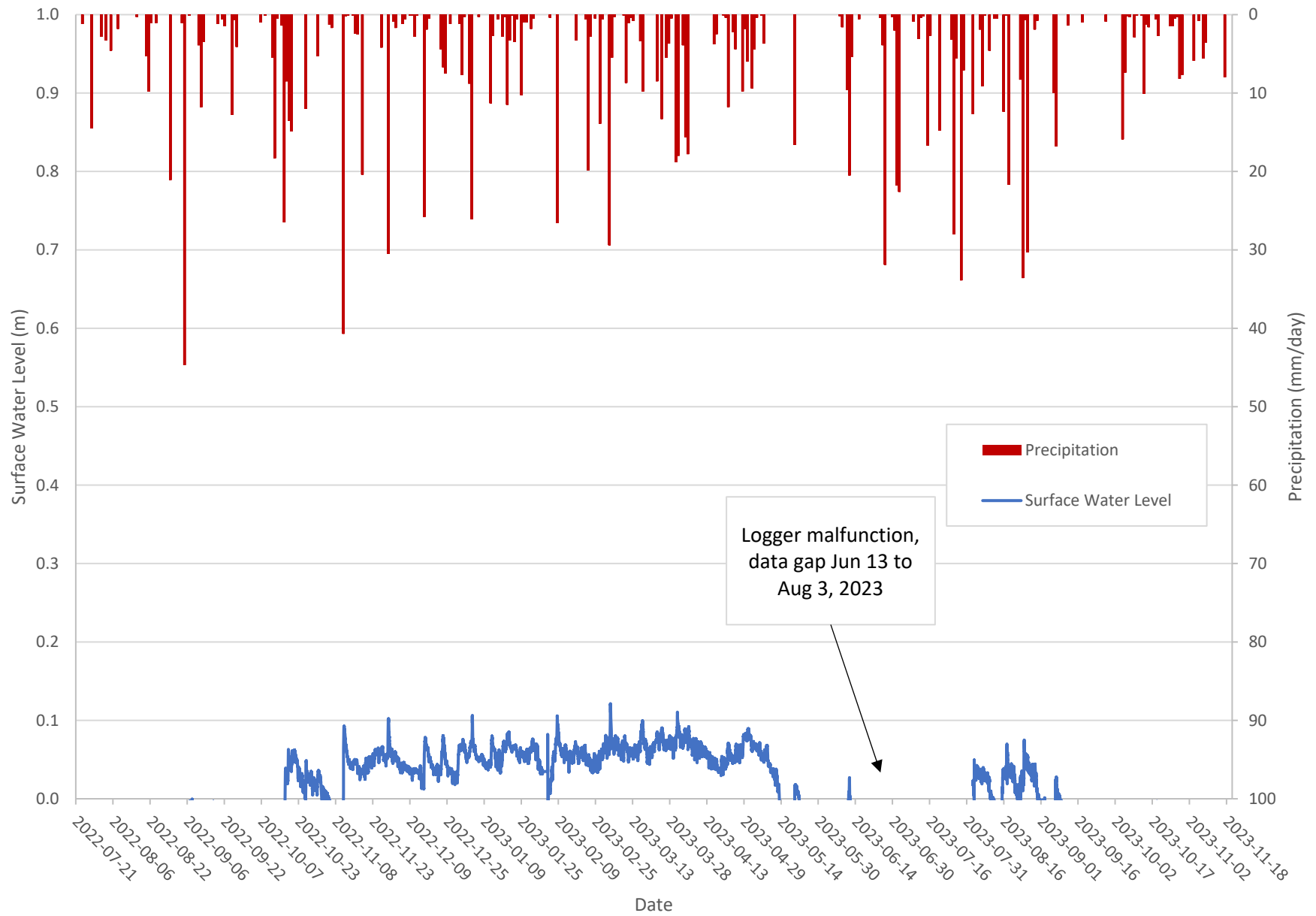
Primont SW-8 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



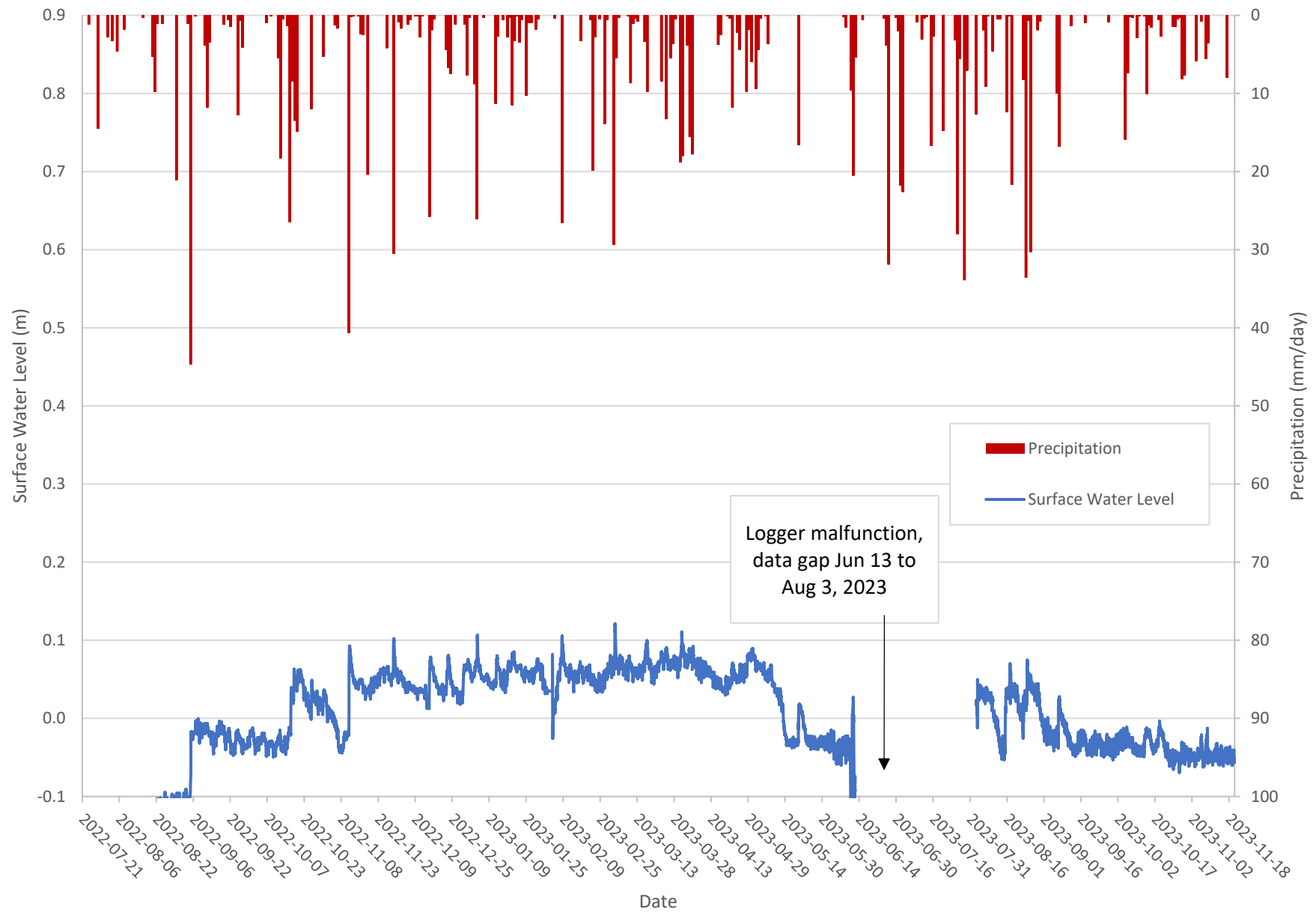
Primont SW-8 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



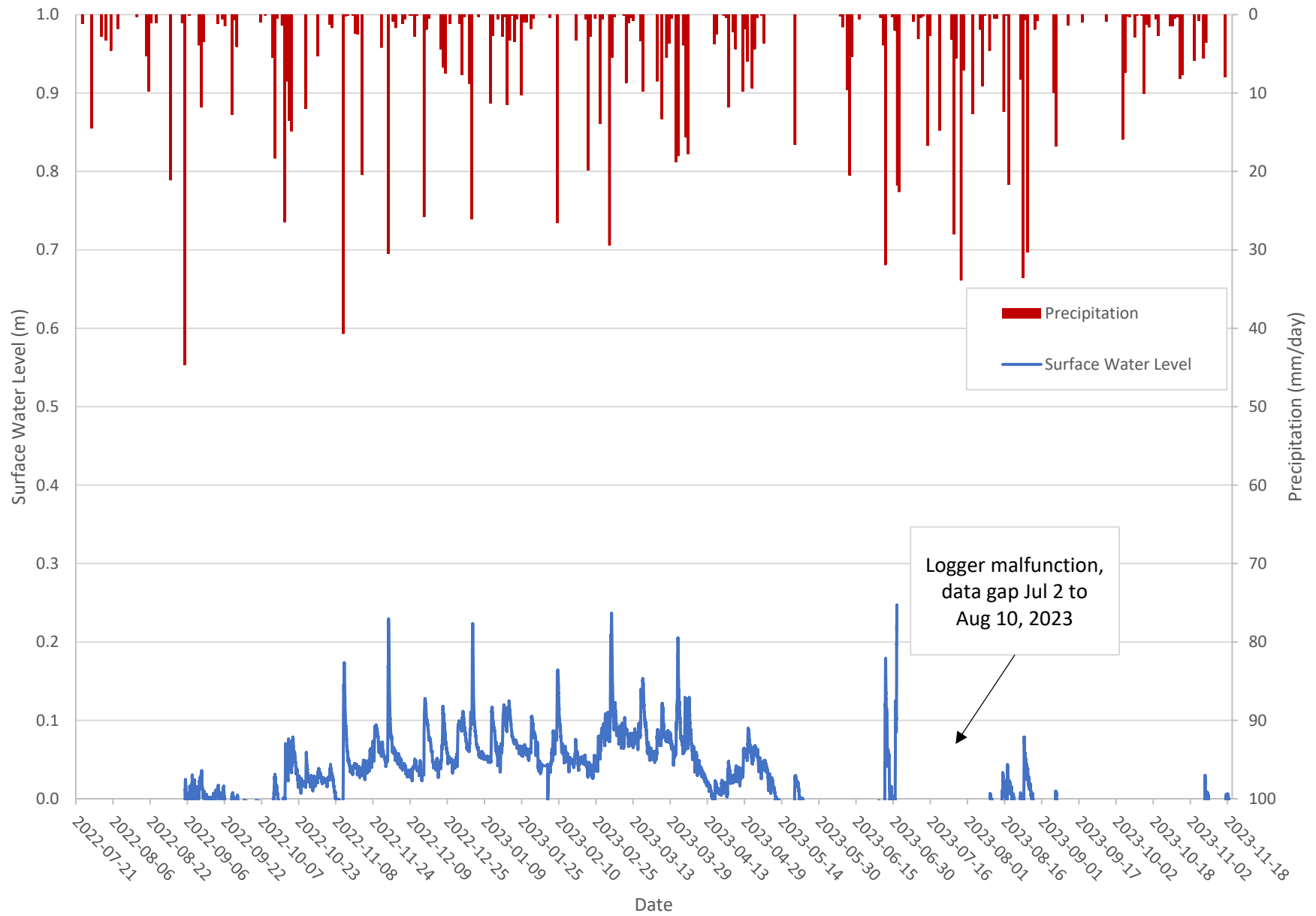
Primont SW-9 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



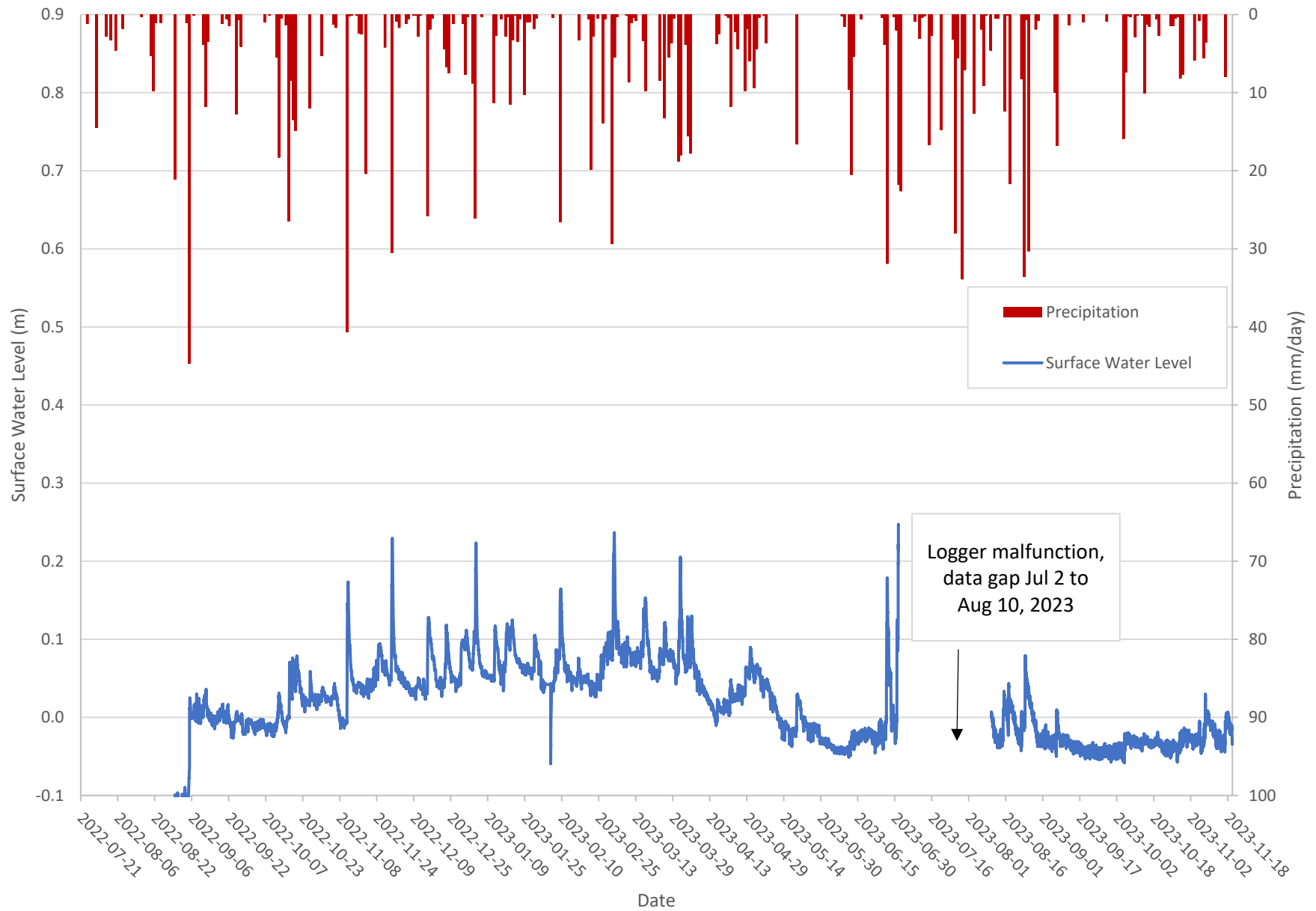
Primont SW-9 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



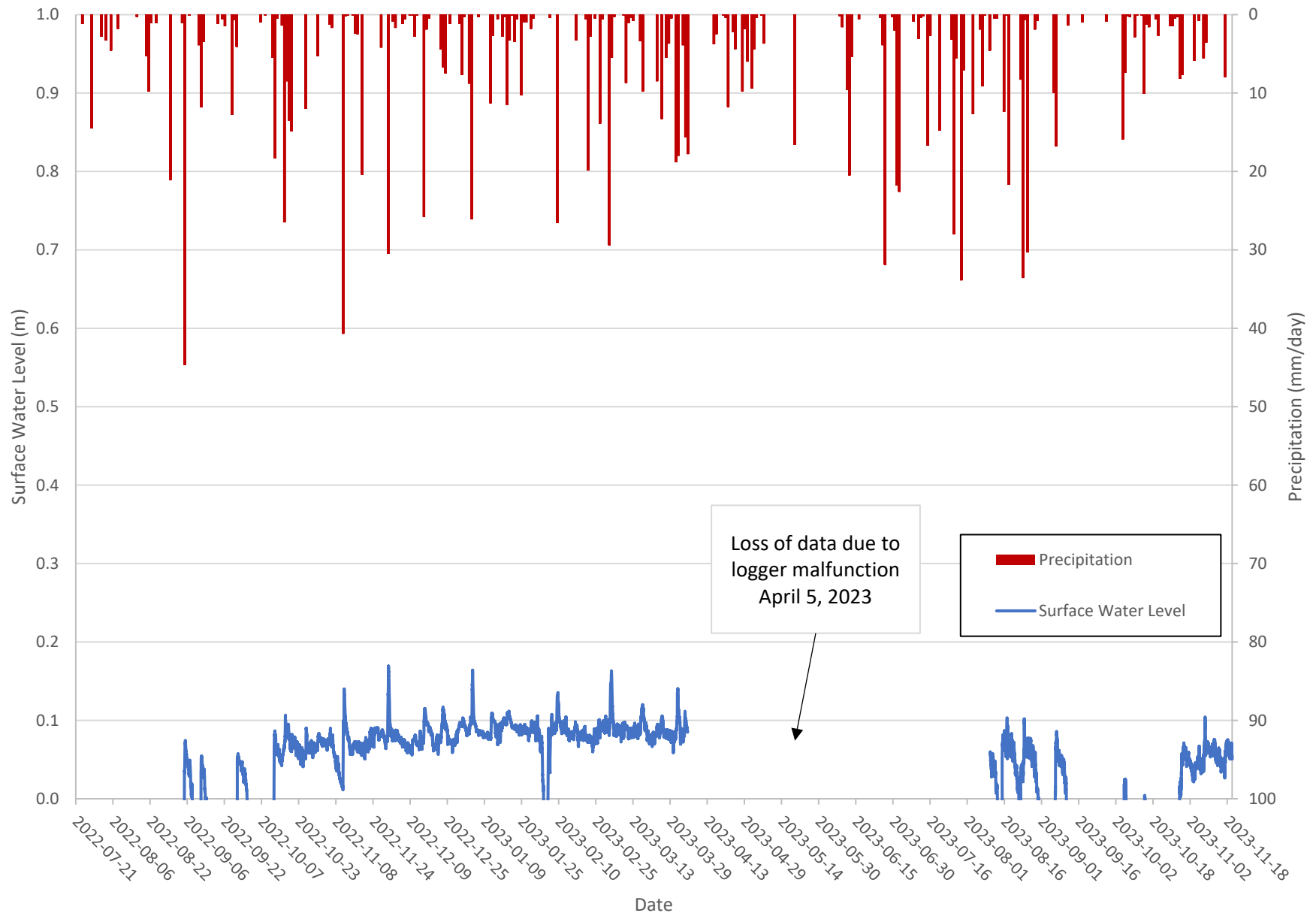
Primont SW-10 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



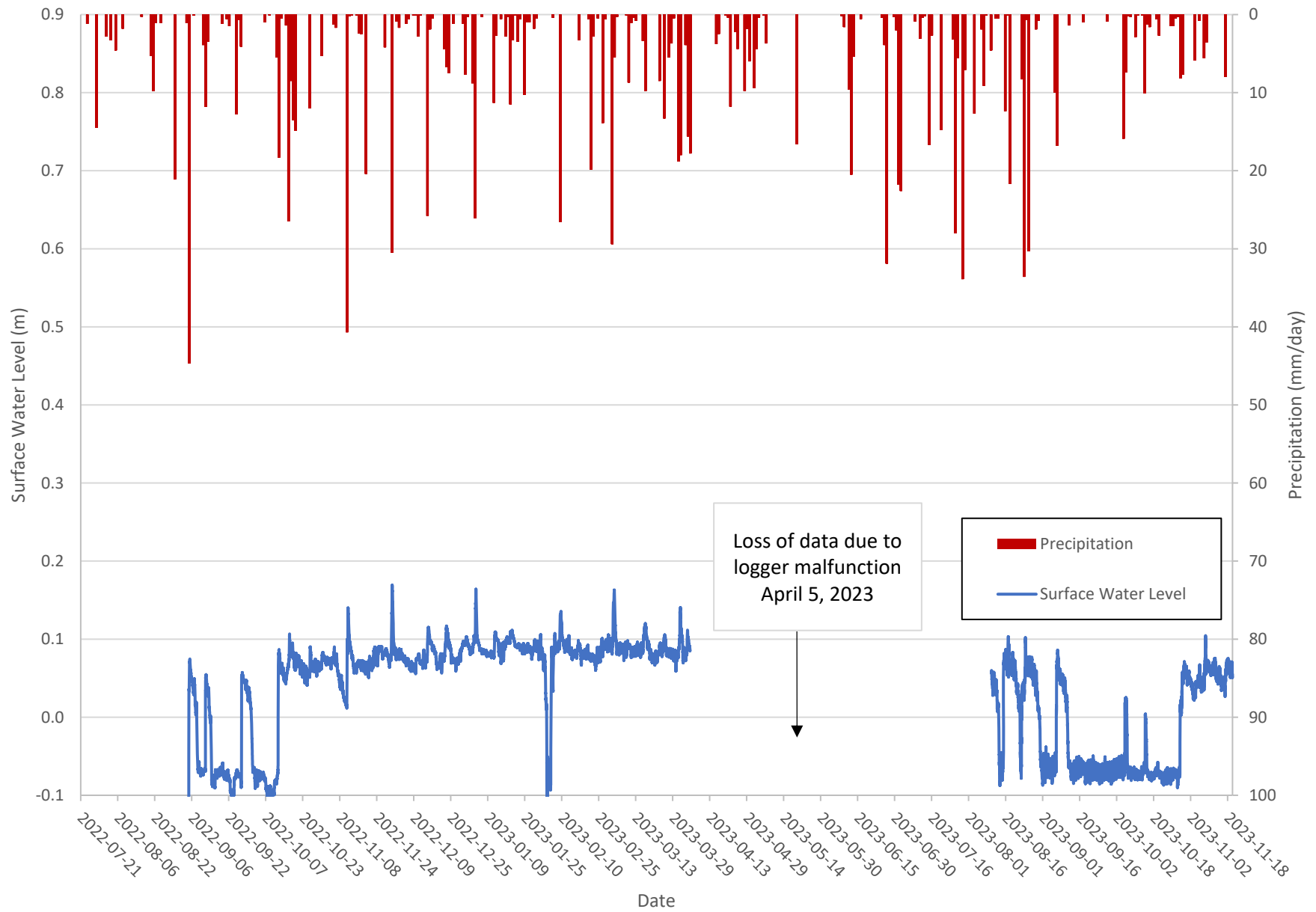
Primont SW-10 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



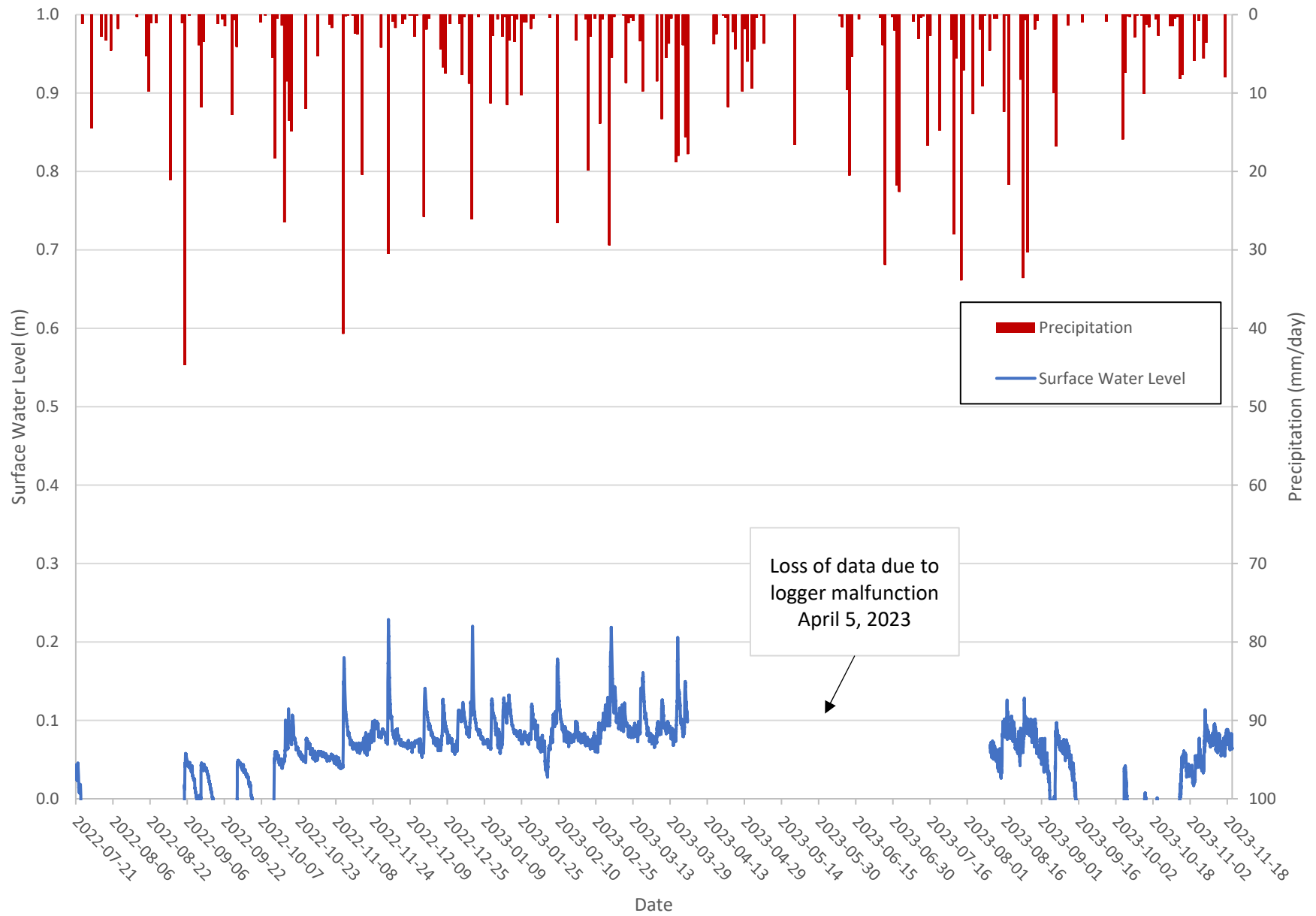
Primont SW-11 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



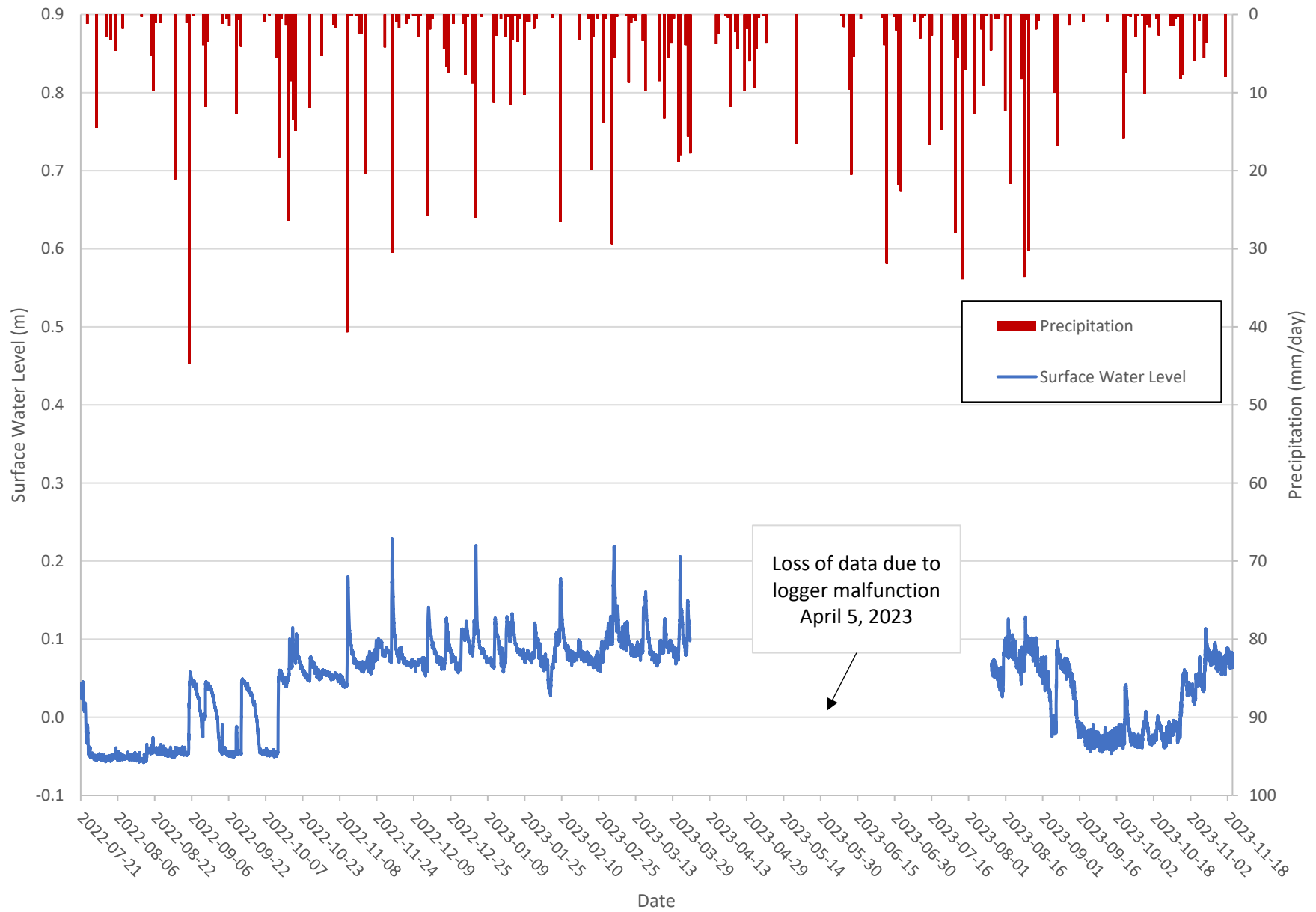
Primont SW-11 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



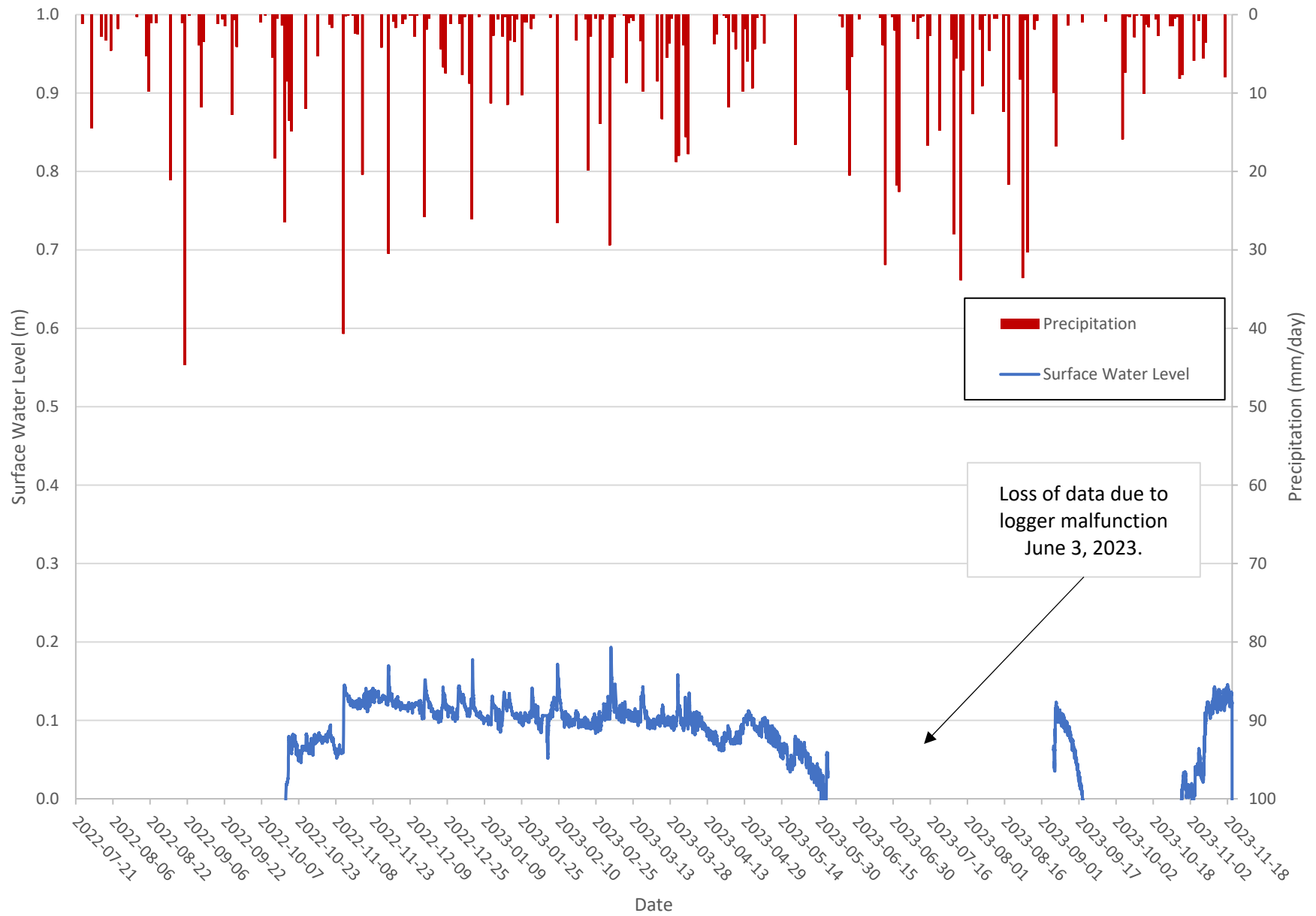
Primont SW-12 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



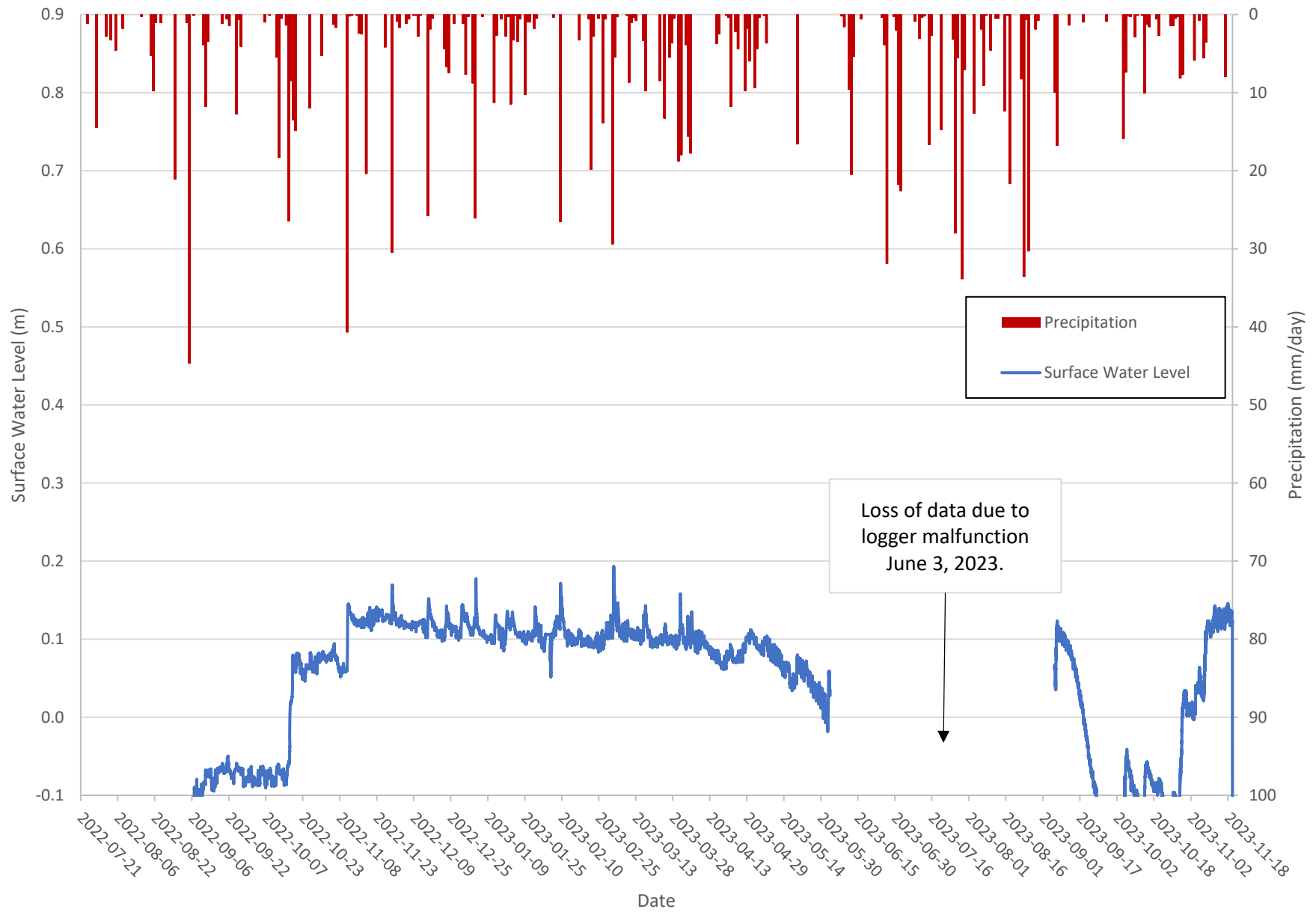
Primont SW-12 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



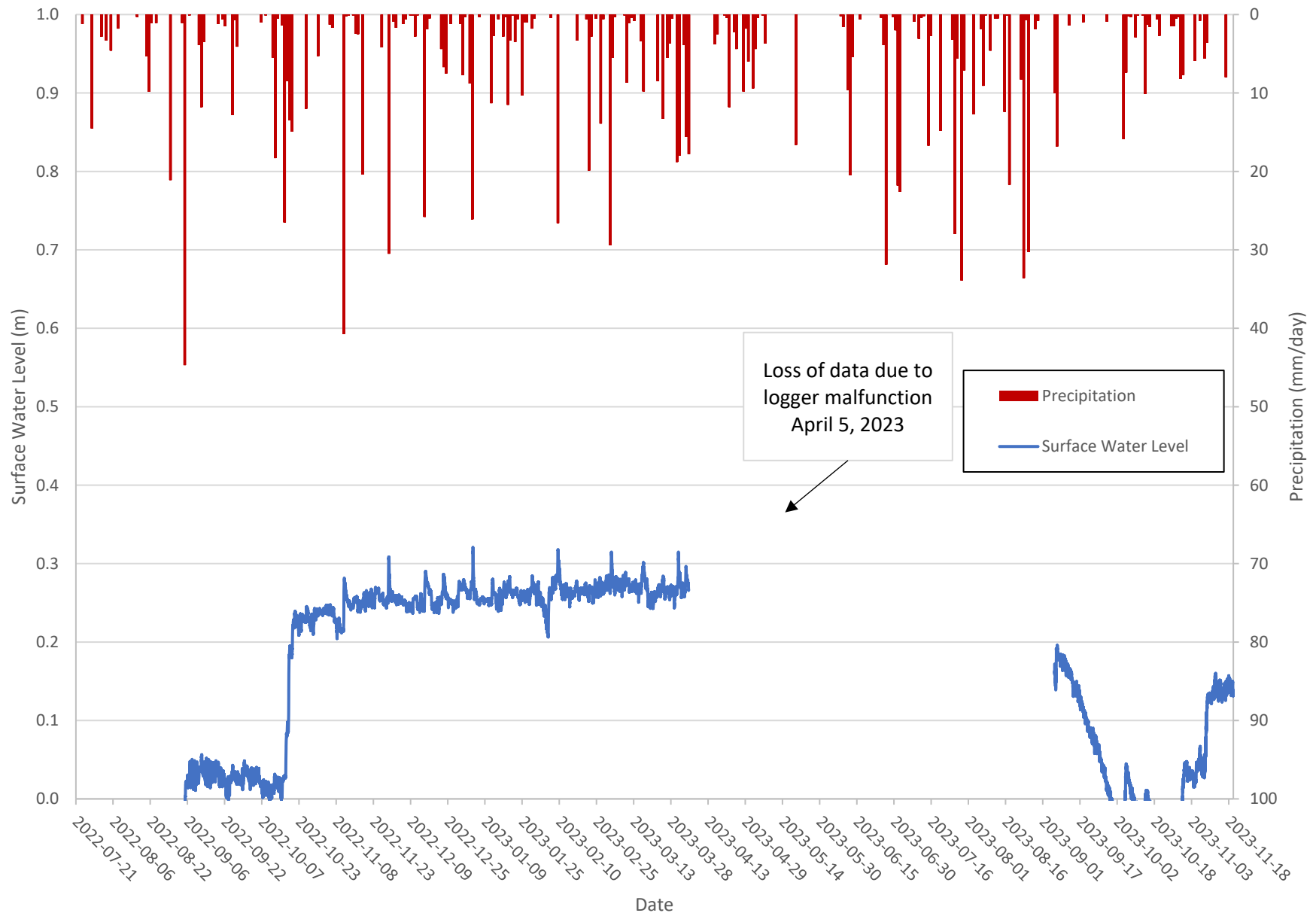
Primont SW-13 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



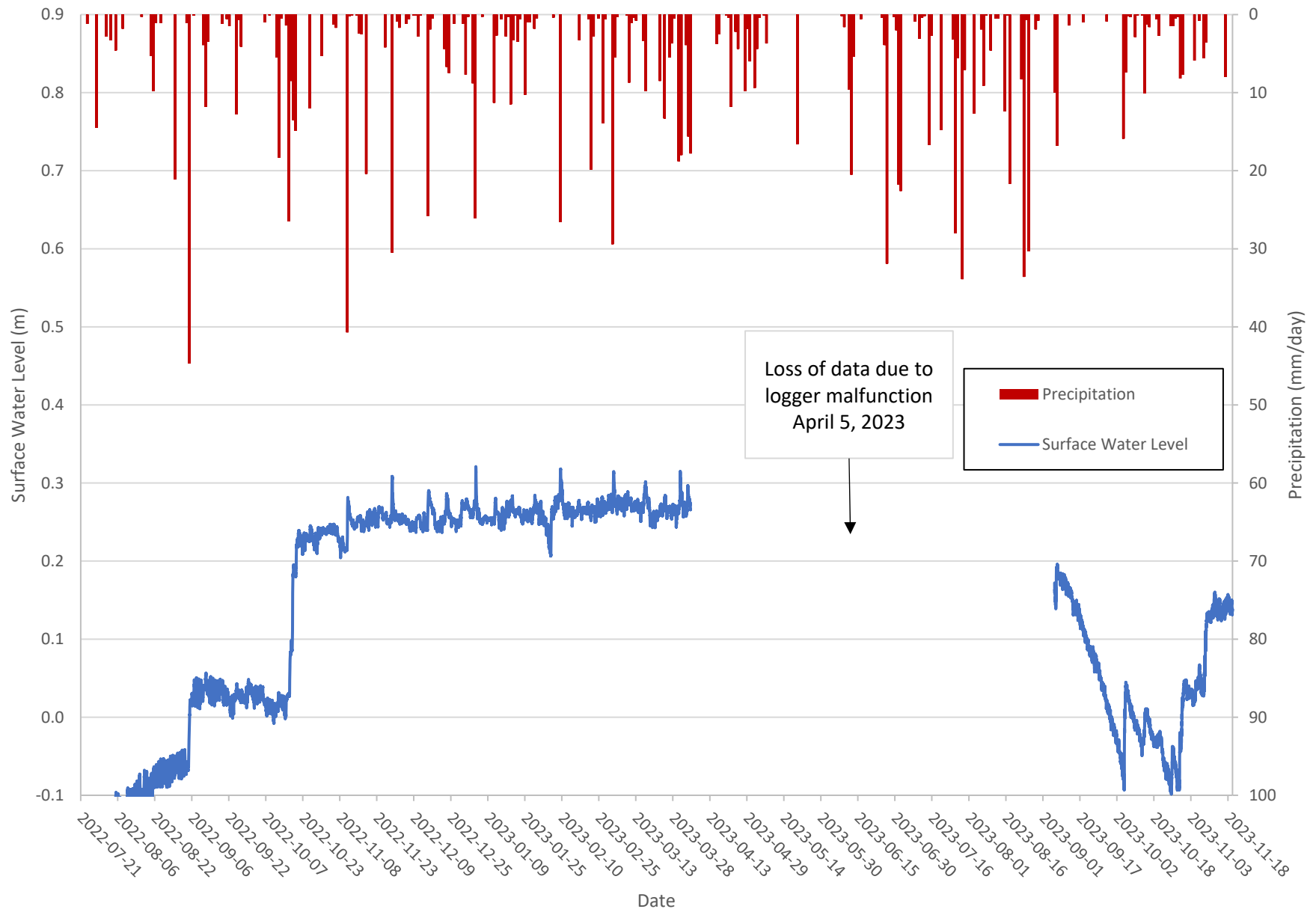
Primont SW-13 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



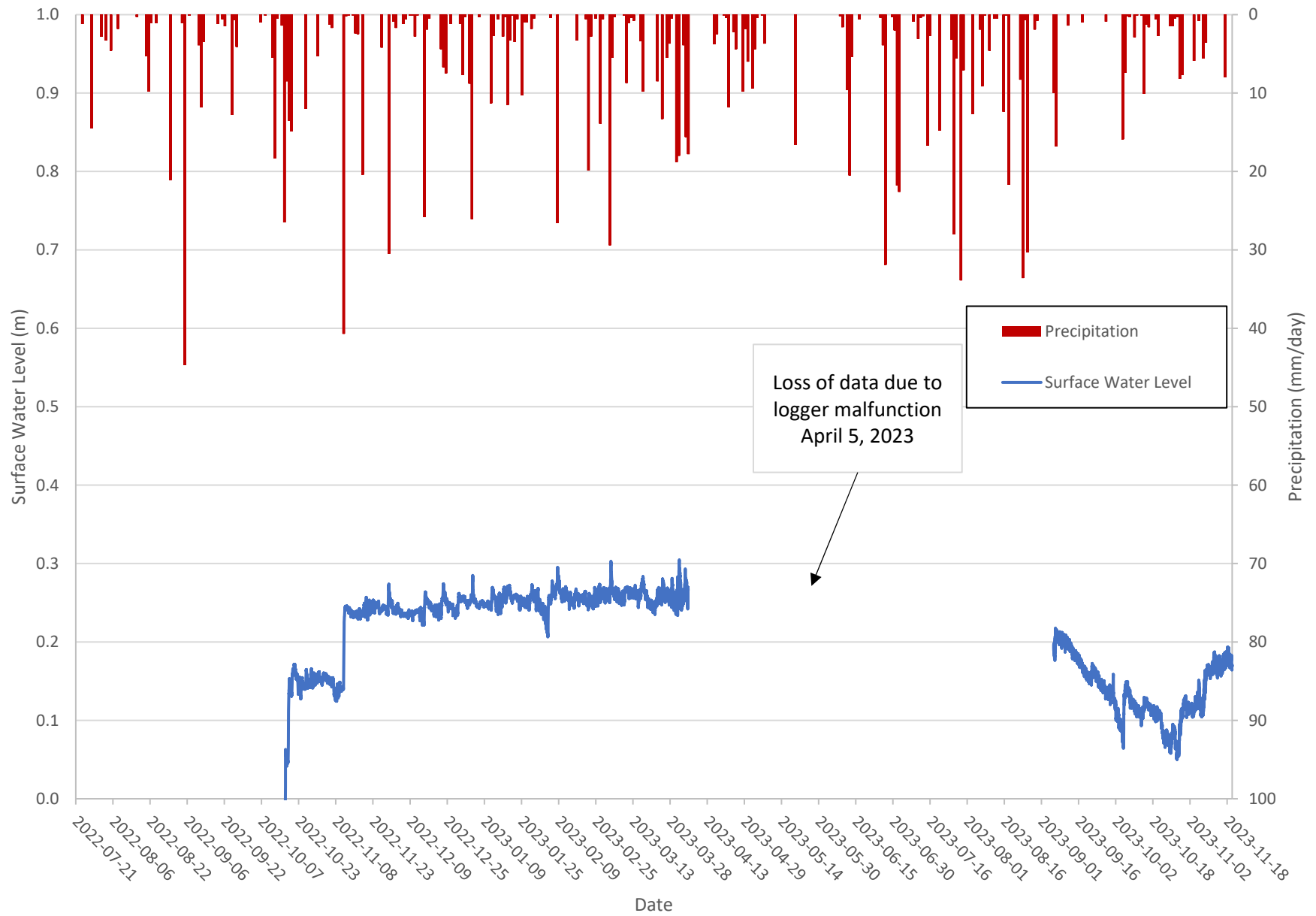
Primont SW-14 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



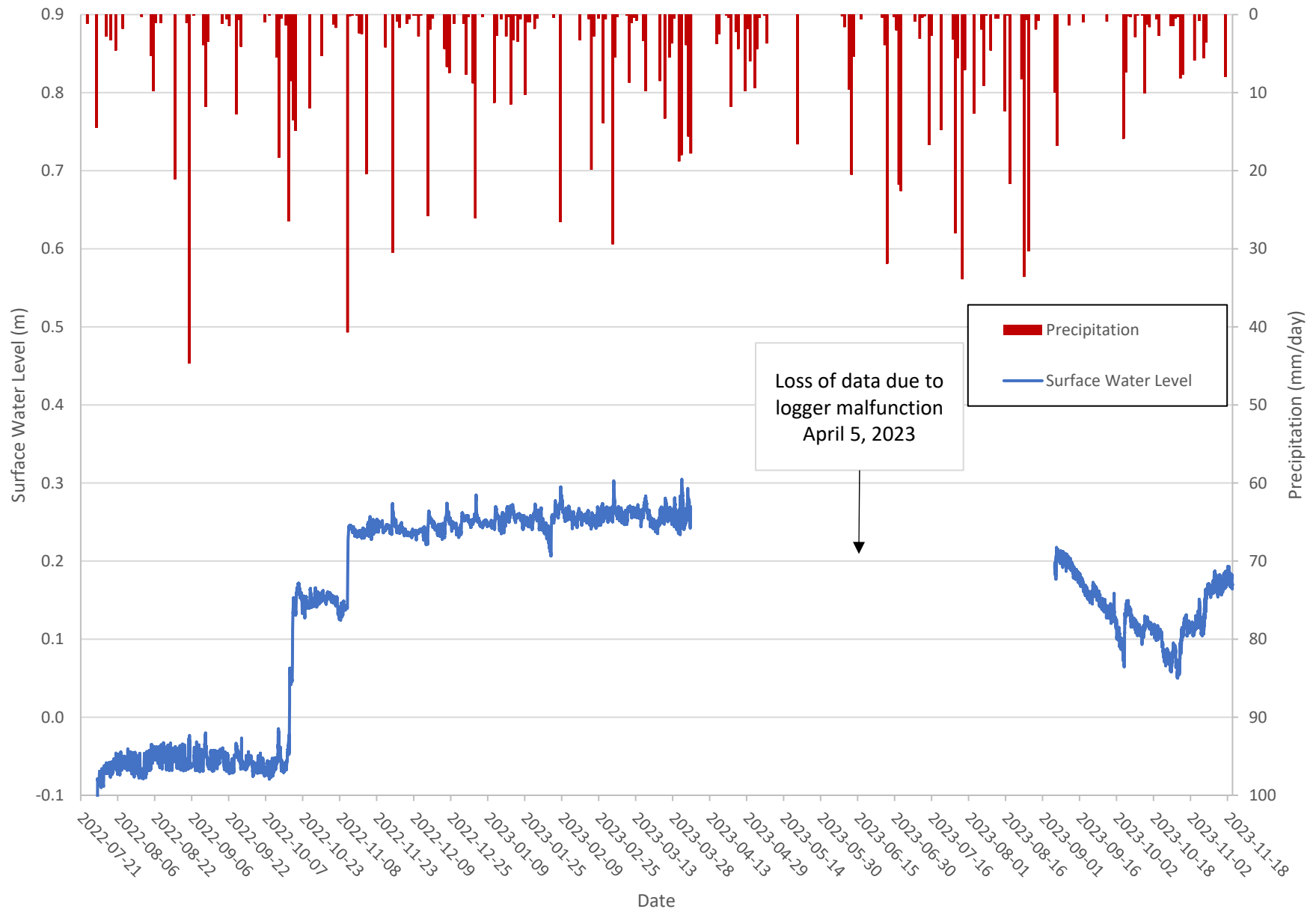
Primont SW-14 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



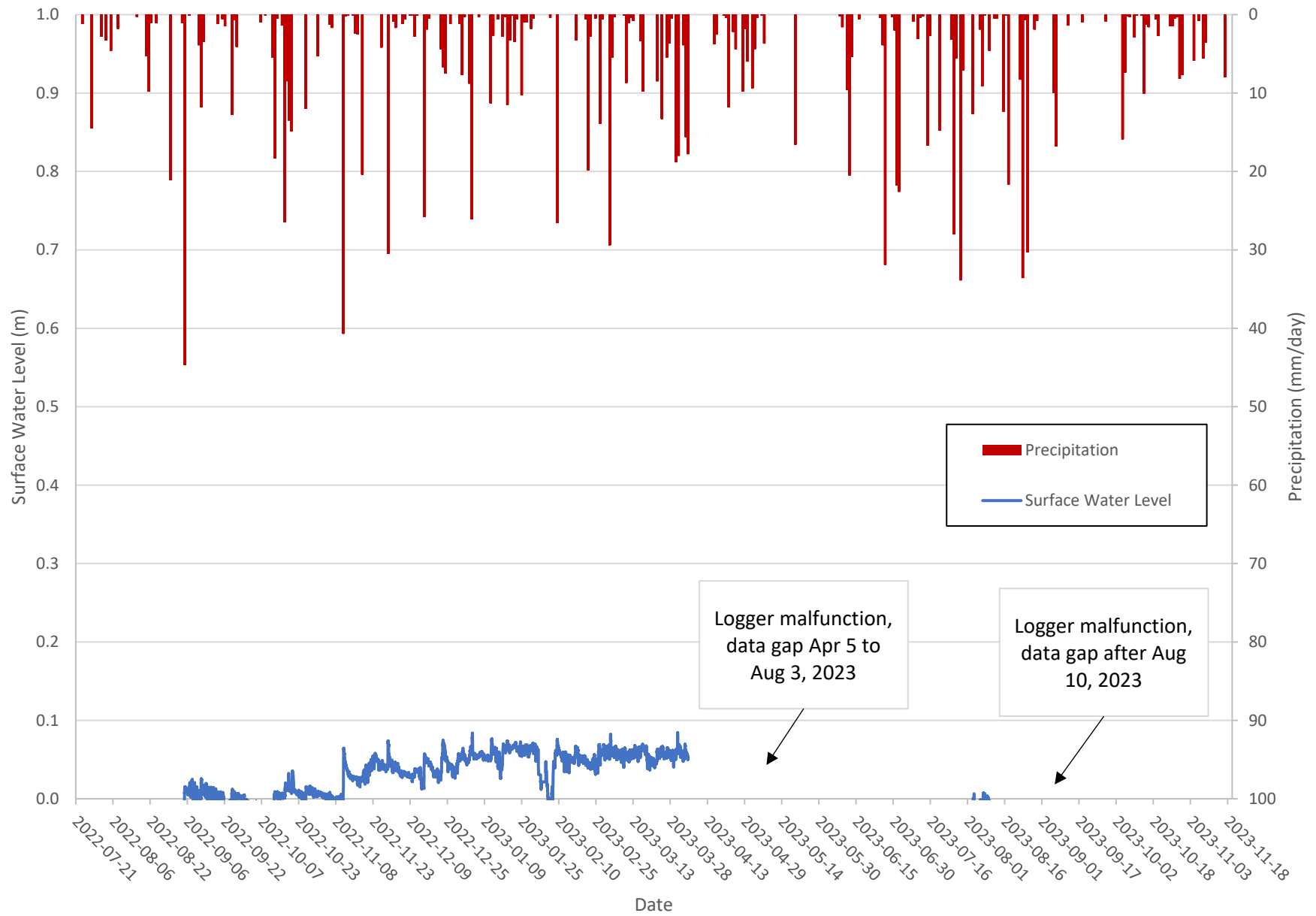
Primont SW-15 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



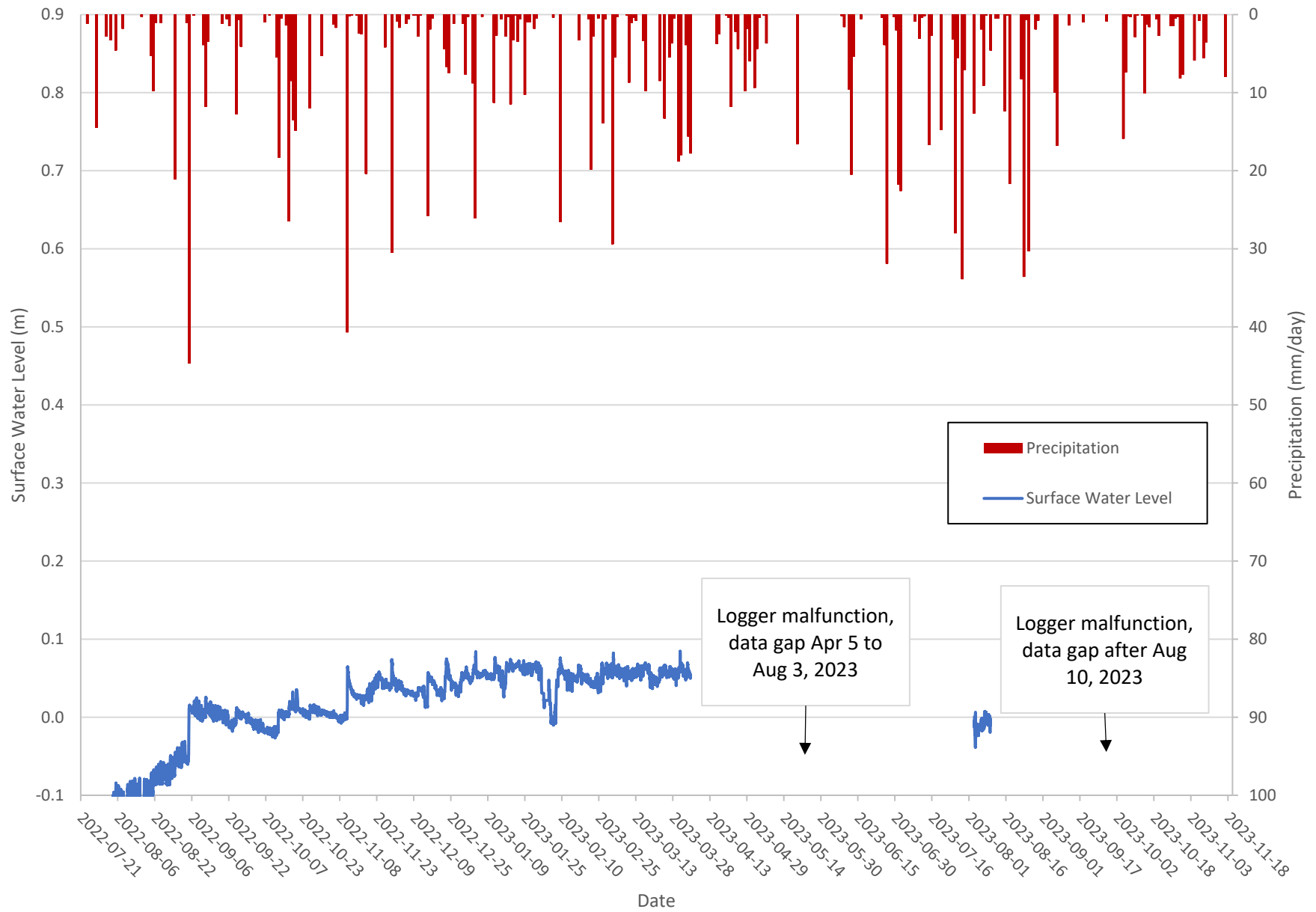
Primont SW-15 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



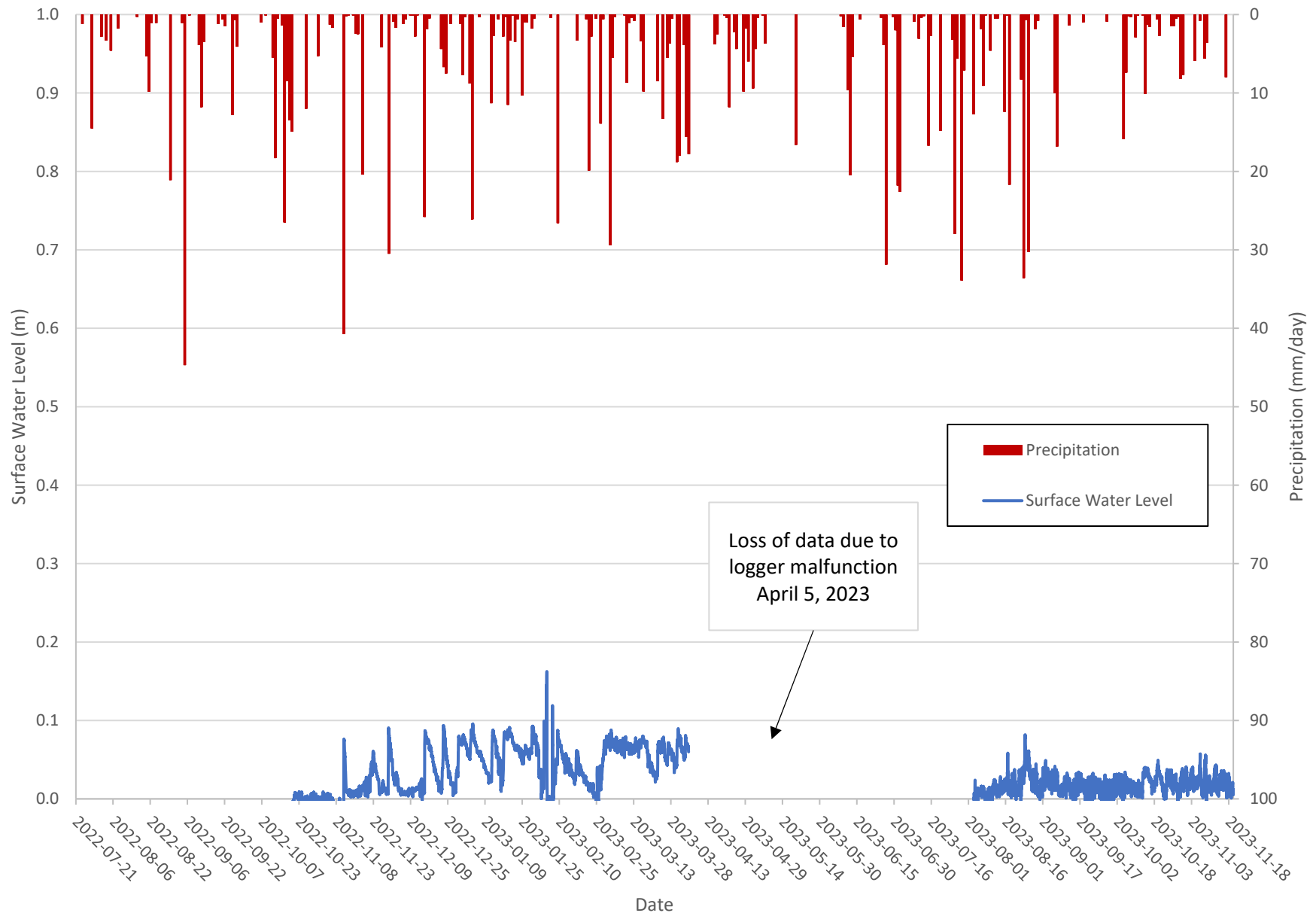
Primont SW-16 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



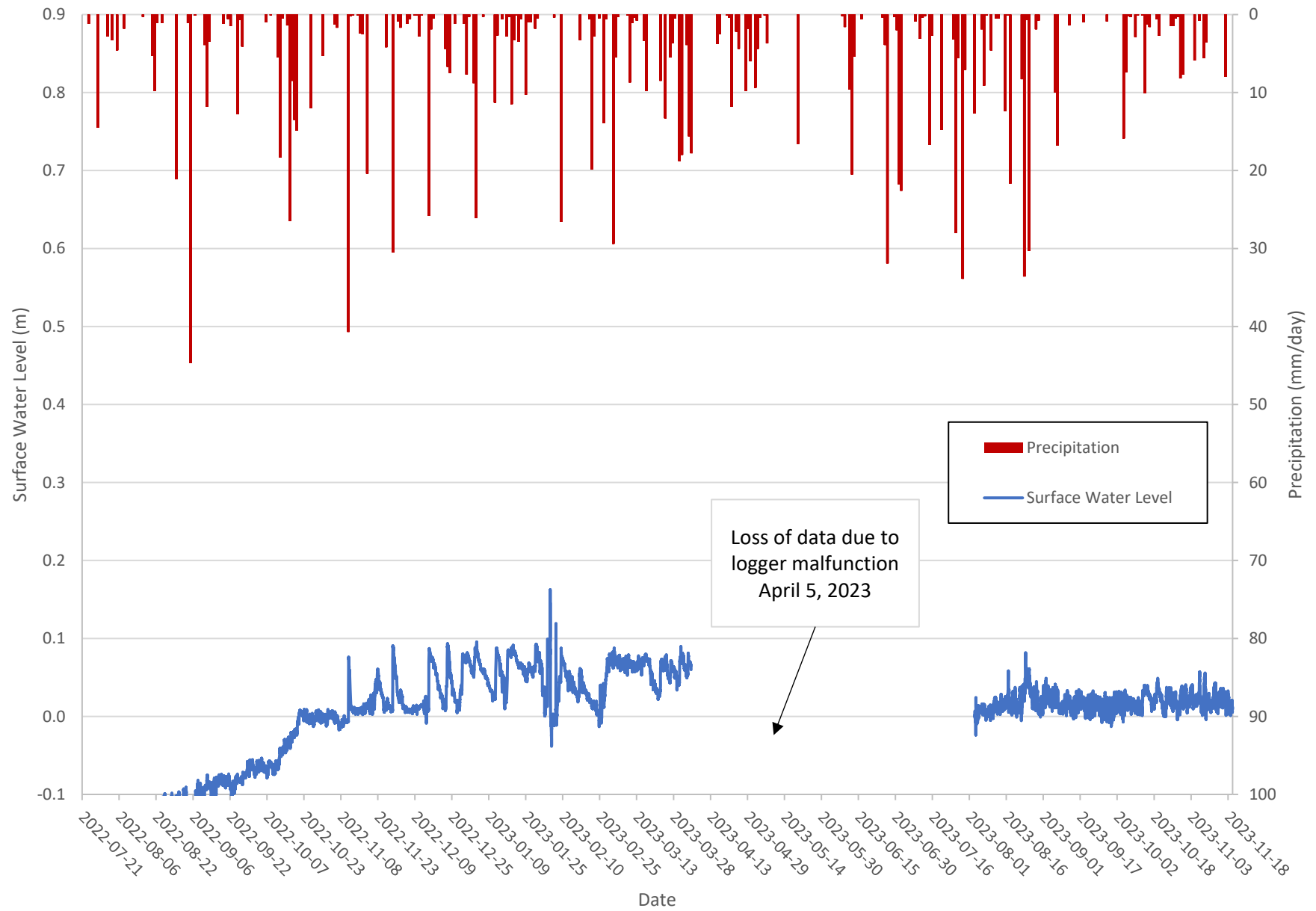
Primont SW-16 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



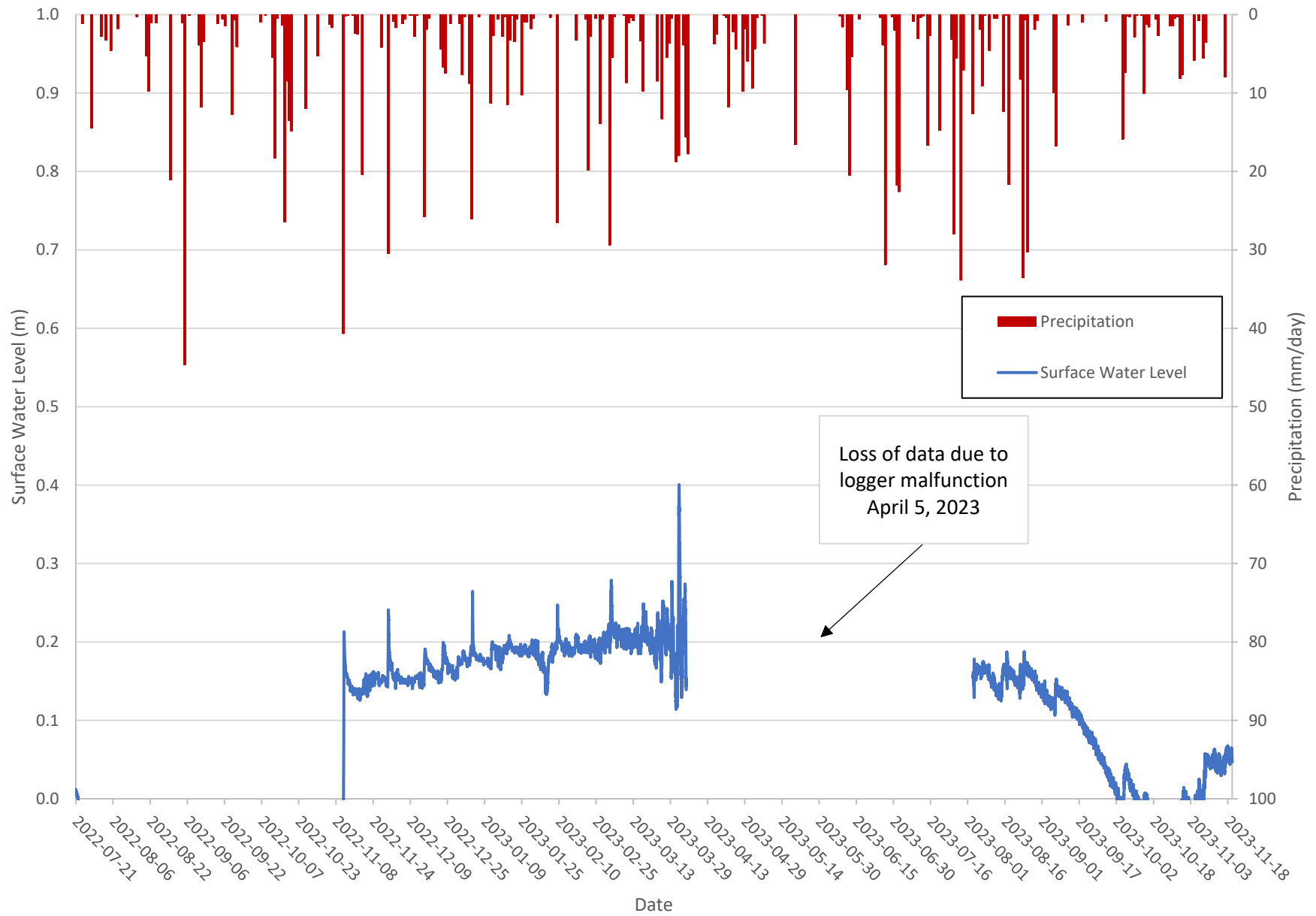
Primont SW-17 Surface Water Level vs Precipitation from July 21, 2022 to November 20, 2023



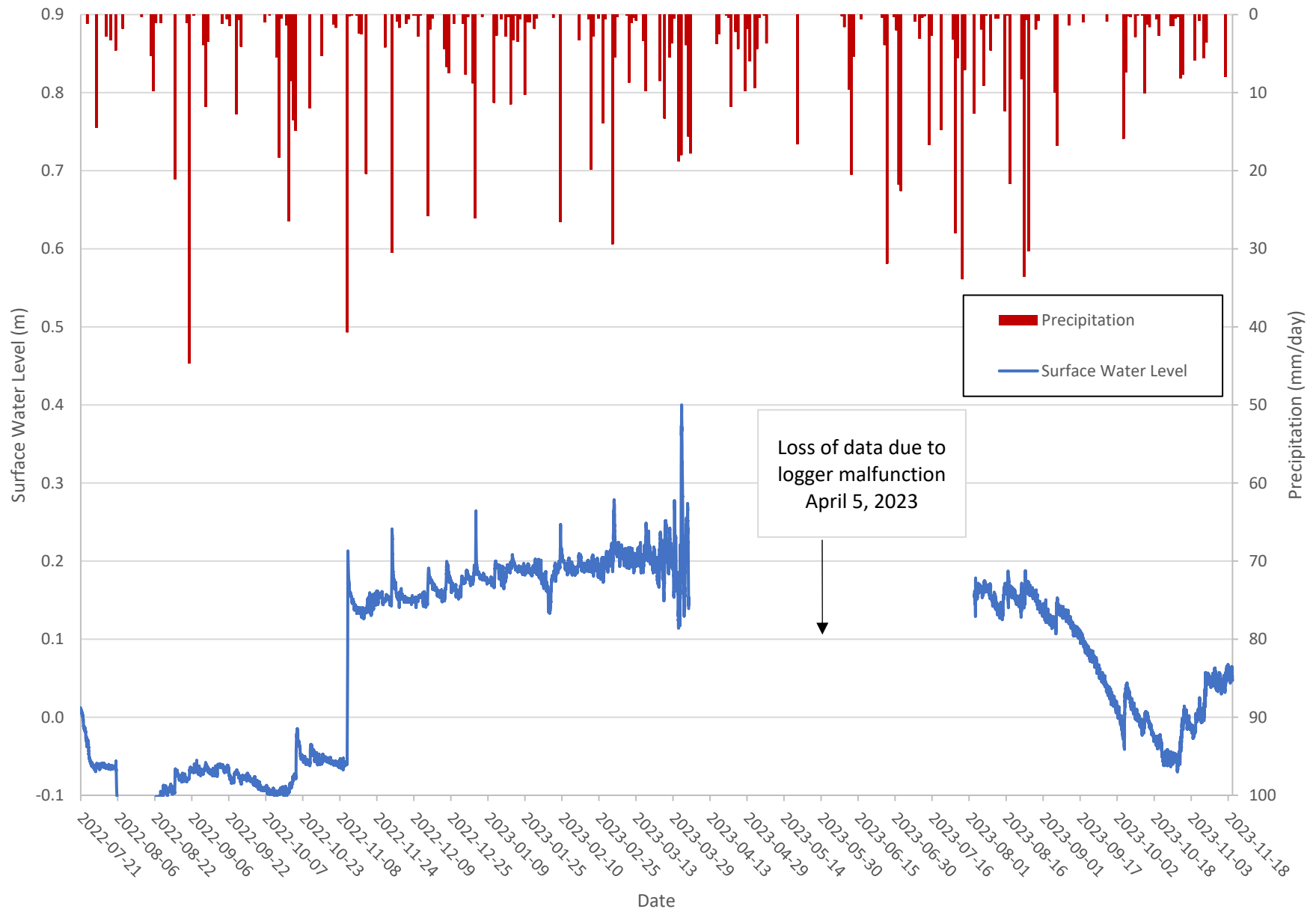
Primont SW-17 Surface Water Level vs Precipitation from July 21, 2022 to November 20, 2023



Primont SW-18 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



Primont SW-18 Surface Water Level vs. Precipitation from July 21, 2022 to November 20, 2023



Appendix F

Tow Path Drain Surface Water Monitoring

Tow Path Drain Staff Gauges, Welland, Ontario

SG-101 (October 23, 2023)



Photo taken at 12:00 facing to the North.

SG-102 (October 23, 2023)



Photo taken at 10:20 facing the West.

SG-103 (October 23, 2023)



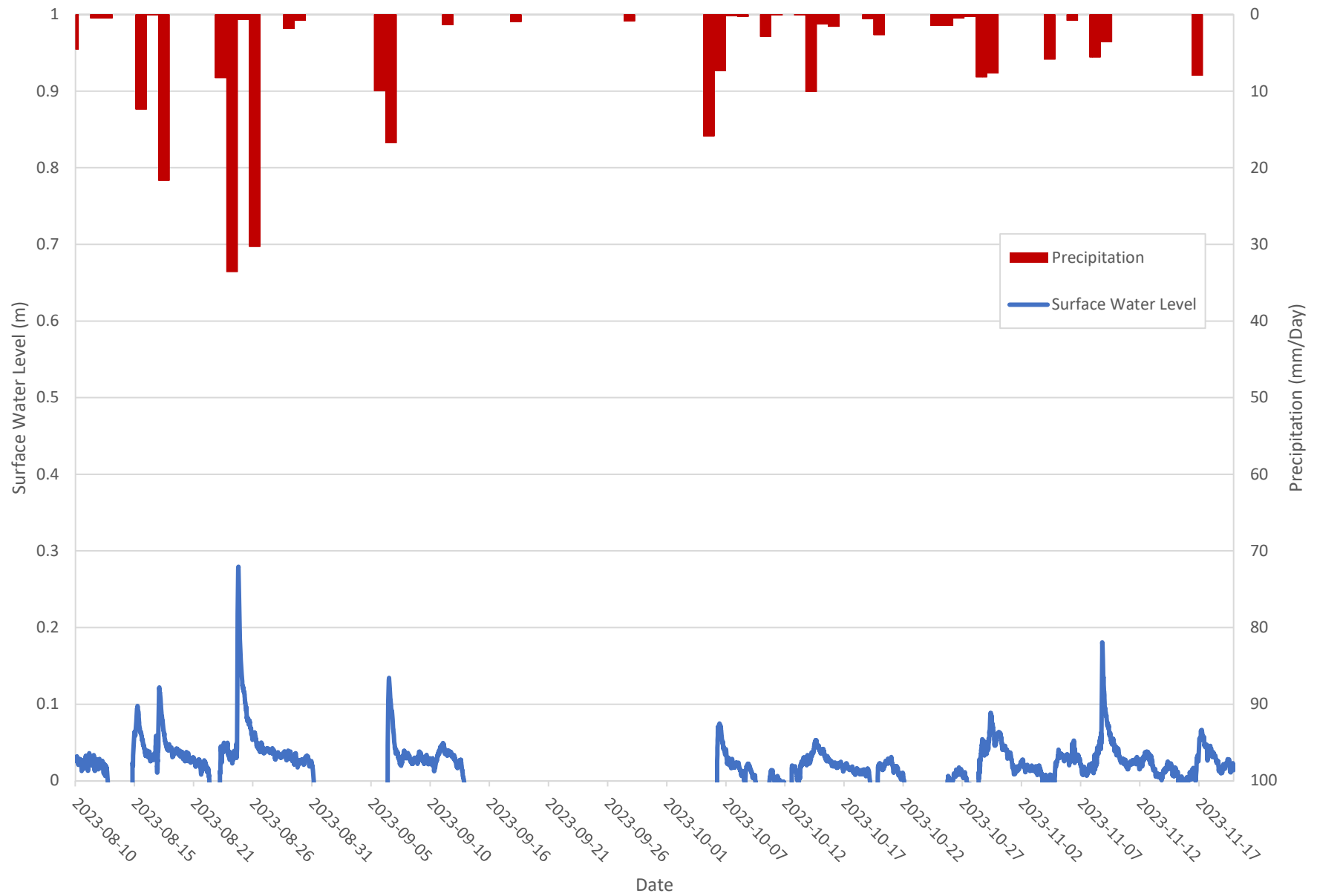
Photo taken at 10:50 facing the West.

SG-104 (October 23, 2023)

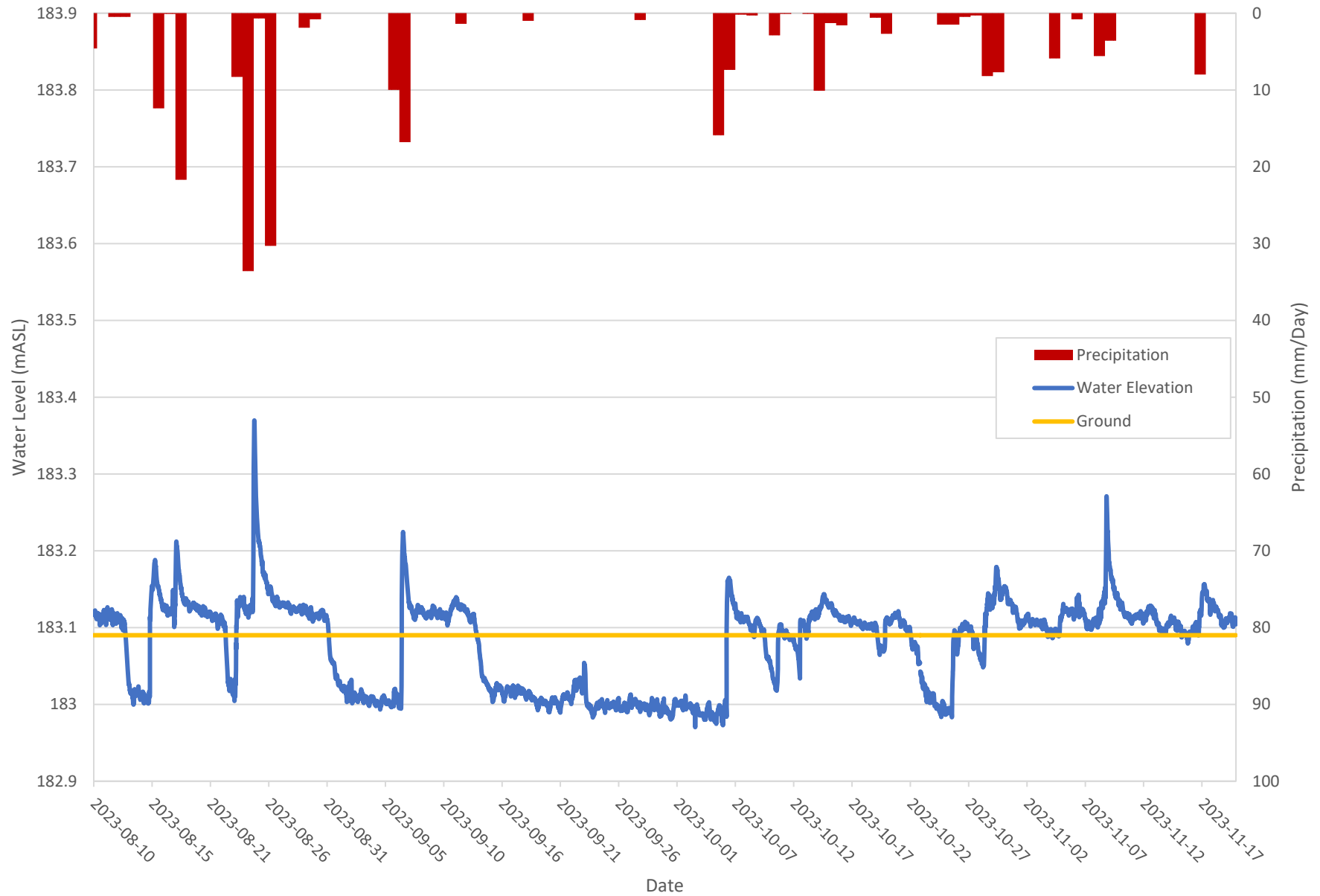


Photo taken at 11:40 facing the South.

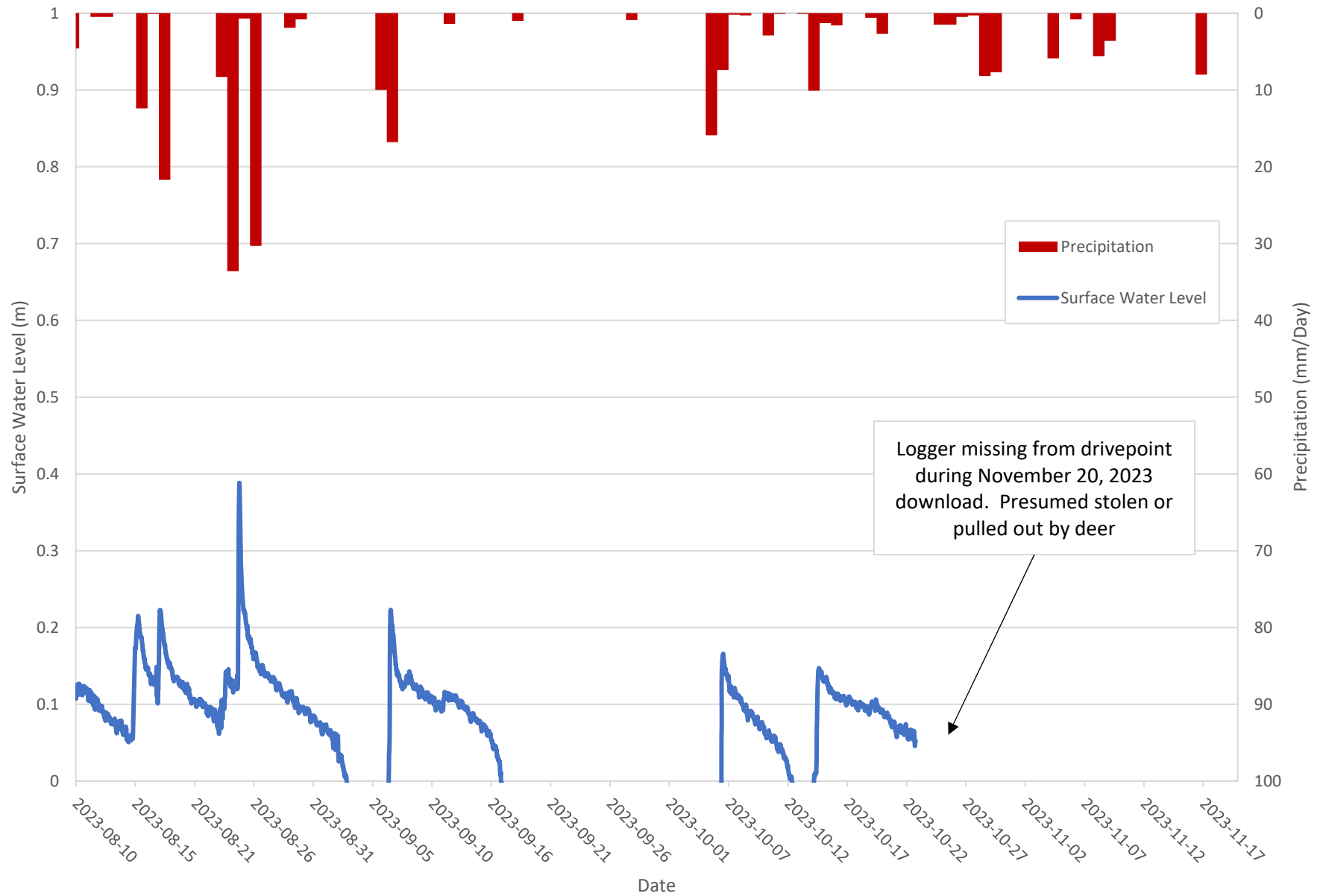
Tow Path Drain SG-101 Water Level and Precipitation August 10 to November 20, 2023



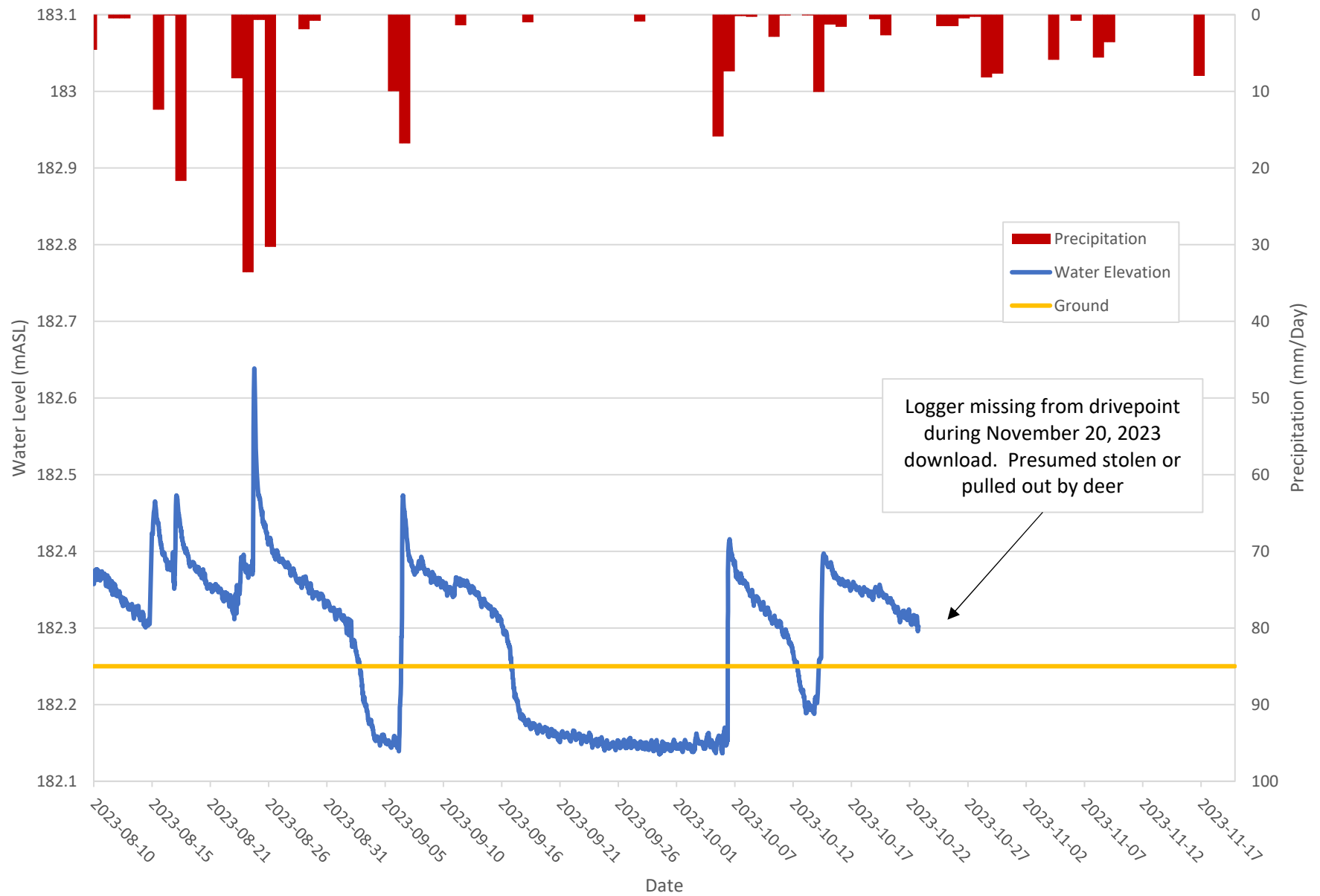
Tow Path Drain SG-101 Water Elevation and Precipitation August 10 to November 20, 2023



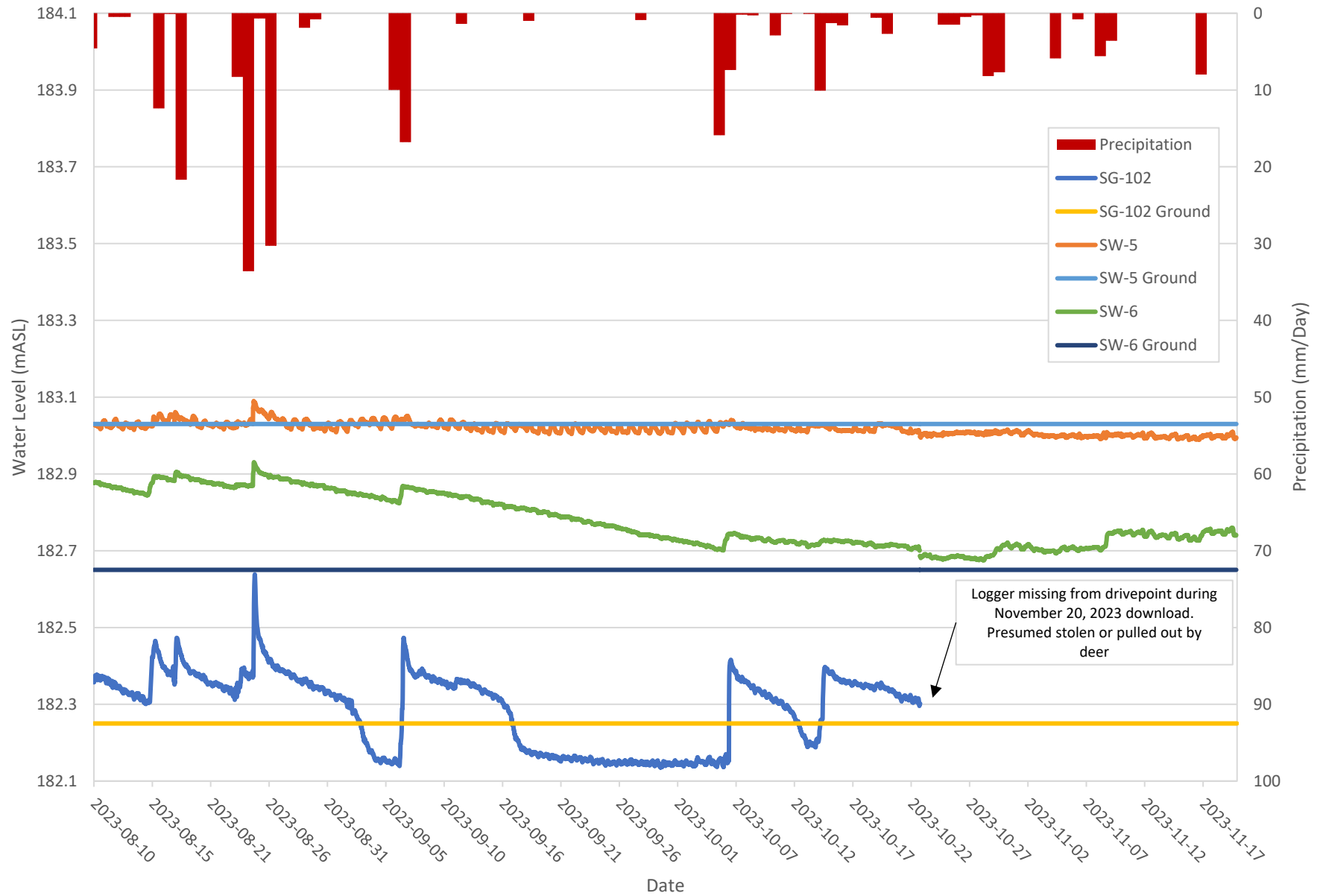
Tow Path Drain SG-102 Water Level and Precipitation August 10 to November 20, 2023



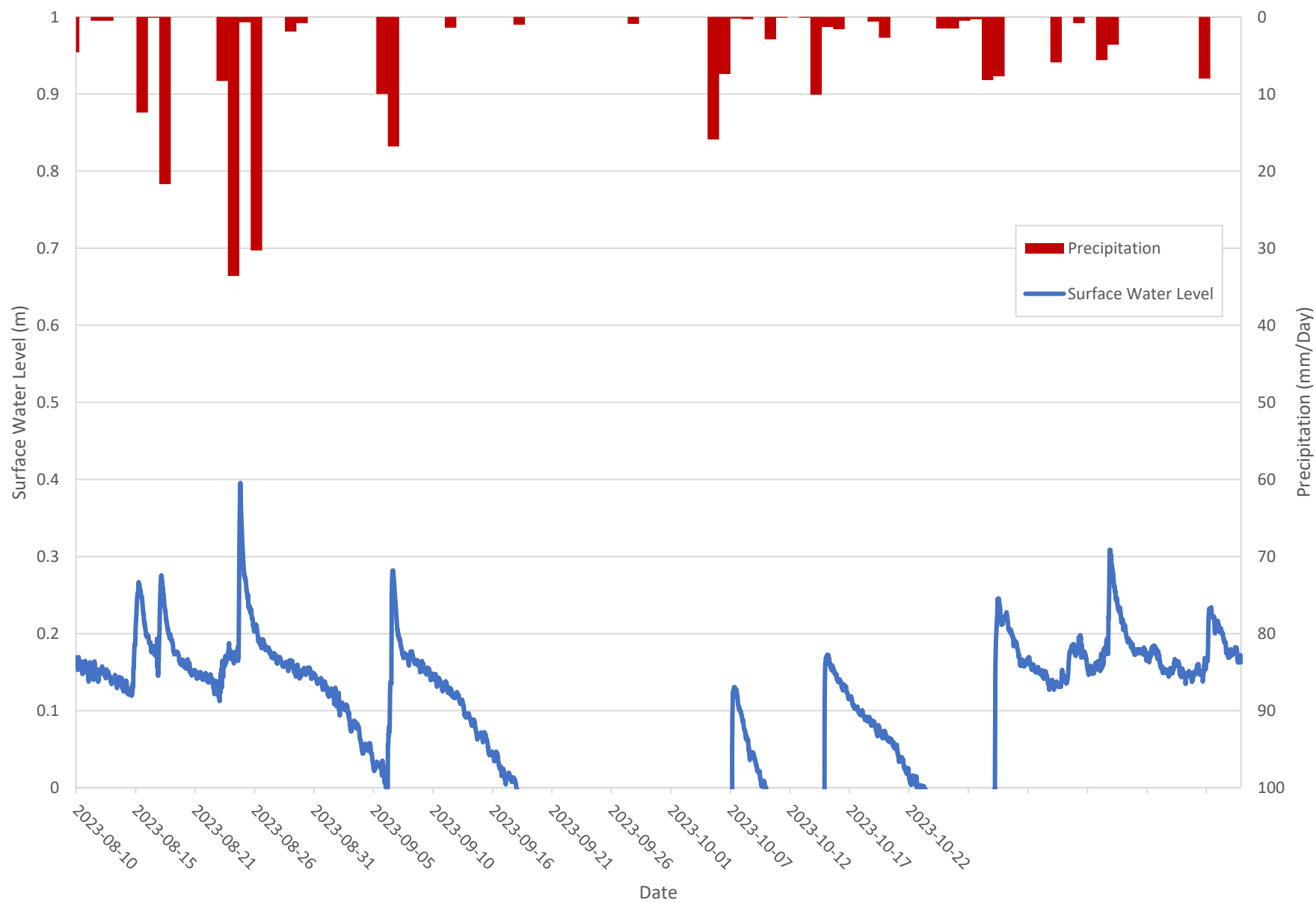
Tow Path Drain SG-102 Water Elevation and Precipitation August 10 to November 20, 2023



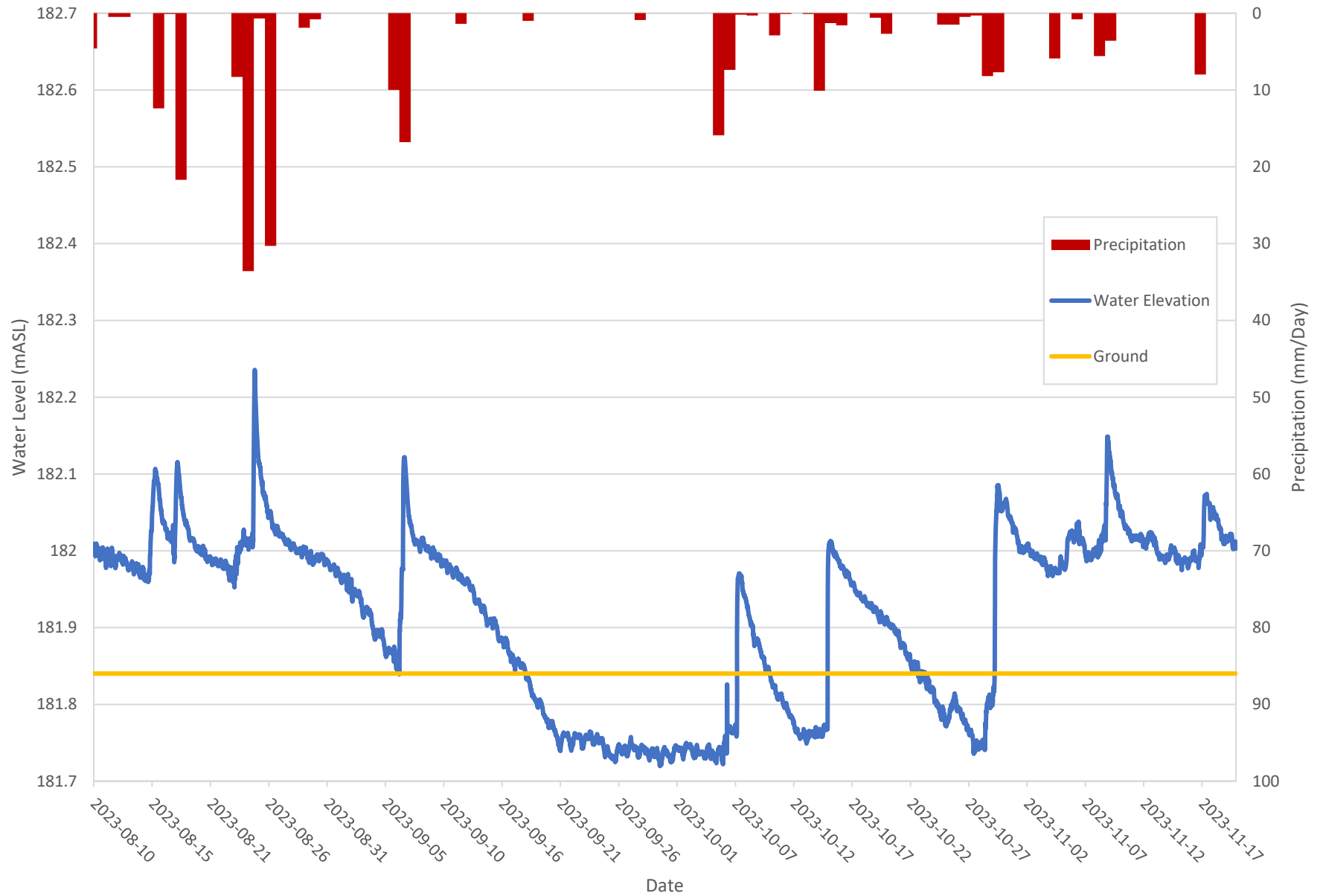
SG-102, SW-5 and SW-6 Water Elevation and Precipitation August 10 to November 20, 2023



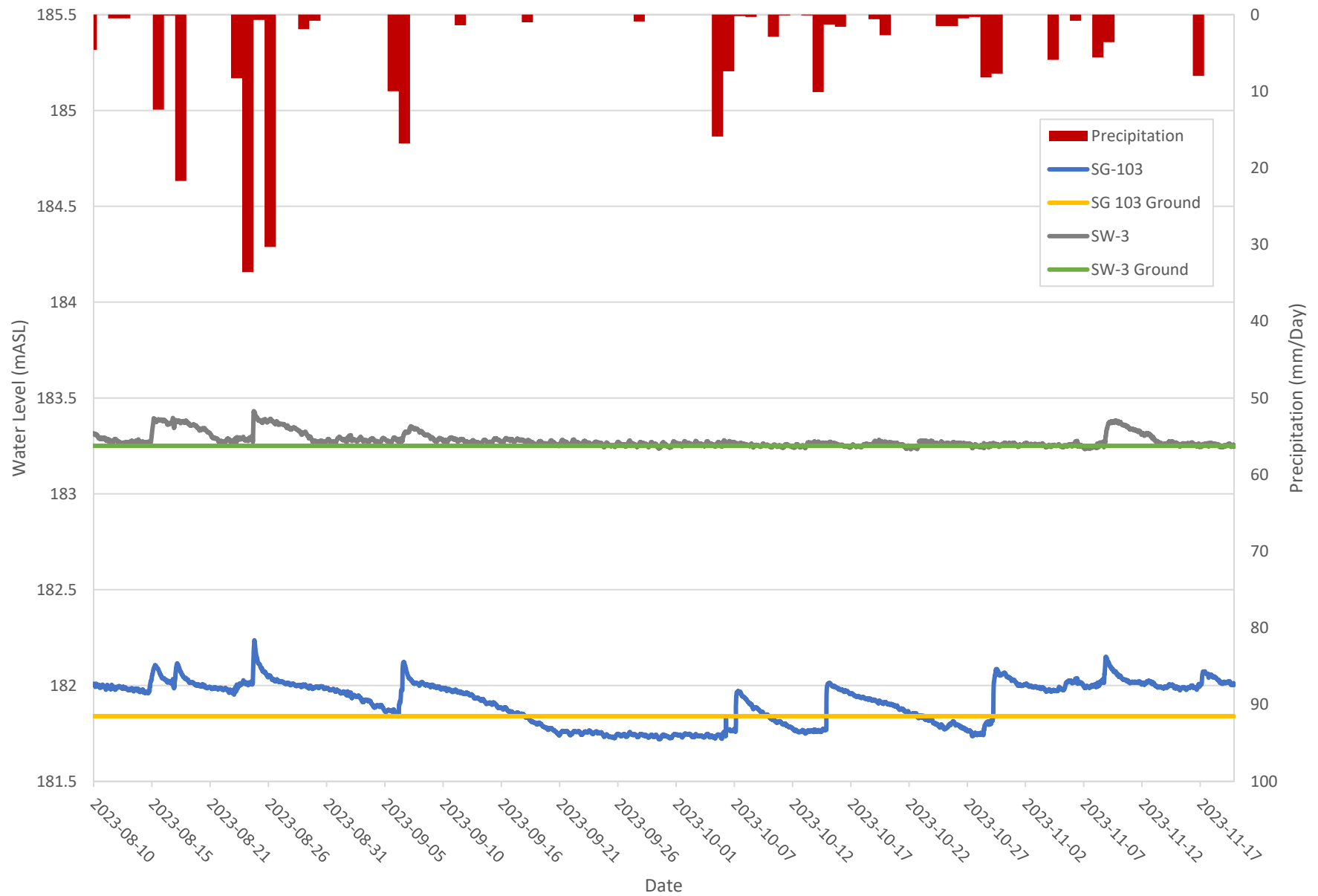
Tow Path Drain SG-103 Water Level and Precipitation August 10 to November 20, 2023



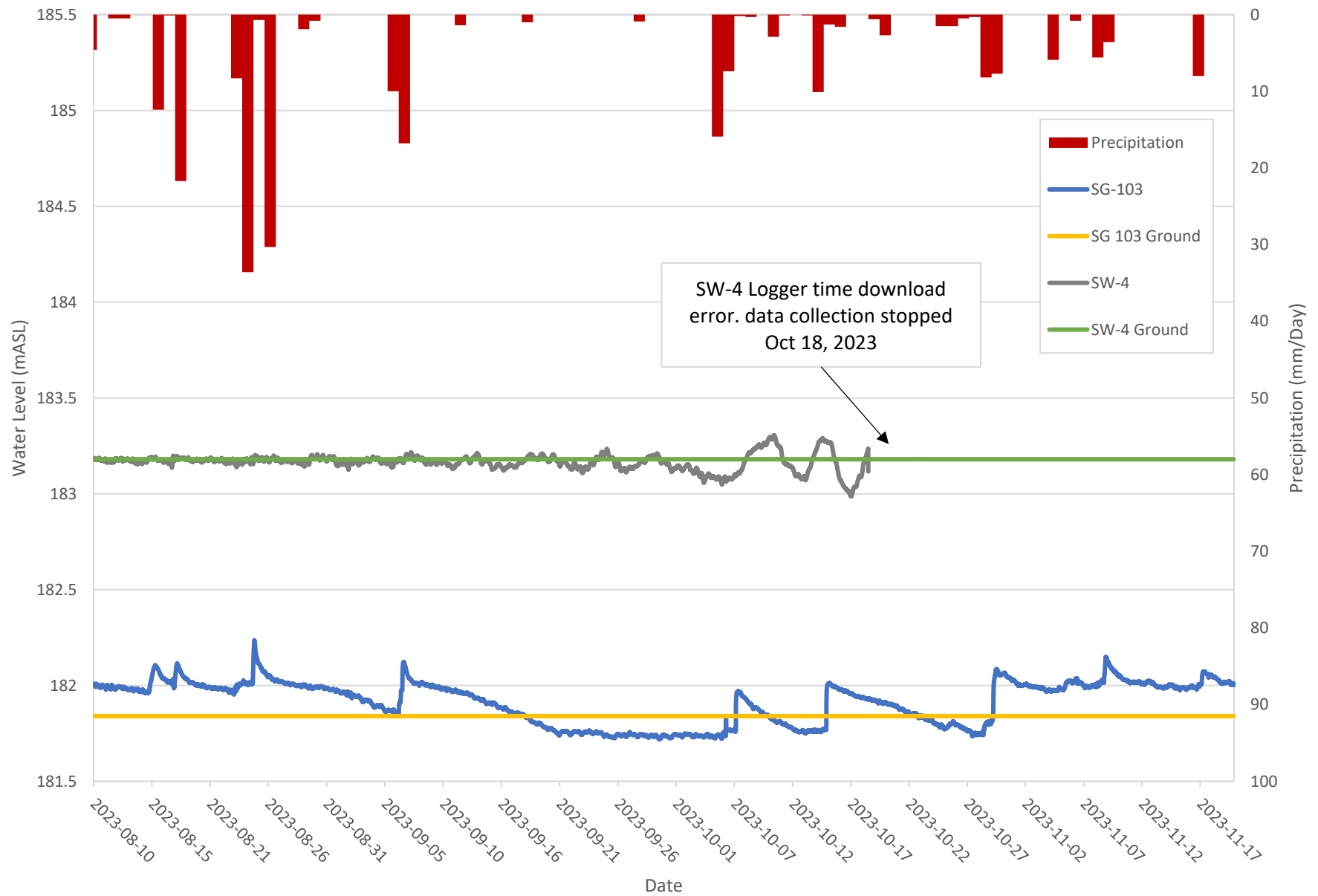
SG-103 Water Elevation and Precipitation August 10 to November 20, 2023



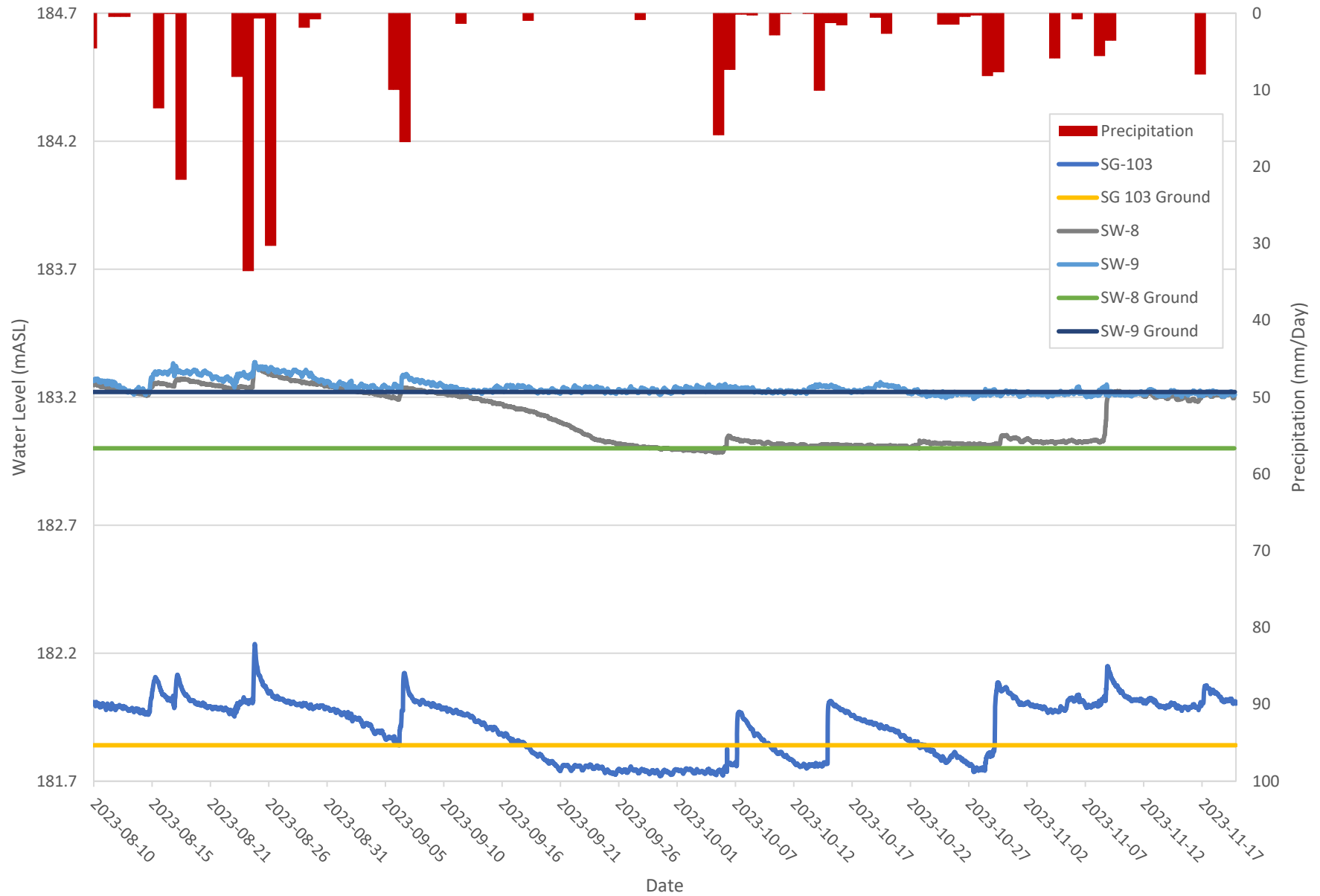
SG-103 and SW-3 Water Elevation and Precipitation August 10 to November 20, 2023



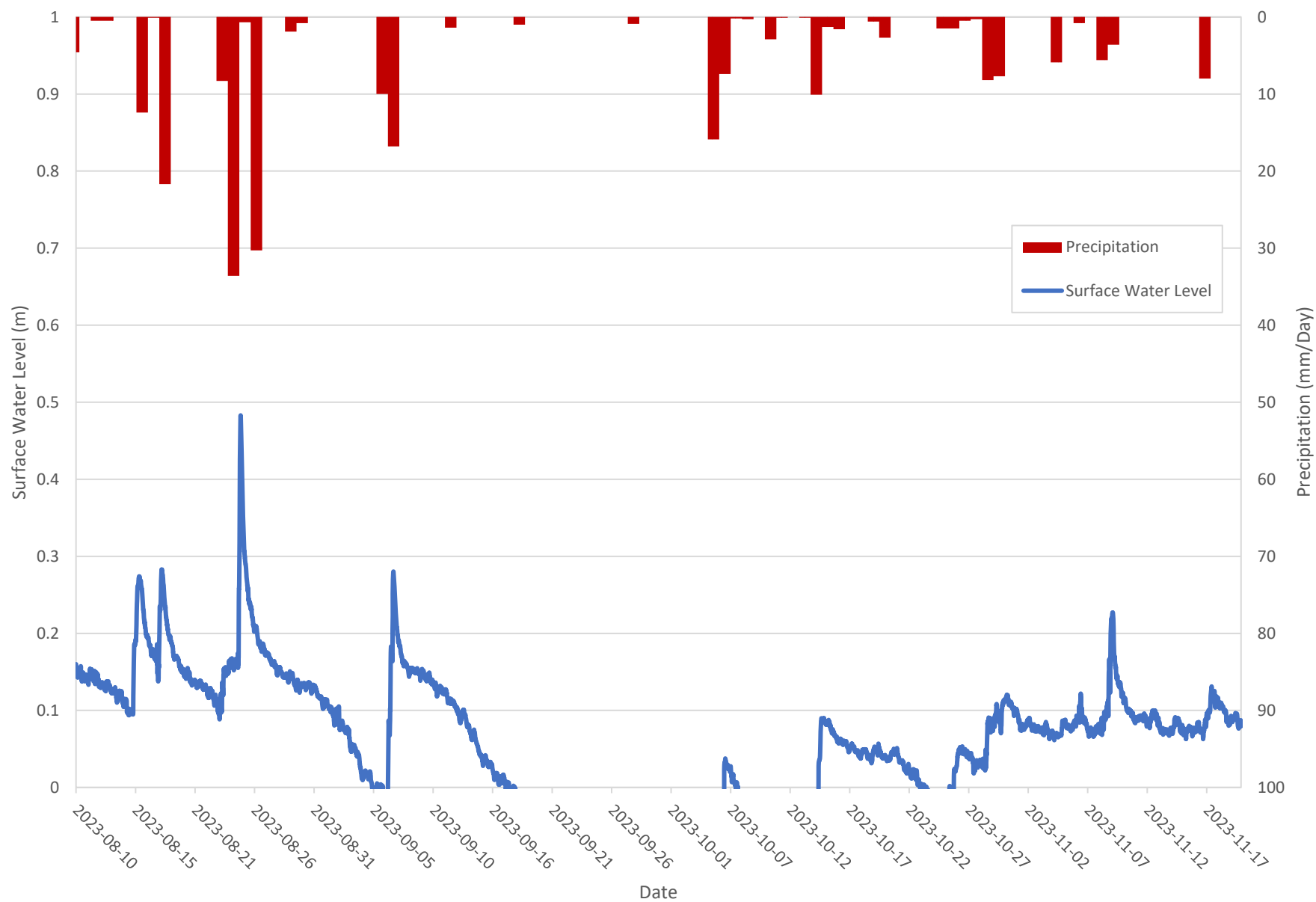
SG-103 and SW-4 Water Elevation and Precipitation August 10 to November 20, 2023



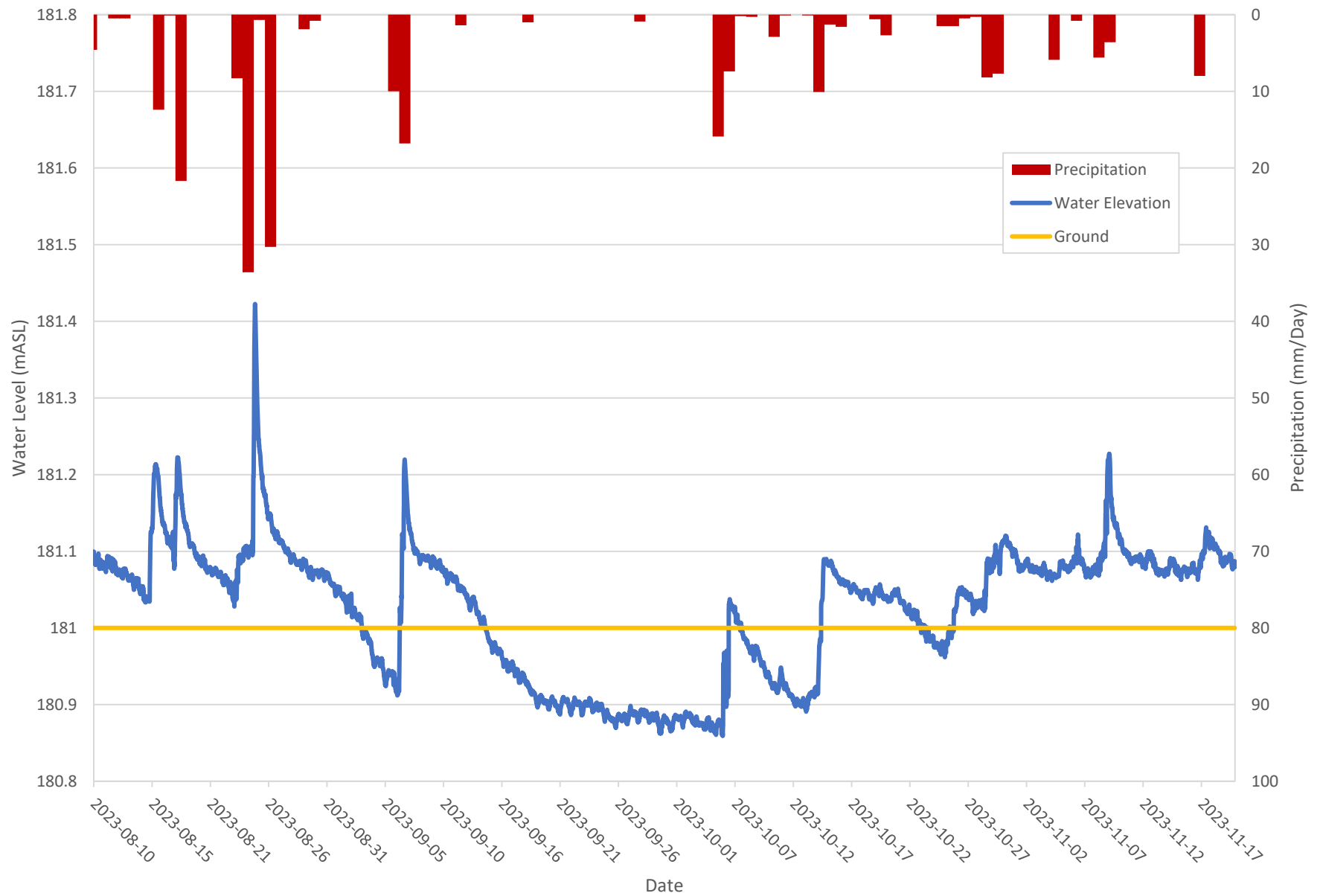
SG-103, SW-8 and SW-9 Water Elevation and Precipitation August 10 to November 20, 2023



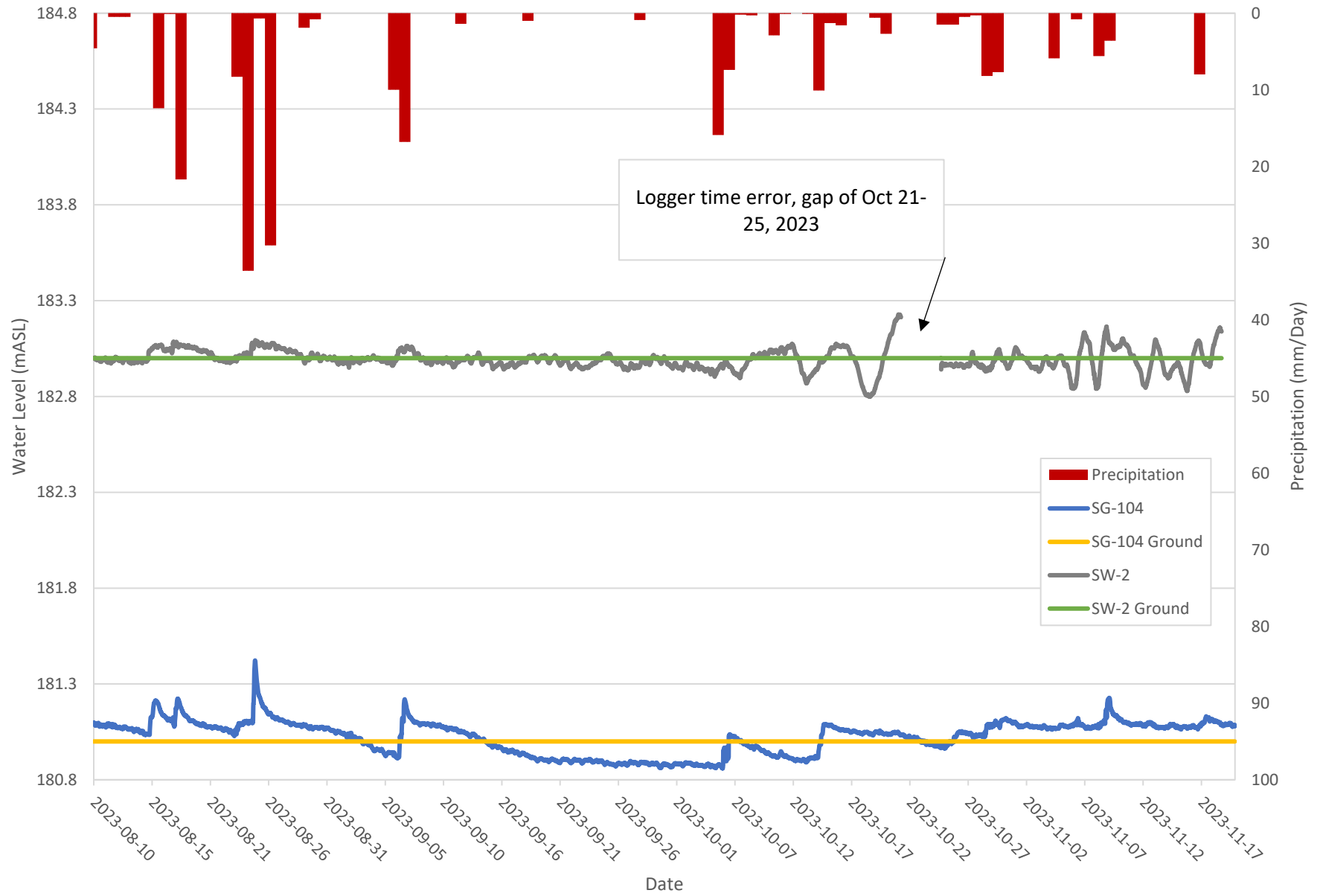
Tow Path Drain SG-104 Water Level and Precipitation August 10 to November 20, 2023



Tow Path Drain SG-104 Water Elevation and Precipitation August 10 to November 20, 2023

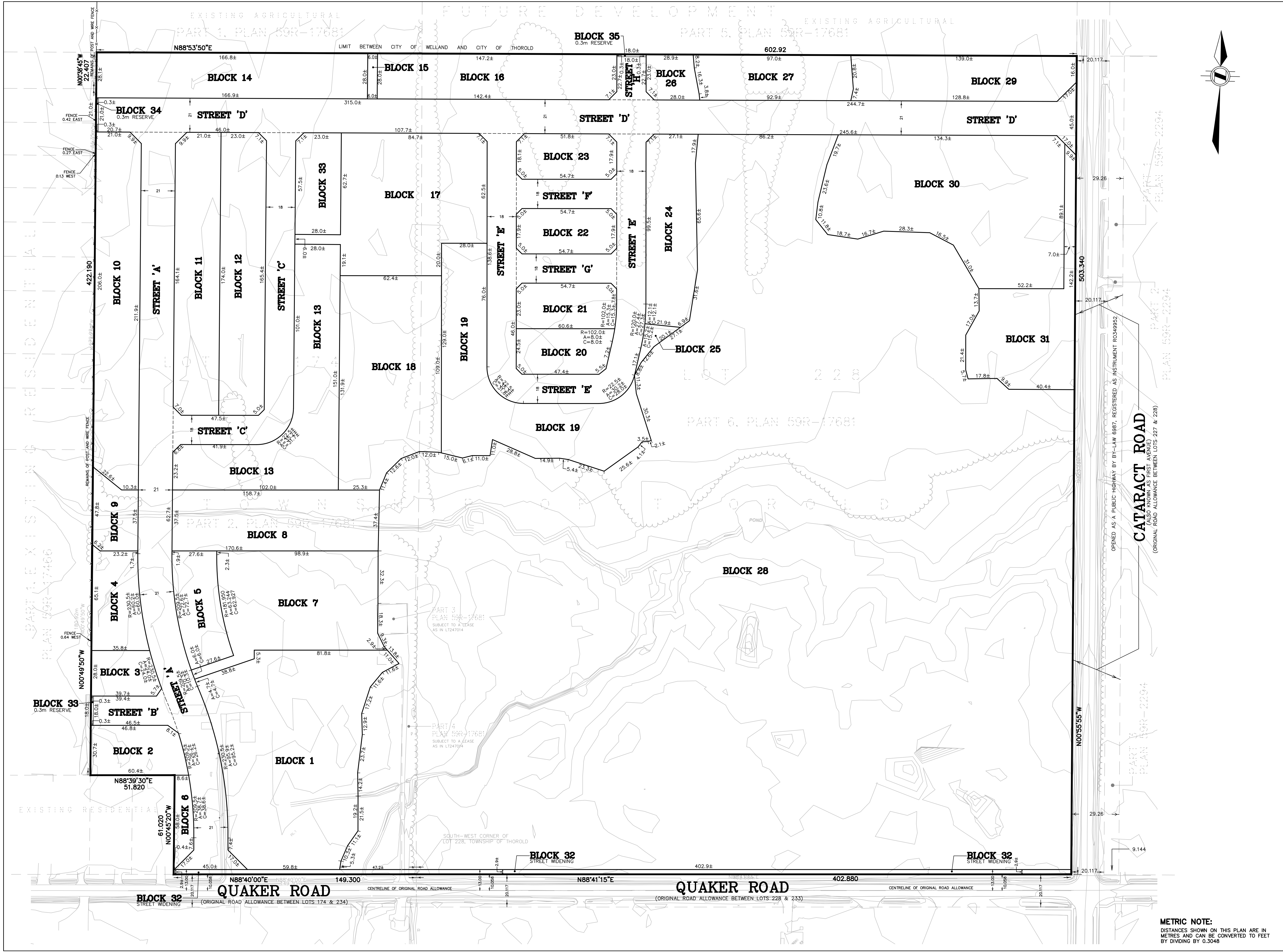


SG-104 and SW-2 Water Elevation and Precipitation August 10 to November 20, 2023



Appendix G

Supporting Information



DRAFT PLAN OF SUBDIVISION

PRIMONT (THOROLD / WELLAND) INC.

PART OF TOWNSHIP LOTS 174 AND 228, GEOGRAPHIC TOWNSHIP OF THOROLD, IN THE CITY OF WELLAND, REGIONAL MUNICIPALITY OF NIAGARA

SCALE 1:1000 METRIC

KEY MAP - NOT TO SCALE

INFORMATION REQUIRED

UNDER SECTION 51 (17) OF THE PLANNING ACT, R.S.O. 1990, c.P.13 AS AMENDED FEBRUARY 21, 2024

(a) - AS SHOWN
(b) - AS SHOWN
(c) - AS SHOWN
(d) - AS LISTED BELOW
(e) - AS SHOWN
(f) - AS SHOWN
(g) - AS SHOWN
(h) - MUNICIPAL WATER
(i) - CLAY LOAM
(j) - AS SHOWN
(k) - MUNICIPAL SANITARY AND STORM SEWERS
(l) - AS SHOWN

SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LANDS TO BE SUBDIVIDED ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

SIGNED _____
ROB A. McLAREN, O.L.S.
A.T. McLAREN LIMITED

DATE _____

OWNER'S CERTIFICATE

I HEREBY CONSENT TO THE FILING OF THIS PLAN

SIGNED _____

DATE _____

LAND USE SCHEDULE			
LAND USE	LOTS/BLOCKS	UNITS	AREA
LOW DENSITY RESIDENTIAL (FREEHOLD)	BLOCKS 2-5, 10-14, 16, 19, 20-24, 26, 29, & 33	245-275±	6.127± Ha.
LOW DENSITY RESIDENTIAL (CONDOMINIUM)	BLOCK 1	44±	1.167± Ha.
MEDIUM DENSITY RESIDENTIAL	BLOCK 30	422±	1.109± Ha.
PARK LAND	BLOCK 17		0.749± Ha.
OPEN SPACE	BLOCKS 6, 15, 25		0.101± Ha.
STORM WATER MANAGEMENT	BLOCKS 7, 18, & 31		1.808± Ha.
ENVIRONMENTAL AREA	BLOCKS 27 & 28		14.547± Ha.
CHANNEL	BLOCKS 8 & 9		0.592± Ha.
ROADS, RESERVES & WIDENINGS	STREETS A, B, C, D, E, F, G, & H AND BLOCKS 32, 33, 34 & 35		3.937± Ha.
TOTAL		711-741±	30.118± Ha.

2	UPDATED STORMWATER BLOCKS	JUNE 13, 2024	KM
1	ORIGINAL DRAWING	MARCH 15, 2024	KM
No.	DESCRIPTION	DATE	BY

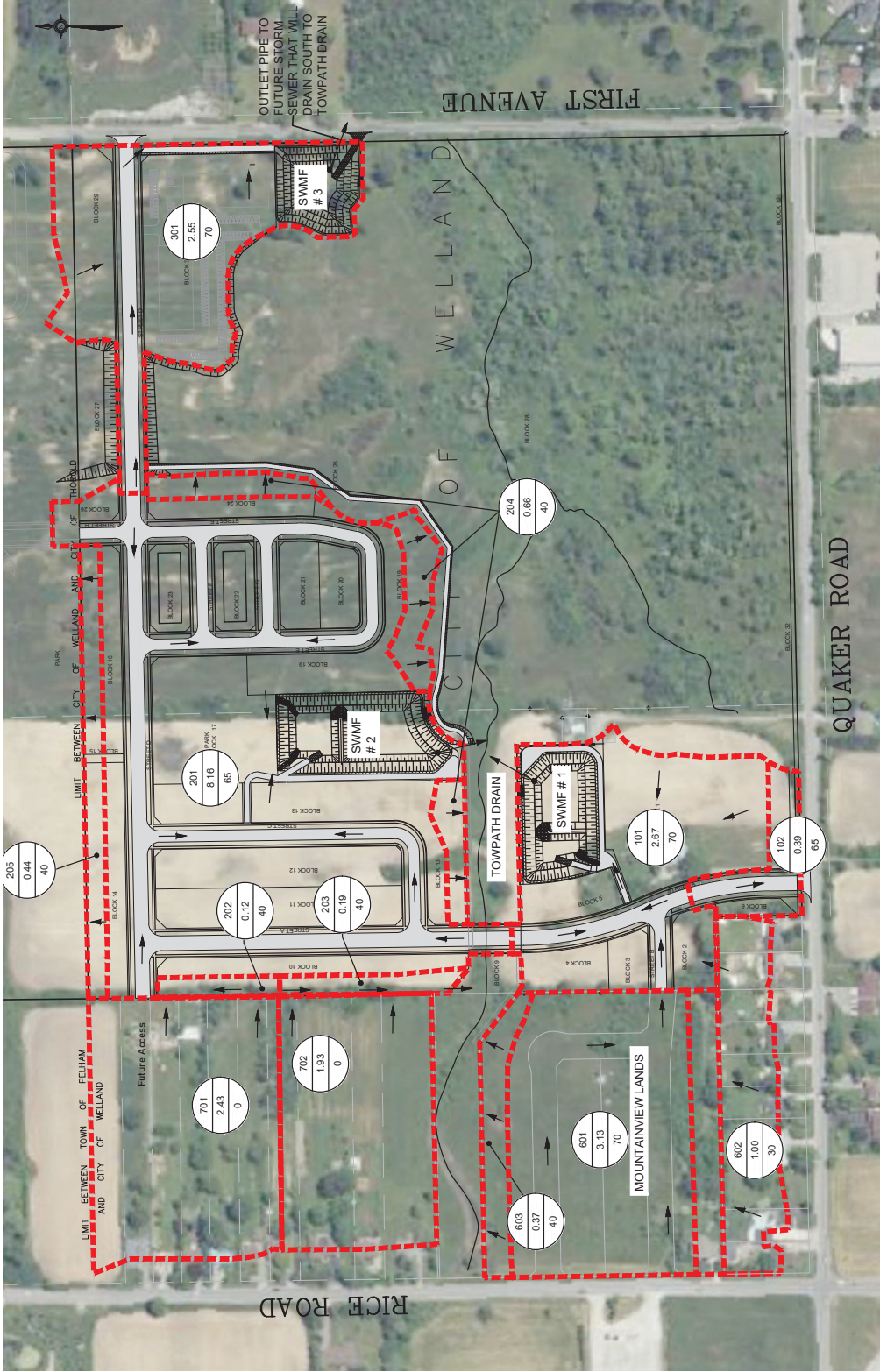
REVISIONS

A.T. McLaren Limited
LEGAL AND ENGINEERING SURVEYS
69 JOHN STREET SOUTH, SUITE 230
HAMILTON, ONTARIO, L8N 2B9
PHONE (905) 527-8559 FAX (905) 527-0032

Drawn	Checked	Crew Chief	Scale	Dwg.No.
KM	RBW	SM	1:1000	36920-0P

METRIC NOTE:

DISTANCES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048



LEGEND

102	CATCHMENT ID
0.39	AREA IN HECTARES
65	% IMPERVIOUS

WALTERFEDY			
HAMILTON OFFICE 20 Hughson Street South, Suite 1000, Hamilton, Ontario, L8N 2A1 T: 905.709.3547 Toll Free 800.665.1378 walterfedy.com			
SCALE:	N.T.S.	DATE:	2024-04-05
DRAWN BY:	ES	PROJECT NO.:	2022-0091-10
CHECKED BY:	JO	FILE:	2022-0091-10 SDAP
SHEET NO.:			

FIG 7.2

PROJECT:
436 QUAKER ROAD
WELLAND

TITLE:
POST-DEVELOPMENT STORM DRAINAGE AREA PLAN
WELLAND

REPRODUCTION OR DISTRIBUTION FOR PURPOSES OTHER THAN AUTHORIZED BY WALTERFEDY IS FORBIDDEN. CONTRACTORS SHALL VERIFY AND BE RESPONSIBLE FOR ALL DIMENSIONS AND CONDITIONS ON THE JOB AND SHALL BE RESPONSIBLE FOR ANY DISCREPANCIES IN THE DIMENSIONS AND CONDITIONS SHOWN ON DRAWINGS TO WALTERFEDY. DO NOT SCALE THIS DRAWING.

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UPDATED REPORT ON
PRELIMINARY GEOTECHNICAL INVESTIGATION
QUAKER ROAD AND FIRST AVENUE
WELLAND, ONTARIO

PREPARED FOR:
PRIMONT HOMES

PREPARED BY:
DS CONSULTANTS LTD.

DS Project No : 21-339-300
Date : July 22, 2022



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1. INTRODUCTION

DS Consultants Ltd. (DS) was retained by Primont Homes to undertake a preliminary geotechnical investigation for the property located at northwest corner of Quaker Road and First Avenue in Welland, Ontario.

It is understood that the proposed development will consist of residential subdivisions with low-rise residential dwellings and mid-rise buildings with two levels of parking garage serviced with storm and sanitary sewers and watermain. Proposed site plan and design grades are not available at the time of this investigation; therefore, the geotechnical investigation is preliminary.

The purpose of this preliminary geotechnical investigation was to obtain information about the subsurface conditions at nineteen (19) borehole locations and from the findings in the boreholes to make preliminary recommendations pertaining to the geotechnical design of site grading, underground utilities, subdivision roads, and to comment on the foundation conditions for general house construction and mid-rise buildings.

This report is provided on the basis of the terms of reference presented above and, on the assumption, that the design will be in accordance with the applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of this office can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for Primont Homes and its architect and designers. Third party use of this report without DS consent is prohibited.

2. FIELD AND LABORATORY WORK

Sixteen (16) boreholes (BH21-1 to BH21-16, see Drawing 1 for borehole locations) were drilled between October 27 and 29, 2021 to depths varying between 6.7 m to 7.3 m below ground surface. Additional three (3) deep boreholes (BH22-01 to BH22-03, see Drawing 1 for borehole locations) were drilled to a depth of 35.6 m below ground surface in March 2022.

The boreholes were drilled with solid and hollow stem continuous flight augers equipment by a drilling sub-contractor under the direction and supervision of DS personnel. Samples were retrieved at regular intervals with a 50 mm O.D. split-barrel sampler driven with a hammer weighing 624 N and dropping 760

mm in accordance with the Standard Penetration Test (SPT) method. In-situ shear vane tests were also carried out in the field on soft to firm clays.

The samples were logged in the field and returned to the DS laboratory for detailed examination by the project engineer and for laboratory testing.

As well as visual examination in the laboratory, all soil samples from the boreholes were tested for moisture contents. Grain size analyses and Atterberg Limits Tests of selected soil samples were conducted, and the results are presented in Drawings 21 to 23.

Water level observations were made during and upon completion of drilling. Thirteen (13) monitoring wells of 50mm diameter were installed in select boreholes for the long-term groundwater monitoring.

The elevation surveying of the borehole locations was undertaken by DS personnel, using the differential GPS unit. It should be noted that the elevations at the as-drilled borehole/well locations were not provided by a professional surveyor and should be considered approximate. Contractors performing any work referenced to the borehole elevations should confirm the borehole elevations for their work.

3. SUBSURFACE CONDITIONS

The subject sites are located at the northwest corner of Quaker Road and First Avenue in Welland, Ontario.

The approximate borehole locations are shown on Drawing 1. Notes on sample descriptions and the general features of the native soils are presented on Drawing 1A. Detailed subsurface conditions observed in the boreholes are presented on the Borehole Logs, Drawings 2 to 20. The subsurface conditions in the boreholes are summarized in the following paragraphs.

3.1 SOIL CONDITIONS

Topsoil: A surficial topsoil layer was encountered at the borehole locations. The measured topsoil thickness at the borehole locations ranged from 300 mm to 450mm. Localized thick topsoil deposits and soils rich in organic content may be encountered, especially in depressed areas and/or near water courses. Topsoil quantities should not be calculated from the borehole information, as large variations in depth may exist between boreholes.

Disturbed/Reworked Soils: Underlying the topsoil, a layer of silty sand or clayey silt soils, disturbed by farming activities, were encountered and extended to 0.8 m to 1 m below grade. The disturbed soils contained traces of topsoil or organics and were in loose or soft to firm state.

Silty Clay to Clayey Silt: Below the topsoil, glaciolacustrine deposits of silty clay to clayey silt were encountered in most of the boreholes. The silty clay to clayey silt contained fine sand seams and silt seams/layers. SPT 'N' values in the cohesive soil were in the range of 3 to 41 blows per 0.3m

penetration, corresponding to a soft to hard consistency, but generally a firm to very stiff consistency. Water contents were measured in the test samples to range from 15% to 34%.

The undrained shear strength from twenty-nine (29) field vane shear tests ranged from 25 to greater than 100 kPa, corresponding to firm to very stiff.

Grain size analyses of fifteen samples from the silty clay to clayey silt deposits (BH21-1/SS6, BH21-2/SS5, BH21-3/SS5, BH21-6/SS5, BH21-8/SS5, BH21-9/SS5, BH21-11/SS5, BH21-13/SS5, BH21-14/SS5, BH21-16/SS5, BH22-01/SS6, BH22-01/SS19, BH22-02/SS6, BH22-02/SS16, and BH22-03/SS6) were carried out and gradation curves for the results are provided on **Drawings 21A and 21B**, with following fractions:

Clay: 12-66%

Silt: 34-88%

Sand: 3-6%

Gravel: upto 1%

Atterberg Limits testing was carried out on fifteen samples of the silty clay to clayey silt deposits (BH21-1/SS6, BH21-2/SS5, BH21-3/SS5, BH21-6/SS5, BH21-8/SS5, BH21-9/SS5, BH21-11/SS5, BH21-13/SS5, BH21-14/SS5, BH21-16/SS5, BH22-01/SS6, BH22-01/SS19, BH22-02/SS6, BH22-02/SS16, and BH22-03/SS6). The test results are provided on the respective borehole logs and on **Drawing 23A and 23B**, and summarized below:

Liquid Limit: 21-44%

Plastic Limit: 14-21%

Plasticity Index: 3-26

Based on these, the soils are classified as low plasticity clay (CL) and clayey silt (CL-ML) according to the modified Unified Soil Classification System.

Silt, Sandy Silt

Silt to sandy silt deposits were encountered in some boreholes at various depths (BH21-1, BH21-4 to BH21-8, BH21-10, BH22-01, BH22-02, and BH22-03). The silt to sandy silt contained trace clay and trace gravel. SPT 'N' values in the non-cohesive soils were in the range of 4 to 77 blows per 0.3m penetration, corresponding to a loose to very dense relative density. Water contents were measured in the test samples ranging from 13% to 31%.

Grain size analyses of four samples from the silt to sandy silt deposits (BH21-1/SS7, BH21-6/SS6, BH22-01/SS8, and BH22-03/SS15) were carried out and gradation curves for the results is provided on **Drawing 22**, with following fractions:

Clay: 5-8%

Silt: 63-92%

Sand: 0- 28%

Gravel: 0-4%

Clayey Silt to Silty Clay Till:

Glacial deposits of clayey silt to silty clay till were encountered in the deep boreholes of BH22-01 to BH22-03 at depths varying between 16.8 m to 22.9 m below existing grade (Elev. 160.7 m to 167.2 m). The till deposits contained trace to some gravel, some sand, were reddish brown to grey in colour, and moist to wet. The SPT 'N' values in the cohesive soils were in the range of 18 to in excess of 100 blows per 0.3m penetration, corresponding to a very stiff to hard consistency. Water contents were measured in the test samples to range from 12% to 23%.

3.2 GROUNDWATER CONDITIONS

Stabilized groundwater levels in the monitoring wells were found at 0.8m above ground to 1.3m below the existing grade, corresponding to Elevations 181.9 to 184.3m, as summarized on Table 3.2. On May 10, 2022, artesian conditions were measured in BH21-1 and BH21-9 with above ground water levels.

Groundwater measurements in the monitoring wells are shown on the attached borehole logs and are also summarized on Table 3.2.

Table 3.2: Groundwater Levels Observed in Monitoring Wells

BH No.	Ground Surface Elev. (m)	Date of Drilling	Date of Observation	Depth of Groundwater (m)	Elevation of Groundwater (m)
BH21-1	183.5	Oct. 29, 2021	Nov. 11, 2021	1.26	182.2
			May 10, 2022*	-0.80**	184.3
BH21-2	184.1	Oct. 29, 2021	Nov. 11, 2021	0.7	183.4
			May 10, 2022*	0.68	183.4
			June 27, 2022	0.54	183.6
BH21-3	182.4	Oct. 27, 2021	Nov. 11, 2021	0.35	182.1
			May 10, 2022*	0.52	181.9
BH21-6	184.1	Oct. 28, 2021	Nov. 11, 2021	0.54	183.6
			May 10, 2022*	0.66	183.4
			June 27, 2022	0.78	183.3
BH21-8	183.6	Oct. 27, 2021	Nov. 11, 2021	1.37	182.2
			May 10, 2022*	1.11	182.5
			June 27, 2022	1.12	182.5
BH21-9	183.5	Oct. 27, 2021	Nov. 11, 2021	0.25	183.3
			May 10, 2022*	-0.5**	184.0
			June 27, 2022	0.97	182.5
BH21-11	184.3	Oct. 27, 2021	Nov. 11, 2021	3.47	180.8
			May 10, 2022*	0.77	183.5

			June 27, 2022	0.57	183.7
BH21-13	183.4	Oct. 27, 2021	Nov. 11, 2021	0.55	182.8
			May 10, 2022*	0.52	182.9
BH21-14	183.6	Oct. 28, 2021	Nov. 11, 2021	0.56	183.1
			May 10, 2022*	0.67	182.9
BH21-16	183.4	Oct. 28, 2021	Nov. 11, 2021	4.43	179.0
			May 10, 2022*	0.54	182.9
			June 27, 2022	0.72	182.7
BH22-01	184.3	Oct. 28, 2021	March 25, 2022	1.57	182.7
			April 12, 2022	1.33	183.0
			June 27, 2022	1.18	183.1
BH22-02	183.6	Oct. 28, 2021	April 12, 2022	1.15	182.4
			June 27, 2022	0.17	183.4
BH22-03	184.0	Oct. 28, 2021	March 25, 2022	0.15	183.8
			April 12, 2022	0.28	183.7
			June 27, 2022	0.87	183.1

*measured by Terra-Dynamics Consulting Inc.

**artesian conditions (above grade water levels)

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events.

4. DISCUSSION AND RECOMMENDATIONS

The site has a fairly plain topography with existing elevations ranging from 182.4 to 184.3m. Proposed grading plan was not available at the time of this investigation.

The field exploration generally revealed that below the topsoil and soft to firm or loose reworked / disturbed surficial soil layer, the site is predominantly underlain by soft to hard glaciolacustrine silty clay and loose to very dense silt to sandy silt deposits. Bedrock was not contacted during the preliminary investigation.

The groundwater table varied generally between 1 m above ground to 1.5 m below ground.

It is proposed to develop the site as a residential subdivision. The lots will be serviced by a network of roads, storm and sanitary sewers and watermain.

4.1 SETTLEMENT AND WEAK GROUND CONSOLIDATION USING PRELOADING SURCHARGE FILL

Weak soils consisting of soft to firm silty clay deposits were encountered in BH21-1 to BH21-3, BH21-6 to BH21-16, BH22-02, and BH22-03. The loads from the engineered fill to raise the grade and from the house structures will cause the weak ground to settle with time. In general, raising the grade by more than 2 meters above the existing grade together with the house loads will cause significant settlement of

the weak soils. Ground consolidation using preloading surcharge fill will be required prior to the construction of the houses in the areas where weak soils are present.

Among the above-mentioned boreholes where weak soils were encountered, soft silty clay soils were found in a number of boreholes, i.e. BH21-2, BH21-3, BH21-8 to BH21-11, and BH21-13 to BH21-15, BH22-02, and BH22-03 with measured SPT 'N' value of 3 to 4 blows per 300 mm spoon penetration. Where soft silty clay soils are present, ground consolidation using preloading surcharge fill will be required prior to the construction of the houses, even if the grade raise is less than 2 m.

For preliminary consideration purpose of house foundations, surcharge fill of up to 3 m above the final grade should be required where weak soils are present as indicated above. The top of surcharge fill (flat area) should extend horizontally to minimum 2.0 m beyond the house exterior walls, and then sloped down at 1.5H:1V (or flatter). The surcharge fill should be placed, and then wait for at least 6 to 12 months prior to its removal for the construction of the houses. Settlement monitoring of the weak ground under surcharge fill will be required to determine the required duration of the preloading surcharge fill. Higher surcharge fill can reduce the required duration of the preloading surcharge fill. Detailed analyses of settlement and required surcharge fill will be required for the design of site grading.

Further geotechnical investigation and consolidation tests will be required for the design of the weak ground consolidation using preloading surcharge fill, when the proposed grading plan is available.

It must be noted that the ground consolidation using surcharge fill, as discussed above, is only suitable for construction of houses. For other buildings (such as school buildings and commercial/office buildings etc.), additional geotechnical investigations will be required for foundation recommendations when the building information (building type, location etc.) is available.

It should also be noted that engineered fill will settle under its own weight approximately 0.5% to 0.75% of the fill thickness. For example, where the engineered fill is 5 m in thickness, the settlement of the engineered fill under its own weight is expected to be in the range of 25 to 40 mm. The settlement of the engineered fill will occur with time. For engineered fill consisting of clayey silt/silt material, about half (50%) of this settlement should be completed within 6 months, and about 70% of the settlement is expected to occur within one year after the placement of the fill.

4.2 SUBGRADE PREPARATION AND ENGINEERED FILL

Based on the existing topography at the site, it is anticipated that cut and fill operations will be required at the site for re-grading.

For the preparation of subgrade, all topsoil, upper weathered/disturbed soils, and existing fill (if any) must be removed. The excavation base consisting of native deposit must be inspected and approved by this office prior to any placement of backfill.

If the grade needs to be raised, engineered fill can be placed to raise the grade to the design elevation. The engineered fill can consist of approved inorganic material compacted to 100% of SPMDD at a placement water content within 2% of its optimum water content.

Weak soil conditions are present across the site. The loads from the engineered fill to raise the grade and from the house structures will cause the weak ground to settle with time. Ground improvement with surcharge preloading prior to construction of houses will be required to reduce the post-construction settlements, as discussed in Section 4.1 of this report.

General guidelines for the placement and preparation of engineered fill are presented in **Appendix A**.

The following is a recommended procedure for an engineered fill:

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained, and samples must be provided to the geotechnical engineer for review, and approval before filling begins.
2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.
3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and DS. Without this confirmation no responsibility for the performance of the structure can be accepted by DS. Survey drawing of the pre and post fill location and elevations will also be required.
4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof-rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by a DS engineer prior to placement of fill.
5. The approved engineered fill must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Granular Fill preferred. Engineered fill should not be placed (where it will support footings) during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur.
6. Full-time geotechnical inspection by DS during placement of engineered fill is required. Work cannot commence or continue without the presence of the DS representative.

7. The fill must be placed such that the specified geometry is achieved. Refer to sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.

8. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.

9. After completion of the pad a second contractor may be selected to install footings. All excavations must be backfilled under full time supervision by DS to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of DS.

10. After completion of compaction, the surface of the pad must be protected from disturbance from traffic, rain and frost.

11. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.

The native silty clay and silt to sandy silt free from topsoil & organics, are considered suitable for re-use as engineered fill, provided that their moisture contents at the time of construction are at or near optimum. Significant aeration of the excavated soils will be required prior to their use as engineered fill material.

The glacial tills containing significant clay contents are likely to be excavated in cohesive chunks or blocks and will be difficult to compact. They should be pulverized and placed in thin layers not exceeding 150 to 200 mm and compacted using heavy equipment suitable for these types of soils (e.g. heavy sheepsfoot compactors).

4.3 ROADS

The investigation has shown that the predominant subgrade soil, after stripping the topsoil and any other organic and otherwise unsuitable subsoil, will generally consist of silty clay to silt. These soils are considered frost susceptible.

Based on the above and assuming that traffic usage will be residential minor local or local, the following minimum pavement thickness is recommended:

40 mm HL3 Asphaltic Concrete

80 mm HL8 Asphaltic Concrete

450 mm Granular 'A' (as per the City of Welland requirements)

For bus routes and collector roads, the following minimum pavement thickness is recommended:

50 mm HL3 Asphaltic Concrete

100 mm HL8 Asphaltic Concrete

525 mm Granular 'A' (as per the City of Welland requirements)

These values are in accordance with the City of Welland's design criteria. The site subgrade and weather conditions (i.e. if wet) at the time of construction may necessitate the placement of thicker granular sub-base layer in order to facilitate the construction. Furthermore, heavy construction equipment may have to be kept off the newly constructed roads before the placement of asphalt and/or immediately thereafter, to avoid damaging the weak subgrade by heavy truck traffic.

4.3.1 STRIPPING, SUB-EXCAVATION AND GRADING

The site should be stripped of all topsoil and any organic, weathered or otherwise unsuitable soils to the full depth of the roads, both in cut and fill areas. Following stripping, the site should be graded to the subgrade level and approved. The subgrade should then be proof-rolled, in the presence of the Geotechnical Engineer, by at least several passes of a heavy compactor having a rated capacity of at least 8 tonnes. Any soft spots thus exposed should be removed and replaced by select fill material, similar to the existing subgrade soil and approved by the Geotechnical Engineer. The subgrade should then be re-compacted from the surface to at least 98% of its Standard Proctor Maximum Dry Density (SPMDD). The final subgrade should be cambered or otherwise shaped properly to facilitate rapid drainage and to prevent the formation of local depressions in which water could accumulate.

Owing to the clayey (i.e. impervious) nature of the subsoils at the site, proper cambering and allowing the water to escape towards the sides (where it can be removed by means of subdrains) is considered to be beneficial for this project. Otherwise, any water collected in the granular sub-base materials could be trapped thus causing problems due to softened subgrade, differential frost heave, etc. For the same reason damaging the subgrade during and after placement of the granular materials by heavy construction traffic should be avoided. If the moisture content of the local material cannot be maintained at $\pm 2\%$ of the optimum moisture content, imported granular material may need to be used.

Any fill required for re-grading the site or backfill should be select, clean material, free of topsoil, organic or other foreign and unsuitable matter. It should be noted that some of the excavated native materials, especially the medium to high plasticity silty clays, will be wet and must be aerated and left to dry out before it can be used for backfill. The fill should be placed in thin layers and compacted to at least 95% of its SPMDD. The degree of compaction should be increased to 98% within the top 1.0 m of the subgrade, or as per the County Standards. The compaction of the new fill should be checked by frequent field density tests.

4.3.2 ROAD CONSTRUCTION

Once the subgrade has been inspected and approved, the granular base and sub-base course materials should be placed in layers not exceeding 200 mm (uncompacted thickness) and should be compacted to 100% of their respective SPMDD. The grading of the material should conform to current OPS Specifications.

The placing, spreading and rolling of the asphalt should be in accordance with OPS Specifications or, as required by the local authorities.

Frequent field density tests should be carried out on both the asphalt and granular base and sub-base materials to ensure that the required degree of compaction is achieved.

4.3.3 DRAINAGE

Installation of full-length subdrains on all roads will be required. The subdrains should be properly filtered to prevent the loss of (and clogging by) soil fines.

All paved surfaces should be sloped to provide satisfactory drainage towards catch-basins. As discussed in Section 4.3.1, by means of good planning any water trapped in the granular sub-base materials should be drained rapidly towards subdrains or other interceptors.

4.4 SEWERS

As part of the site development, a network of new storm and sanitary sewers are assumed to be constructed 4 to 5m below the existing grade within the site.

4.4.1 TRENCHING

As indicated in the borehole logs, the trenches will be excavated through cohesive, generally firm to very stiff silty clays and silt deposits. It is expected that any seepage above the groundwater table, which occurs during wet periods or from wet sandy seams, can be removed by pumping from sumps. It should be noted that sloughing of the excavation face might occur where wet sandy layers are encountered, or the silt is in a wet condition. This may require the use of oversized excavations with flatter than normal slopes.

Provisions must be made in the excavation contract for the removal of possible cobbles and boulders in clayey silt till and fill materials.

Groundwater levels of generally at 1.5 m below ground or higher were measured in monitoring wells throughout the project area; therefore it is expected that some of the trench excavations will intercept the groundwater table. The rate of seepage from the clayey silt to silty clay deposits can be expected to be slow and, if necessary, the trenches can be dewatered by gravity pumping from temporary sumps. Water bearing coarser silt or sand seams/layers would be more pervious and yield more water in

excavations extending below the groundwater table. These areas would need dewatering where they occur.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, fill material and clay and silt soils can be classified as Type 3 Soil above the groundwater table and Type 4 Soil below.

4.4.2 BEDDING

The native soils above the groundwater level, or properly dewatered if encountered below the groundwater level, will provide adequate support for the sewer pipes and allow for the use of Class 'B' Type bedding. The subgrade condition must be inspected and approved by geotechnical personnel. The recommended minimum thickness of granular bedding below the invert of the pipes is 150mm. However, the thickness of the bedding may have to be increased depending on the pipe diameter, in accordance with local standards.

If weak subgrade conditions are encountered, the weak soils must be sub-excavated and backfilled by compacted Granular 'A'. The bedding material should consist of well graded granular material such as Granular 'A' or equivalent. Granular cover of approved bedding material, which extends at least 300mm above the obvert of the pipe, should be placed after installing the pipe.

Where soft to firm soils were encountered (BH21-1 to BH21-3, and BH21-6 to BH21-16) which are considered incompetent to support the sewer pipes, a Geoweb reinforced base can be constructed at the trench base and then conventional Class B type bedding can be used on top of Geoweb. Details of the Geoweb pipe bedding are provided on **Drawing 27**.

It is recommended that the bedding material consist of well-graded granular material such as Granular 'A' (OPSS 1010). To avoid the loss of soil fines from the subgrade, uniformly graded clear stone should not be used unless, below the granular bedding material, a suitable, approved filter fabric (geotextile) is placed. The geotextile should extend along the sides of the trench and should be wrapped all around the uniformly graded bedding material.

4.4.3 BACKFILLING OF TRENCHES

Based on visual and tactile examination, the majority of the on-site excavated inorganic soil deposits will be too wet to compact and will require significant aeration before their use as backfill material. It will be difficult to aerate excavated soils in months other than summer. The selected onsite silty clay is considered suitable for backfill, provided its moisture content is within 2 percent of optimum moisture content.

The clayey soils will have to be compacted using heavy equipment suitable for these soils which may be difficult to operate in the narrow confines of the trenches. Unless the clayey materials are properly pulverized and compacted in sufficiently thin lifts, post-construction settlements could occur. Their use

in narrow trenches such as laterals (where heavy compaction equipment cannot be operated) may not be feasible.

Imported granular fill, which can be compacted with handheld equipment, should be used in confined areas.

The excavated soils are not considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used.

The backfill should be placed in maximum 200 mm thick layers at or near ($\pm 2\%$) their optimum moisture content and each layer should be compacted to at least 95% SPMDD. In the upper 1.0 m of the subgrade, underneath the road base, the compaction should be increased to 98% SPMDD. Unsuitable materials such as organic soils, boulders, cobbles, frozen soils, etc. should not be used for backfilling.

It should be noted that the excavated soils are subject to moisture content increase during wet weather which would make these materials too wet for adequate compaction. Stockpiles should be compacted at the surface or be covered with tarpaulins to minimize moisture uptake.

The topsoil encountered at the site can be used for landscaping fill to raise the grades. Topsoil cannot be reused as foundation and trench backfill material.

4.5 LOW-RISE RESIDENTIAL DWELLINGS

4.5.1 FOUNDATION CONDITIONS

Where weak soils are present, ground consolidation using preloading surcharge fill will be required for construction of houses, as discussed in Section 4.1. For foundation recommendations of other buildings (such as school buildings, commercial buildings, etc.), additional geotechnical investigation will be required.

The proposed houses can be supported by spread and strip footings founded on the undisturbed native soils or engineered fill material. Based on the borehole information, in general, footings founded on undisturbed native soils or engineered fill can be designed for bearing capacity values of 75 kPa at SLS (Serviceability Limit State) and 112.5 kPa at ULS (Ultimate Limit State). This value would be suitable for the use of normal spread footing foundations to support normal single-family dwellings.

For footings founded on engineered fill, footings must be provided with nominal steel reinforcement. The engineered fill supporting footings should be constructed in accordance with the guidelines presented in Appendix A. Other requirements of engineered fill are given in Section 4.2.

All footings exposed to seasonal freezing conditions must have at least 1.2 metres of soil cover for frost protection.

All footing bases must be inspected by this office to confirm the bearing capacity values, prior to pouring concrete.

Where it is necessary to place footings at different levels, the upper footing must be founded below an imaginary 10 horizontal to 7 vertical line drawn up from the base of the lower footing. The lower footing must be installed first to help minimize the risk of undermining the upper footing.

It should be noted that the recommended bearing capacities have been calculated by DS from the borehole information for the preliminary design stage only. The investigation and comments are necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by DS to validate the information for use during the construction stage.

4.5.2 FLOOR SLAB AND PERMANENT DRAINAGE

The floor slab can be supported on grade provided all topsoil, fill, and surficially softened soils are removed and the base thoroughly proof rolled. The fill required to raise the grade can consist of inorganic soil, placed in shallow lifts and compacted to 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

A moisture barrier consisting of at least 200 mm of 19 mm clear crushed stone should be installed under the floor slab.

A perimeter drainage system shown on Drawing 24 will be required around the exterior basement walls. Exterior basement walls should be damp-proofed above the water table. Basements located below the water table should be water-proofed. Underfloor drainage is also recommended.

DS recommends vertical drains be installed along the basement walls and connected to the perimeter tiles to reduce basement dampness. DS recommends that 'dimple board' be used on all below ground surfaces. It is recommended to keep footings as high as possible to avoid or minimize penetration below groundwater levels.

4.6 MID-RISE BUILDINGS

4.6.1 FOUNDATIONS

We understand that mid-rise buildings with two-levels of underground parking are considered at the site. Finished floor elevation at the lowest basement floor is not available to us at the time of writing this report. It is assumed that P2 basement level will approximately be at 6m depth below the existing grade. Additional deep boreholes will be required when design details are available.

Three deep boreholes, BH22-01 to BH22-03 were drilled at potential mid-rise building locations to depths of 35.6 m below grade. Below about 8 m depth, the soils consisted of compact silts in wet

condition and very stiff silty clay to clayey silt. These soils are not suitable to support the mid-rise structures with two (2) levels of basement supported by conventional footings.

Based on the borehole information, the proposed buildings with two (2) levels of basement can be supported by deep foundations such as drilled caissons. Drilled caissons founded in the hard clayey silt till/silty clay ill can be designed for a bearing capacity of 500 kPa to 800 kPa at SLS (serviceability limit states), and for a factored geotechnical resistance of 700 kPa to 1,120 kPa at ULS (ultimate limit states), provided that the caisson bases are proven to be clean of any mud and water.

The bearing values and the corresponding founding elevations for drilled caissons at the borehole locations are summarized on Table 4.6.1.

Table 4.6.1: Bearing Values and Founding Levels for Drilled Caissons

BH No.	Material	Bearing Capacity at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)	Minimum Depth below Existing Ground (m)	Founding Level At or Below Elevation (m)	Note
BH22-1	Clayey Silt Till	800	1120	22.0	162.3	Water level at 1.2m on June 27, 2022 (El. 183.1 m)
BH22-2	Silty Clay/Clayey Silt Till	500 800	700 1120	19.0 33.6	164.6 150.0	Water level at 0.2m on June 27, 2022 (El. 183.4 m)
BH22-3	Clayey Silt Till	500 800	700 1120	18.0 34.0	166.0 150.0	Water level at 0.9m on June 27, 2022 (El. 183.1m)

The bearing capacity values provided above include both friction and end bearing capacity of caissons.

The presence of groundwater table in the cohesionless deposits will make the construction of the caissons difficult. An oversize liner will be required and must be sealed in the underlying hard clayey silt till or silty clay, in order to prevent the water seepage and caving of the wet layers.

During construction, is the founding soils at the design base level consist of cohesionless soils (sand, silt, sandy silt to silty sand), the caissons must be installed deeper to the underlying clayey silt to silty clay deposits.

Prior to placing concrete, all foundation bases must be inspected by qualified geotechnical personnel to confirm competent soil elevation/depth and design bearing value. The drilling contractor must provide evidence that the caisson bases are clean from any mud and water prior to pouring the concrete. However, if the manual evaluation of the caisson base cannot be performed due to the Health and Safety policies, alternative approach is to use down-hole camera inspection.

It should be noted that the recommended bearing capacities have been calculated by DS Consultants Ltd from the borehole information for the design stage only. The investigation and comments are

necessarily on-going as new information of the underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field inspections provided by a qualified geotechnical engineer to validate the information for use during the construction stage.

4.6.2 FROST PROTECTION

All foundations exposed to seasonal freezing conditions must have at least 1.2m of soil cover for frost protection.

There is no official rule governing the required founding depth for footings below unheated basement floors. Certainly, it will not be greater than the 1.2 m required in Southern Ontario for exterior footings. Un-monitored experience indicates that a shallower depth ranging from 0.82 to 0.9 m for interior column footings and 0.4 m for wall footings has been successful where 2 or more basement levels apply. The 0.82 m depth is believed to be close to the minimum structural requirement for interior column footings. Adjacent to air shafts and entrance and exit doors, a footing depth of 1.2 m below floor level is required or, alternatively, insulation protection must be provided.

It is also emphasized that underfloor drainage and/or an adequate free draining gravel base is required to minimize the risk of floor dampness. Floor dampness could lead to temporary icing and the risk of accidents.

4.6.3 FLOOR SLAB AND PERMANENT DRAINAGE

With two levels of basement, the floor slab can be supported on grade provided all disturbed soils are removed and the base thoroughly proof rolled. The fill required to raise the grade can consist of inorganic soil, placed in shallow lifts and compacted to 98 percent of Standard Proctor Maximum Dry Density (SPMDD).

A moisture barrier consisting of at least 200 mm of 19 mm clear crushed stone should be installed under the floor slab.

A perimeter and underfloor drainage system will be required. Typical drainage and backfill recommendations are illustrated on Drawings 25 and 26 for the shored excavation system.

4.6.4 ELEVATOR AND SUMP PITS

If elevator/sump pits are to be installed in cohesionless soils (sandy silt, sand, silt) below the water table, drainage systems at the base level of the pits are not recommended, due to the concern of loss of fines. In this case, the pits can be designed as water-tight structures, and water pressure on the pit walls and the pit base slab should be considered.

4.6.5 EARTH AND WATER PRESSURES

The lateral earth and water pressure acting at any depth on basement walls can be calculated as follows:

In soils above the groundwater table ($z < d_w$):

$$p = K (\gamma z + q)$$

In soils below the groundwater table ($z \geq d_w$):

$$p = K \{ \gamma d_w + \gamma_1 (z - d_w) + q \} + p_w$$

$$\text{In which, } p_w = \gamma_w (z - d_w)$$

where p	=	lateral earth and water pressure in kPa acting at a depth of z below ground surface
K	=	earth pressure coefficient $K = 0.40$ for basement walls
γ	=	unit weight of soil above groundwater table, assuming $\gamma = 21.5 \text{ kN/m}^3$
γ_1	=	submerged unit weight of soil below groundwater table, assuming $\gamma_1 = 11.7 \text{ kN/m}^3$
γ_w	=	unit weight of water, assuming $\gamma_w = 9.8 \text{ kN/m}^3$
z	=	depth below ground surface to point of interest, in metres
d_w	=	depth of groundwater table below ground surface, in metres
q	=	value of surcharge in kPa
p_w	=	hydrostatic water pressure in kPa

When the basement wall is poured against the shoring caisson wall, the basement wall as well as the shoring caisson wall should be designed for hydrostatic pressure assuming the water level at about Elev. 183m, even though a drainage board is provided between the basement wall and the caisson wall.

4.6.6 EXCAVATIONS AND GROUNDWATER CONTROL

With 2 levels of basement, the excavations will continue to a depth of ± 6 metres. Sumps and elevator pits may require localized excavations to continue approximately one metre deeper.

Excavations can be carried out with heavy hydraulic backhoe.

Positive dewatering will be required prior to any excavation in water bearing cohesionless soils (sand, silt, sandy silt to silty sand) below the groundwater table (refer to Table 3.2 for groundwater levels), otherwise it will result in an unstable base and flowing sides. A contractor specializing in dewatering should be retained to design the dewatering systems for excavations below the groundwater table.

Further comments on groundwater control during construction and permanent drainage are provided in our hydrogeology report.

It should be noted that the glacial till soils may contain boulders. Provisions must be made in the excavation contract for the removal of boulders in the till and large obstructions in the fill material, if any.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the fill material can be classified as Type 3 soil above the groundwater table. The very stiff to hard clayey soils can be classified as Type 2 Soil above the groundwater table and as Type 3 below the groundwater table. The stiff to firm clayey silt to silty clay and cohesionless soils of sand, silt, and silty sand to sandy silt can be classified as Type 3 Soil above the groundwater table and Type 4 soil below the groundwater table. Soft clayey silt to silty clay can be classified as Type 4 soil.

The native soils free from topsoil and organics can be used as general construction backfill, provided its moisture content is within 2 percent of the optimum moisture content. Loose lifts of soil, which are to be compacted, should not exceed 200 mm. Depending on the time of construction and weather, some excavated material may be too wet to compact and will require aeration prior to its use.

Imported granular fill, which can be compacted with hand held equipment, should be used in confined areas. The excavated soils are not considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used.

It should be noted that the excavated soils are subject to moisture content increase during wet weather which would make these materials too wet for adequate compaction. Stockpiles should be compacted at the surface or be covered with tarpaulins to minimize moisture uptake.

4.6.7 TEMPORARY SHORING

It is understood that the proposed excavations may be supported by a temporary shoring system consisting of timber lagging and soldier piles. A caisson wall may be required to support adjacent structures. The requirement for caisson walls is given on Drawing 28.

The soil parameters estimated to be applicable for this design are as follows:

- 1) Earth Pressure Coefficients
 - (a) where movement must be minimal, $K=0.45$
 - (b) where minor movement ($.002H$) can be tolerated, $K=0.3$
 - (c) passive earth pressure for soldier piles (unfactored), $K_p=3.0$ for the stiff to hard and dense soils.
- 2) For stability check

$$\phi = 30^\circ$$

$$c = 0$$

$$\gamma = 21.5 \text{ kN/m}^3$$

Surcharge is to be determined by shoring contractor.

3) For earth anchors

Based on the borehole information, an allowable bond value of 50 kPa is suggested for the dense or very stiff to hard soils. The bond values depend on anchor installation methods and grouting procedures. Gravity poured concrete can result in low bond values while pressure grouted anchors will give higher values and produce a more satisfactory anchor.

Safe net bearing value for soldier pile caissons in the dense or very stiff to hard soils can be taken as $q = 600 \text{ kPa}$, provided the caisson holes are clean and dry prior to pouring concrete. Assuming a slurry procedure and tremie concrete, then $q = 300 \text{ kPa}$.

Casing will be required during the construction of the tiebacks to prevent caving of soils. The contractor must ensure that the soils below the adjacent buildings and structures will not be disturbed or undermined during the installation of the shoring system and tiebacks.

The soldier piles should be installed in pre-augered holes taken below the deepest excavation. The holes should be filled with concrete below the excavation level and half bag mix above the base of the excavation. The concrete strength must be specified by the shoring designer. Temporary liners may be required to help prevent the sand and sandy silt deposits from caving during the installation period.

Soil anchors will be required to support the shoring. The anchors must be of a length that meets the Canadian Foundation Manual recommendations. It is important to note that the minimum length lies beyond the $45 - \phi/2 + .15H$ line drawn from the base of the soldier pile and the overall stability of the system must be checked at each anchor level.

The top anchor must not be placed lower than 3.0 metres below the top of level ground surface. Anchors will require casing when penetrating through wet sand and sandy silt layers. Bond values of 50 KPa are suggested for soil anchors but these values are arbitrary since the contractor's installation procedures will determine the actual soil to concrete bond value. Hence, the contractor must decide on a capacity and confirm its availability. All anchors must be tested as indicated in the Foundation Manual, 4th edition.

Adhesion on the buried caisson shaft or behind the shoring system must be neglected when designing this shoring system.

Movement of the shoring system is inevitable. Vertical movements will result from the vertical load on the soldier piles resulting from the inclined tiebacks and inward horizontal movement results from earth

and water pressures. The magnitude of this movement can be controlled by sound construction practices, and it is anticipated that the horizontal movement will be in the range of 0.1 to 0.25%H.

To ensure that movements of the shoring are within an acceptable range, monitoring must be carried out. Vertical and horizontal targets on the soldier piles must be located and surveyed before excavation begins. Weekly readings during excavation should show that the movements will be within those predicted; if not, the monitoring results will enable directions to be given to improve the shoring.

4.6.8 EARTHQUAKE CONSIDERATIONS

Based on the existing borehole information and according to Table 4.1.8.4.A of OBC 2012, the subject site for the proposed buildings with 2 levels of basement can be classified as “Class D” for seismic site response.

5. GENERAL COMMENTS AND LIMITATIONS OF REPORT

DS Consultants Ltd. (DS) should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, DS will assume no responsibility for interpretation of the recommendations in the report.

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to DS at the time of preparation. Unless otherwise agreed in writing by DS, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this

project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. DS accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

DS CONSULTANTS LTD.

Eva Papp, P.Eng.

Shabbir Bandukwala, M.Eng., P.Eng.

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Drawings



Legend

- Approx Property Boundary
- ⊕ Borehole
- ⊗ Monitoring Well



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Client:

PRIMONT HOMES

Project:

GEOTECHNICAL INVESTIGATION
Quaker Road and First Ave, Welland, ON

Title:

BOREHOLE LOCATION PLAN



Size:
8.5 x 11

Approved By: E.P

Drawn By: S.Y

Date: April 2022

Rev:
0

Scale: As Shown

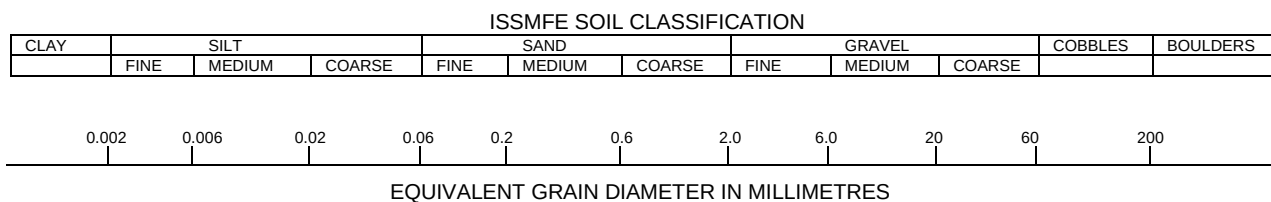
Project No.: 21-339-300

Figure No.: **1**

Image/Map Source: Google Satellite Image

Drawing 1A: Notes On Sample Descriptions

1. All sample descriptions included in this report generally follow the Unified Soil Classification. Laboratory grain size analyses provided by DS also follow the same system. Different classification systems may be used by others, such as the system by the International Society for Soil Mechanics and Foundation Engineering (ISSMFE). Please note that, with the exception of those samples where a grain size analysis and/or Atterberg Limits testing have been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.



CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

2. **Fill:** Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional preliminary geotechnical site investigation.
3. **Till:** The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765685 E 641199

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-29-2021

REF. NO.: 21-339-300

ENCL NO.: 2

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN. (C _u) (MPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)				
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m		STRENGTH (kPa)									WATER CONTENT (%)				GR
183.5	TOPSOIL: 300 mm						W. L. 184.3 m May 10, 2022													
0.0 183.2	SILTY SAND: disturbed/reworked, trace organics, brown, moist, loose		1	SS	5		20 40 60 80 100				20 40 60 80 100									
0.3																				
182.7																				
0.8			SILTY CLAY: trace sand, fine sand seams, brown, very moist to moist, very stiff to firm	2	SS		13													
1																				
				3	SS		20													
2																				
	grey below 3m	4	SS	17																
3																				
		5	SS	14																
4																				
	wet, firm below 4.6m		6	SS	6															
5																				
			VANE																	
6																				
6.1 177.4	SANDY SILT: trace gravel, trace clay, brown, wet, compact		7	SS	16															
176.8	END OF BOREHOLE																			
6.7	Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgl): Nov. 11, 2021 1.26 May 10, 2022 -0.8																			

GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ $\epsilon = 3\%$ Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site
 CLIENT: Primont Homes
 PROJECT LOCATION: Welland, Ontario
 DATUM: Geodetic
 BOREHOLE LOCATION: See Drawing 1 N 4765487 E 641216

DRILLING DATA

Method: Solid Stem Augers
 Diameter: 150 mm
 Date: Oct-29-2021

REF. NO.: 21-339-300

ENCL NO.: 3

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN. (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80						100	20	40				
184.1	TOPSOIL: 300 mm						184																
0.0 183.8	SILTY SAND: disturbed/reworked, trace organics, brown, moist, loose		1	SS	4		183.5																
0.3 183.3							183.4																
0.8	SILTY CLAY: fine sand seams, brown, moist to very moist, very stiff to firm		2	SS	16		183																
1																							
2																							
3																							
4	very moist below 2.3m		4	SS	9		182																
5	grey below 3m		5	SS	8		181																
6																							
7	firm below 4.6m		6	SS	4		180																
8																							
9																							
10	silt layers, trace gravel		7	SS	6		179																
11																							
12	END OF BOREHOLE						178																
13							177																
14																							
15																							
16																							
17																							
18																							
19																							
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DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765461 E 641631

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 4

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		W _p	W	W _L			
182.4								20 40 60 80 100							GR SA SI CL
0.0	TOPSOIL: 350 mm		1	SS	4										
182.0	CLAYEY SILT: disturbed/reworked, trace organics, brown, moist, firm						W. L. 182.1 m Nov 11, 2021 May 10, 2022								
0.4															
181.5	SILTY CLAY: trace sand, silt seams/layers, brown, moist to very moist, very stiff to firm		2	SS	14										
0.9															
			3	SS	18		181								
	grey, very moist below 2.3m		4	SS	17		180								
			5	SS	11		179								0 2 48 50
	wet, firm below 4.6m		6	SS	7		178								
				VANE			177		7.0						
			7	SS	4		176								
				VANE					3.0						
175.1															
7.3	END OF BOREHOLE														
	Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbg): Nov. 11, 2021 0.35 May 10, 2022 0.52														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, × 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765324 E 641710

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 5

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				W _P W W _L								
								○ UNCONFINED + FIELD VANE & Sensitivity	● QUICK TRIAXIAL × LAB VANE	20	40	60	80	100			10	20	30	
184.1																				
0.0 183.8	TOPSOIL: 300 mm		1	SS	2		184													
0.3	CLAYEY SILT: disturbed/reworked, trace organics, brown, moist, soft																			
183.2																				
1 0.9	SILTY CLAY: trace sand, silt seams/layers, brown, moist, very stiff		2	SS	19		183											175		
			3	SS	27													225		
2							182													
			4	SS	27													225		
3	grey below 3m																			
			5	SS	19		181											175		
4							180													
179.5																				
4.6	SILT: reddish brown, moist, compact to dense		6	SS	20		179											225		
5																				
6																				
177.4			7	SS	36		178													
6.7	END OF BOREHOLE																			
	Notes: 1. Borehole dry upon completion.																			

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

REF. NO.: 21-339-300

Date: Oct-27-2021

ENCL NO.: 6

BOREHOLE LOCATION: See Drawing 1 N 4765353 E 641503

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN. (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				WATER CONTENT (%)					
								20	40	60	80	100	W _P	W			
183.9	TOPSOIL: 300 mm																
0.0 183.6 0.3	CLAYEY SILT: disturbed/reworked, trace organics, brown, moist, firm		1	SS	5												
183.1																	
0.8	SILT: some clay, trace sand, brown, moist, compact		2	SS	19		183										
			3	SS	20		182										
			4	SS	23		181										
	grey below 3m		5	SS	24		180								225		
			6	SS	20		179								225		
	wet						178										
			7	SS	18										150		
177.2																	
6.7	END OF BOREHOLE																
	Notes: 1. Borehole wet at 6m depth during drilling.																

GROUNDWATER ELEVATIONS

	1st	2nd	3rd	4th
Measurement				

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ $\epsilon = 3\%$ Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765297 E 641336

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 7

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT	
															W _p		W		W _L	
184.1																				
0.0																				
183.8																				
0.3			1	SS	5		184													
183.2																				
1			2	SS	17															
0.9																				
			3	SS	13															
2																				
			4	SS	20															
3																				
			5	SS	7															
4																				
				VANE																
179.5																				
4.6			6	SS	26															
5																				
6																				
			7	SS	28															
177.4																				
6.7																				

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, X 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site
 CLIENT: Primont Homes
 PROJECT LOCATION: Welland, Ontario
 DATUM: Geodetic
 BOREHOLE LOCATION: See Drawing 1 N 4765120 E 641247

DRILLING DATA
 Method: Solid Stem Augers
 Diameter: 150 mm
 Date: Oct-28-2021
 REF. NO.: 21-339-300
 ENCL NO.: 8

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				W _p	W	W _L			
184.2	TOPSOIL: 300 mm							20	40	60	80	100					GR SA SI CL
183.9	CLAYEY SILT: disturbed/reworked, trace organics, brown, moist, soft		1	SS	3		184										
183.3	SILTY CLAY: trace sand, silt seams/layers, brown, moist to very moist, very stiff to firm		2	SS	15		183										
182			3	SS	24		182								225		
181	grey, very moist, stiff below 3m		4	SS	16		181								225		
180			5	SS	9		180								75		
179			6	SS	7		179										
178.2	firm below 4.6m			VANE			178										
178.2	SILT: some sand, brown, wet, compact		7	SS	28		178										
177.5	END OF BOREHOLE																
6.7	Notes: 1. Borehole wet at 6m depth during drilling.																

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

GROUNDWATER ELEVATIONS
 Measurement 1st 2nd 3rd 4th

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ = 3% Strain at Failure

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

REF. NO.: 21-339-300

Date: Oct-27-2021

ENCL NO.: 9

BOREHOLE LOCATION: See Drawing 1 N 4765201 E 641601

GRAPH NOTES + 3, $\times 3$: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765147 E 641707

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 10

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION (m)	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)				W _p	W	W _L			GR	SA	SI	CL
183.5	TOPSOIL: 300 mm						W. L. 184.0 m May 10, 2022													
0.0 183.2			1	SS	5		W. L. 183.3 m Nov 11, 2021						○							
0.3	SANDY SILT: disturbed/reworked, trace topsoils, brown, moist, loose																			
182.6			2	SS	23		W. L. 182.6 m Jun 27, 2022						○							
1	SILTY CLAY: trace sand, silt seams/layers, brown, moist, very stiff to firm																			
0.9			3	SS	20		182						○							
2			4	SS	10		181						○							
3	grey, firm below 3m		5	SS	6		180						○							
4				VANE			179	3.5												
5			6	SS	4		178						○							
6	wet below 4.6m			VANE			177	2.7												
7			7	SS	6								○							
176.2				VANE				3.0												
7.3	END OF BOREHOLE																			
Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgf): Nov. 11, 2021 0.25 May 10, 2022 -0.5 June 27, 2022 0.97																				

GROUNDWATER ELEVATIONS

 Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3 , × 3 : Numbers refer
to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765113 E 641466

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 11

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							WATER CONTENT (%)			GR	SA	SI	CL
								20 40 60 80 100							W _P W W _L						
							○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE														
183.7	0.0	TOPSOIL: 300 mm																			
183.4	0.3	CLAYEY SILT: disturbed/reworked, trace topsoils, brown, moist, firm	1	SS	6																
182.9	0.8	SILTY CLAY: trace sand, silt seams/layers, brown, moist, very stiff to firm	2	SS	21																
		grey, wet, firm below 3m	3	SS	21																
			4	SS	12																
			5	SS	4																
			VANE																		
			6	SS	5																
			VANE																		
177.7	6.0	SANDY SILT: brown, wet, compact	7	SS	12																
177.0	6.7	END OF BOREHOLE																			
		Notes: 1. Borehole wet below 3m depth during drilling.																			

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, × 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765056 E 641193

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-27-2021

REF. NO.: 21-339-300

ENCL NO.: 12

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)					
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		WATER CONTENT (%)				GR	SA	SI	CL		
184.3	TOPSOIL: 450 mm		1	SS	4		184												
183.8	CLAYEY SILT: disturbed/reworked, trace topsoil, brown, moist, firm SILTY CLAY: trace sand, silt seams/layers, brown, moist to very moist, very stiff to firm very moist, stiff below 2.3m grey below 3m						183.7												
0.5							183												
183.5							182												
0.8							181												
							180												
			2	SS	14		183												
			3	SS	18		182												
			4	SS	11		181												
			5	SS	10		180												
			6	SS	4		179												
				VANE			178												
			7	SS	7														
				VANE															
177.0	END OF BOREHOLE																		
7.3	Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgl): Nov. 11, 2021 3.47 May 10, 2022 0.77 June 27, 2022 0.57																		

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4765024 E 641312

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 13

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT			POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		W _p	W	W _L			
183.8	TOPSOIL: 300 mm							20 40 60 80 100							GR SA SI CL
183.5	SILTY SAND: disturbed/reworked, trace topsoil, brown, moist, loose		1	SS	5			20 40 60 80 100							
183.0	SILTY CLAY: trace sand, brown, moist to very moist, very stiff to firm		2	SS	16		183								
182.0			3	SS	26		182								
181.0	stiff below 2.3m		4	SS	14		181								
180.0	grey, wet, firm below 3m		5	SS	6		180								
179.0			6	SS	6		179								
178.0			7	SS	7		178								
177.0							177								
176.5	END OF BOREHOLE														
7.3	Notes: 1. Borehole wet below 3m depth during drilling.														

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

REF. NO.: 21-339-300

Date: Oct-27-2021

ENCL NO.: 14

BOREHOLE LOCATION: See Drawing 1 N 4765022 E 641489

GRAPH NOTES + 3, $\times 3$: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

BOREHOLE LOCATION: See Drawing 1 N 4764872 E 641346

GRAPH NOTES + 3, $\times 3$: Numbers refer to Sensitivity ○ **8**=3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4764896 E 641312

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 16

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			POCKET PEN (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)						
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)							WATER CONTENT (%)			GR	SA	SI	CL
								20	40	60	80	100			W _P	W	W _L				
						○ UNCONFINED + FIELD VANE & Sensitivity															
						● QUICK TRIAXIAL × LAB VANE															
184.1	TOPSOIL: 300 mm		1	SS	5		184														
0.0 183.8	CLAYEY SILT: disturbed/reworked, trace topsoil, brown, wet, firm																				
0.3 183.3	SILTY CLAY: trace sand, trace gravel, brown, moist to very moist, very stiff to soft		2	SS	17			183													
1 0.8			3	SS	23			182													
			4	SS	17			181													
			5	SS	11			180													
2			grey, wet, soft below 4.6m	6	SS		3		179												
3																					
4				VANE																	
5																					
6		7	SS	4		178															
7																					
176.8 7.3	END OF BOREHOLE		VANE			177															
	Notes: 1. Borehole wet below 4.6m during drilling.																				

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH
NOTES+ 3, × 3: Numbers refer
to Sensitivity

○ = 3% Strain at Failure

PROJECT: Preliminary Geotechnical Investigation, Welland Thorold Site

CLIENT: Primont Homes

PROJECT LOCATION: Welland, Ontario

DATUM: Geodetic

BOREHOLE LOCATION: See Drawing 1 N 4764776 E 641281

DRILLING DATA

Method: Solid Stem Augers

Diameter: 150 mm

Date: Oct-28-2021

REF. NO.: 21-339-300

ENCL NO.: 17

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	POCKET PEN. (C _u) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)							
(m) ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)									WATER CONTENT (%)				GR	SA	SI	CL
																	○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE & Sensitivity × LAB VANE						
183.4 0.0	TOPSOIL: 600 mm		1	SS	4		183																	
182.8 0.6	CLAYEY SILT: disturbed/reworked, trace topsoil, brown, wet, firm						W. L. 182.9 m W. L. 182.7 m Jun 27, 2022																	
182.4 1.0	SILTY CLAY: trace sand, trace gravel, brown, moist to very moist, very stiff to firm		2	SS	11																			
			3	SS	18																			
	stiff below 2.3m		4	SS	9																			
	grey, firm below 3m		5	SS	5																			
				VANE																				
			6	SS	5		W. L. 179.0 m Nov 11, 2021																	
				VANE																				
176.7 6.7	END OF BOREHOLE		7	SS	6																			
Notes: 1. 50mm dia. monitoring well installed upon completion. 2. Water Level Readings: Date: Water Level(mbgI): Nov. 11, 2021 4.43 May 10, 2022 0.54 June 27, 2022 0.72																								

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, X 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 21-339-300 BOREHOLE LOGS.GPJ DS.GDT 22-7-19

PROJECT: Additional Geotechnical Investigation

CLIENT: Primont Homes

PROJECT LOCATION: Quaker Road and First Avenue, Welland, ON

DATUM: Geodetic

BOREHOLE LOCATION: See Figure 1 N 4765406.469 E 641715.248

DRILLING DATA

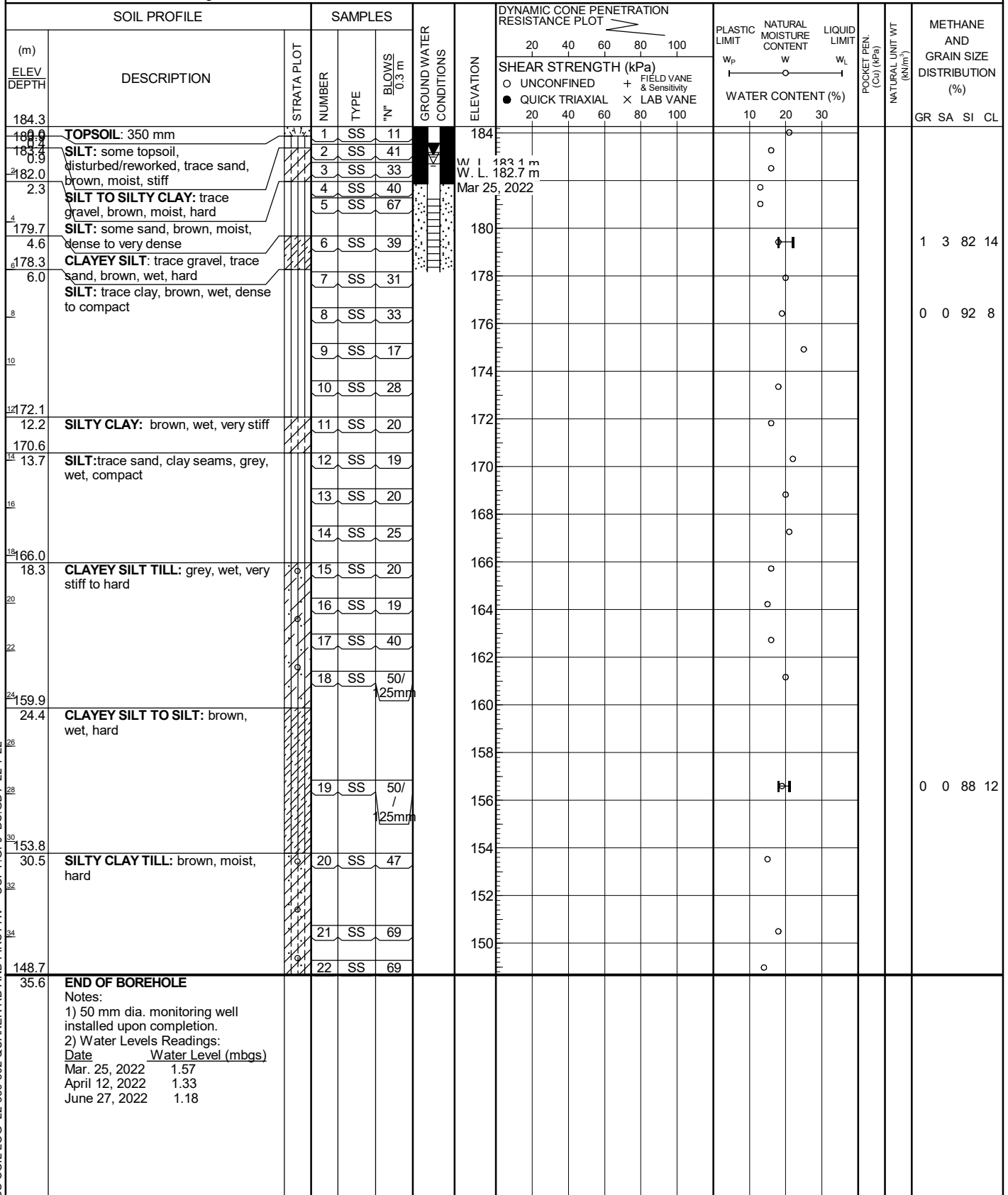
Method: Hollow Stem Auger

Diameter: 200 mm

Date: Mar-08-2022

REF. NO.: 21-339-302

ENCL NO.: 18



GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, X 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

PROJECT: Additional Geotechnical Investigation

CLIENT: Primont Homes

PROJECT LOCATION: Quaker Road and First Avenue, Welland, ON

DATUM: Geodetic

BOREHOLE LOCATION: See Figure 1 N 4764772.797 E 641331.348

DRILLING DATA

Method: Hollow Stem Auger

Diameter: 200 mm

Date: Mar-02-2022

REF. NO.: 21-339-302

ENCL NO.: 19

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m ³)	METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m			SHEAR STRENGTH (kPa)		W _p	W	W _L		GR	SA	SI	CL
183.6	TOPSOIL: 400 mm		1	SS	3		183.4 m	20 40 60 80 100									
182.7	SILTY CLAY: disturbed/reworked, brown, moist, soft		2	SS	17		182.7	20 40 60 80 100									
2	SILTY CLAY: with silt seams, trace gravel, brown, moist to wet, very stiff to firm		3	SS	20		182.2	20 40 60 80 100									
4			4	SS	12		181.7	20 40 60 80 100									
6	layer of silt, grey, wet, loose		5	SS	9		181.2	20 40 60 80 100									
			6	SS	4		180.7	20 40 60 80 100									
			VANE				178.2	20 40 60 80 100									
7.6	SILT: some sand, with clay seams/layers, brown, wet, loose		7	SS	4		177.7	20 40 60 80 100									
8			8	SS	8		177.2	20 40 60 80 100									
10			9	SS	4		176.7	20 40 60 80 100									
12			10	SS	5		176.2	20 40 60 80 100									
14			11	SS	8		175.7	20 40 60 80 100									
169.9	SILTY CLAY: trace to some gravel, reddish brown, moist, very stiff to hard		12	SS	15		175.2	20 40 60 80 100									
16			13	SS	16		174.7	20 40 60 80 100									
18			14	SS	23		174.2	20 40 60 80 100									
20			15	SS	31		173.7	20 40 60 80 100									
163.8	CLAYEY SILT TO SILT: trace sand, some clay, brown, moist, hard		16	SS	54		173.2	20 40 60 80 100									
19.8			17	SS	55		172.7	20 40 60 80 100									
22			18	SS	37		172.2	20 40 60 80 100									
160.7	CLAYEY SILT TILL: brown, moist, hard to very stiff		19	SS	43		171.7	20 40 60 80 100									
24			20	SS	46		171.2	20 40 60 80 100									
26			21	SS	25		170.7	20 40 60 80 100									
28			22	SS	18		170.2	20 40 60 80 100									
30			23	SS	28		169.7	20 40 60 80 100									
32			24	SS	25		169.2	20 40 60 80 100									
34			25	SS	39		168.7	20 40 60 80 100									
148.0	END OF BOREHOLE		26	SS	33		148.0	20 40 60 80 100									
35.6	Notes: 1) 50 mm dia. monitoring well installed at 6.10 mbgs upon completion. 2) Water Levels Readings: Date Water Level (mbgs) Mar. 25, 2022 Not Accessible April 12, 2022 1.15 June 27, 2022 0.17																

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ = 3% Strain at Failure

DS SOIL LOG 22-339-302 QUAKER RD AND FIRST AV - COPY.GPJ DS.GDT 22-7-22

PROJECT: Additional Geotechnical Investigation

CLIENT: Primont Homes

PROJECT LOCATION: Quaker Road and First Avenue, Welland, ON

DATUM: Geodetic

BOREHOLE LOCATION: See Figure 1 N 4764874.239 E 641283.907

DRILLING DATA

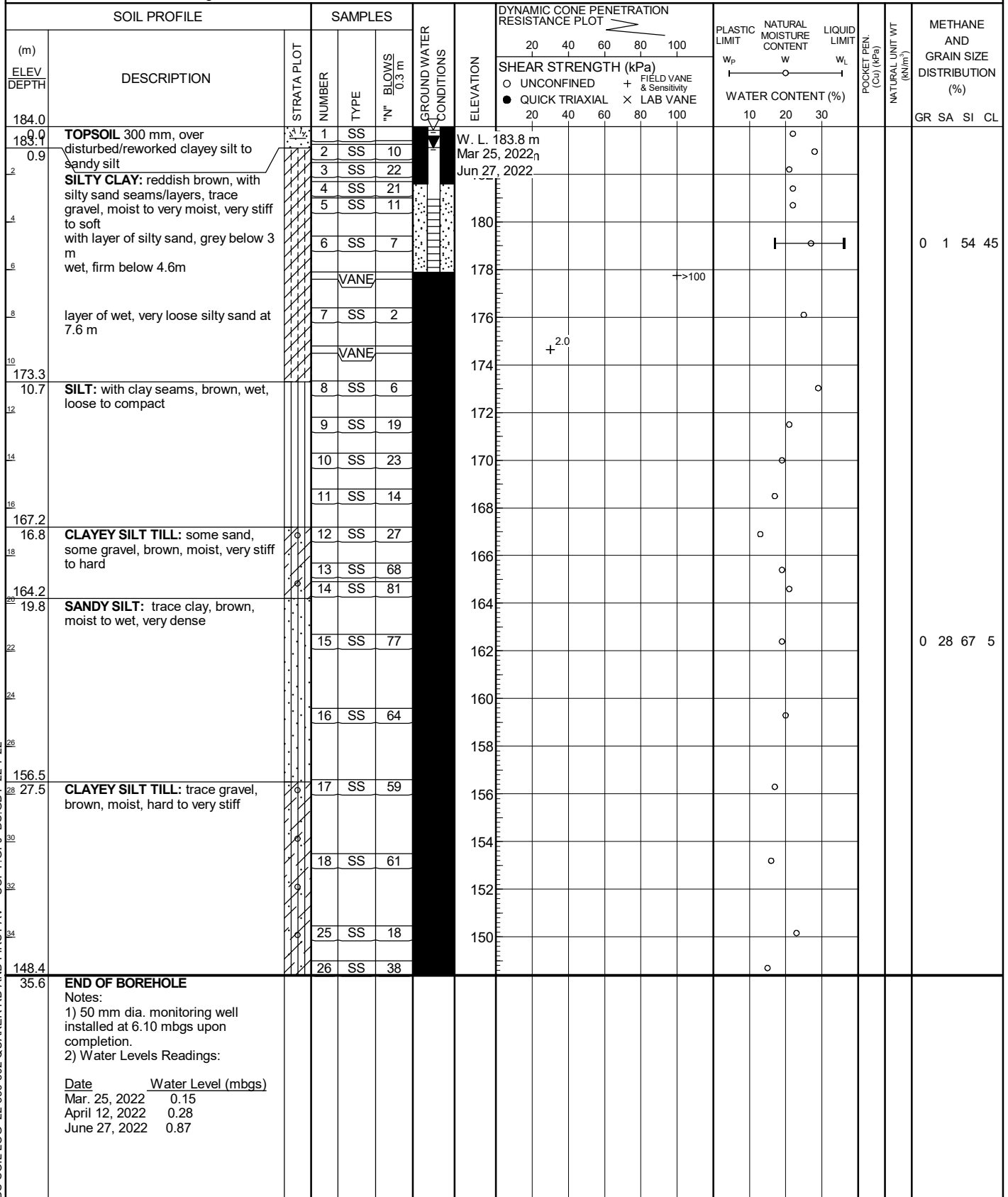
Method: Hollow Stem Auger

Diameter: 200 mm

Date: Mar-03-2022

REF. NO.: 21-339-302

ENCL NO.: 20



GROUNDWATER ELEVATIONS

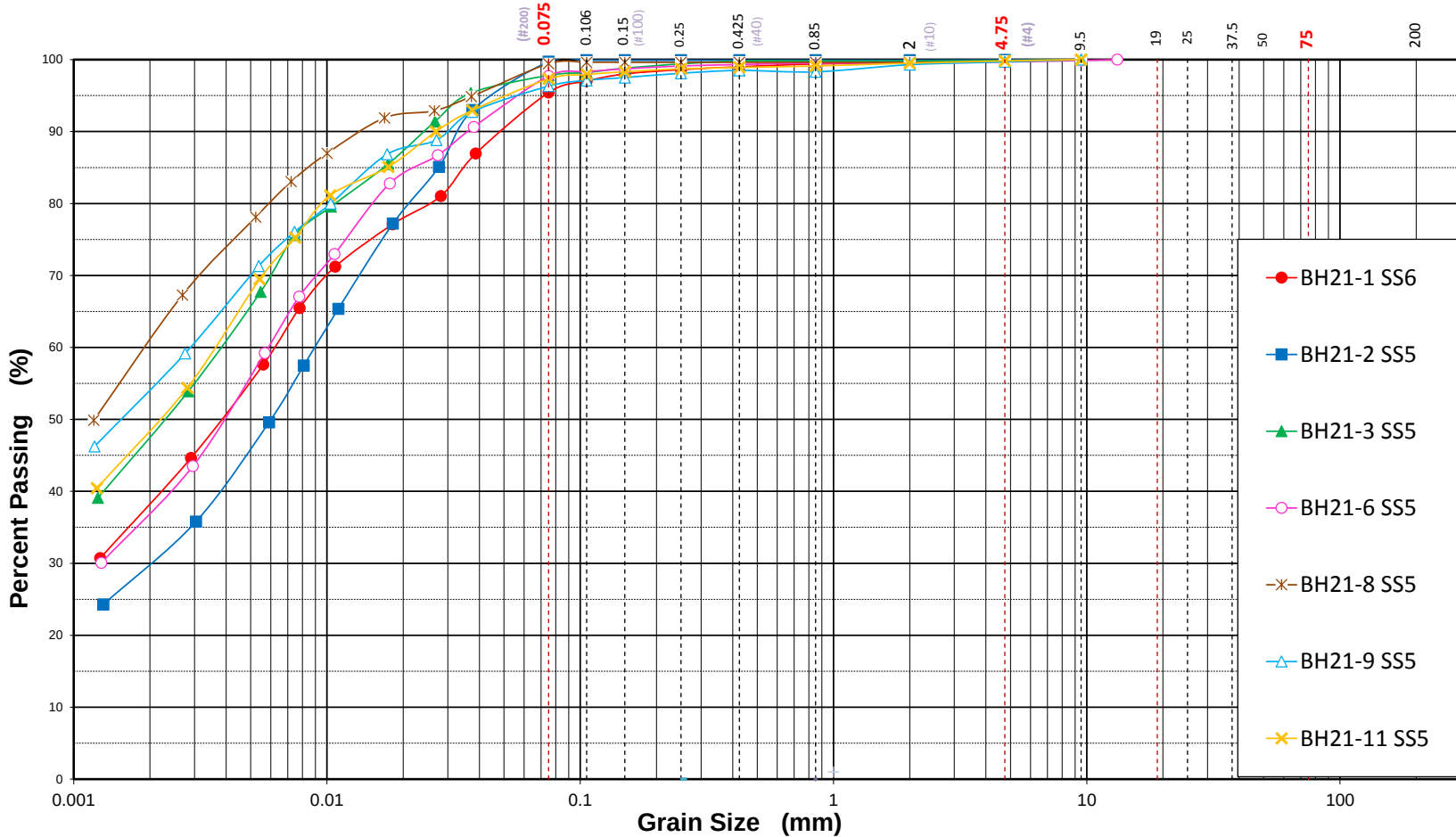
Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

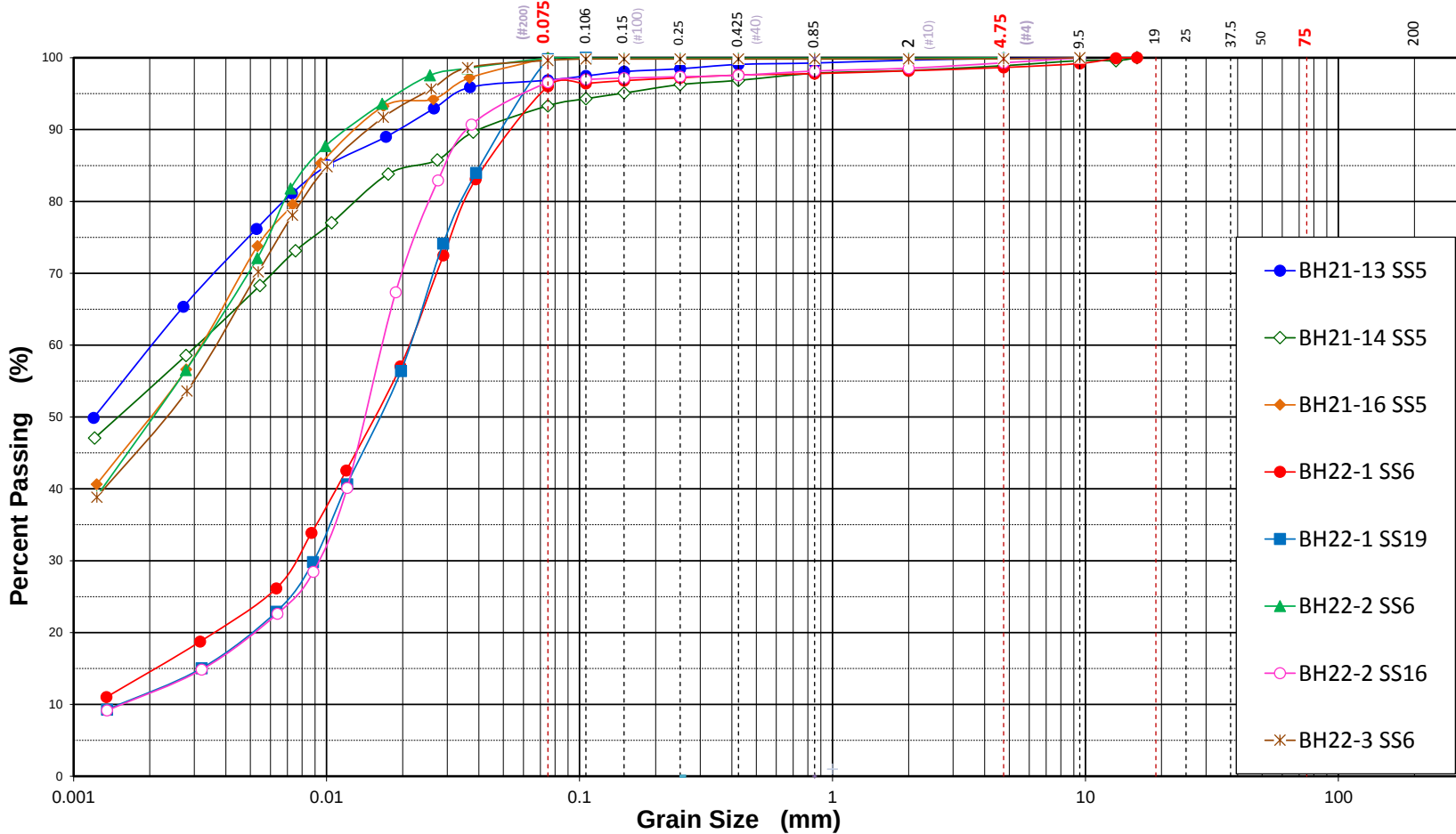
○ = 3% Strain at Failure

Particle Size Distribution (ASTM-D421/D422)



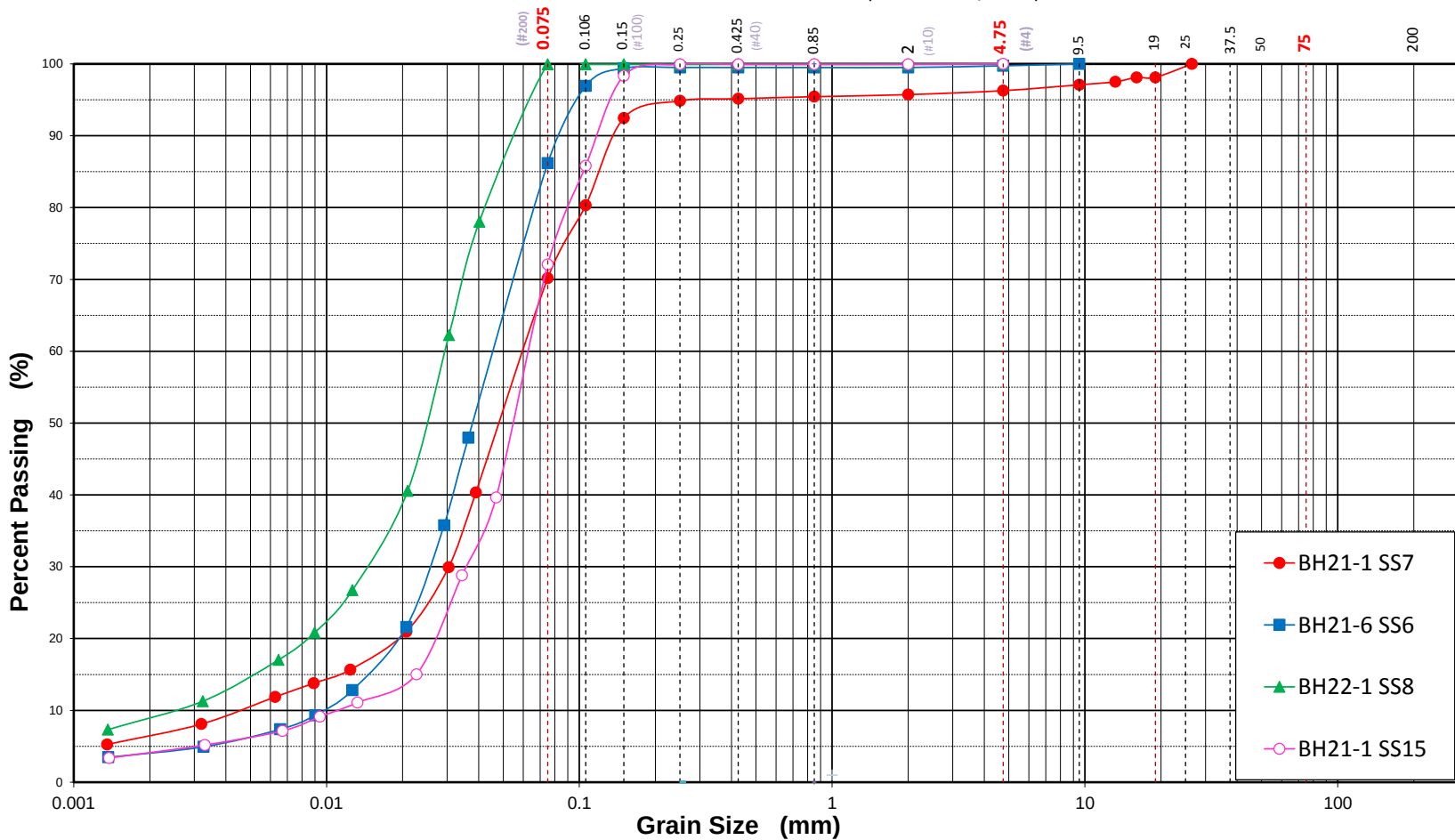
Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	
 DS CONSULTANTS LTD. 6221 Highway 7, Unit 16 Vaughan, Ontario, L4H 0K8 Telephone: (905) 264-9393 www.dsconsultants.ca		Project	Preliminary Geotechnical Investigation Welland			Project No	21-339-300
		Location	Welland, ON			Date	July 19/22
		Client	Primont Homes			Figure No	21a

Particle Size Distribution (ASTM-D421/D422)



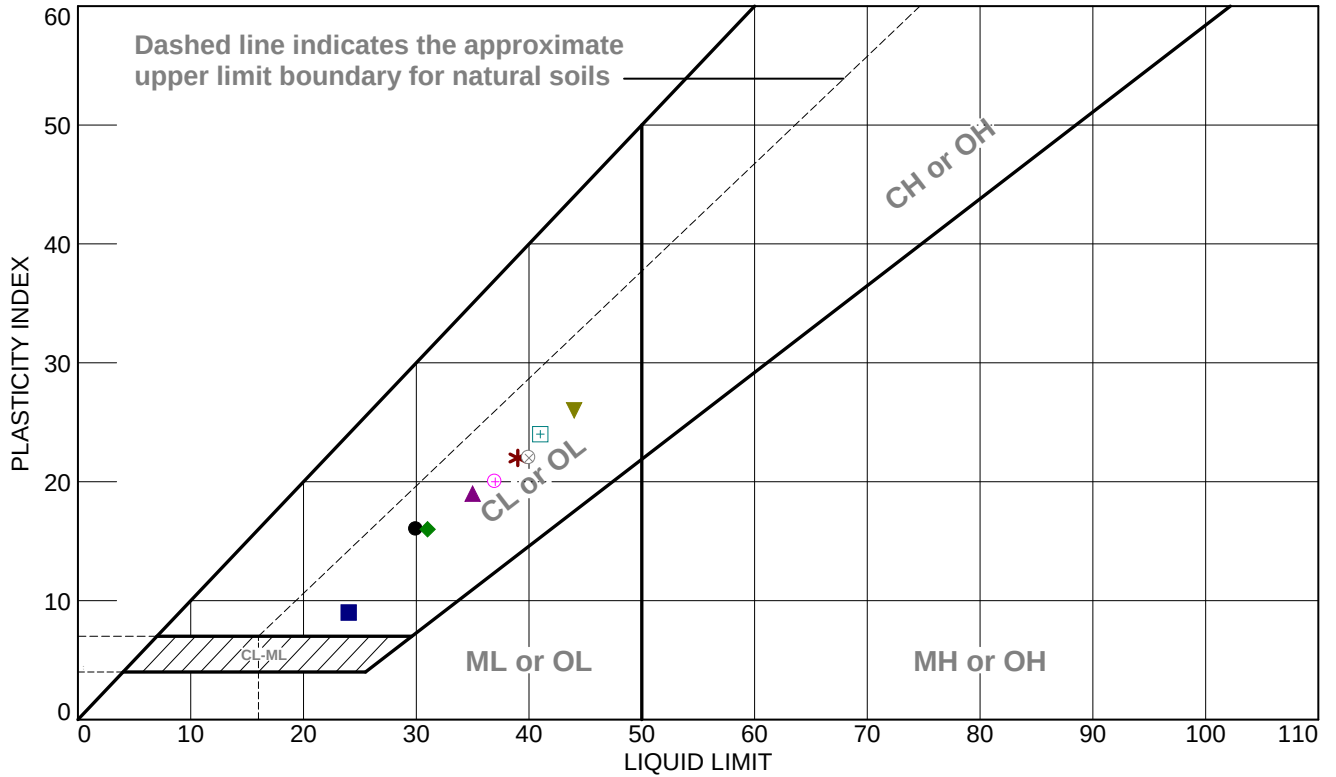
Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	
 DS CONSULTANTS LTD. 6221 Highway 7, Unit 16 Vaughan, Ontario, L4H 0K8 Telephone: (905) 264-9393 www.dsconsultants.ca		Project	Preliminary Geotechnical Investigation Welland			Project No	21-339-300
		Location	Welland, ON			Date	July 19/22
		Client	Primont Homes			Figure No	21b

Particle Size Distribution (ASTM-D421/D422)



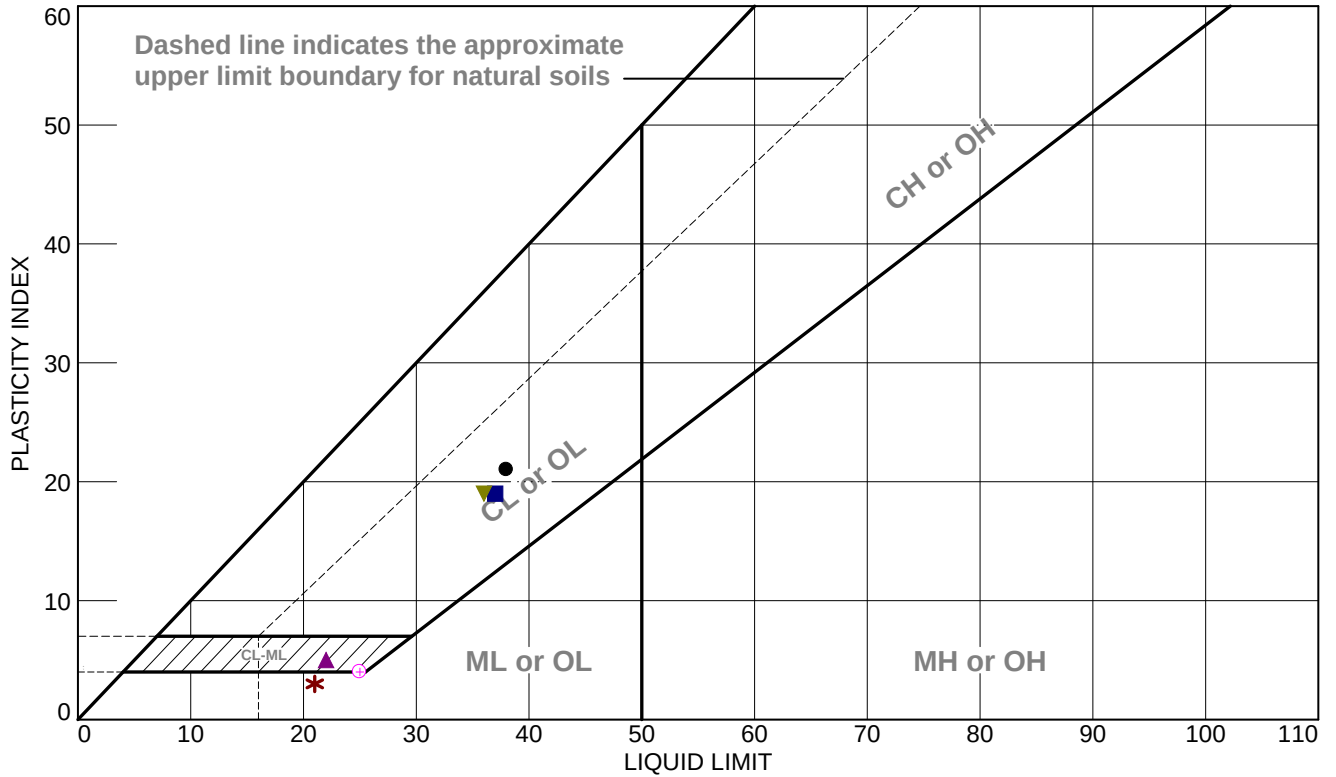
Silt and Clay		Sand			Gravel		Cobble +
Clay	Silt	Fine	Medium	Coarse	Fine	Coarse	
 DS CONSULTANTS LTD. 6221 Highway 7, Unit 16 Vaughan, Ontario, L4H 0K8 Telephone: (905) 264-9393 www.dsconsultants.ca		Project	Preliminary Geotechnical Investigation Welland			Project No	21-339-300
		Location	Welland, ON			Date	July/19/22
		Client	Primont Homes			Figure No	22

LIQUID AND PLASTIC LIMITS TEST REPORT

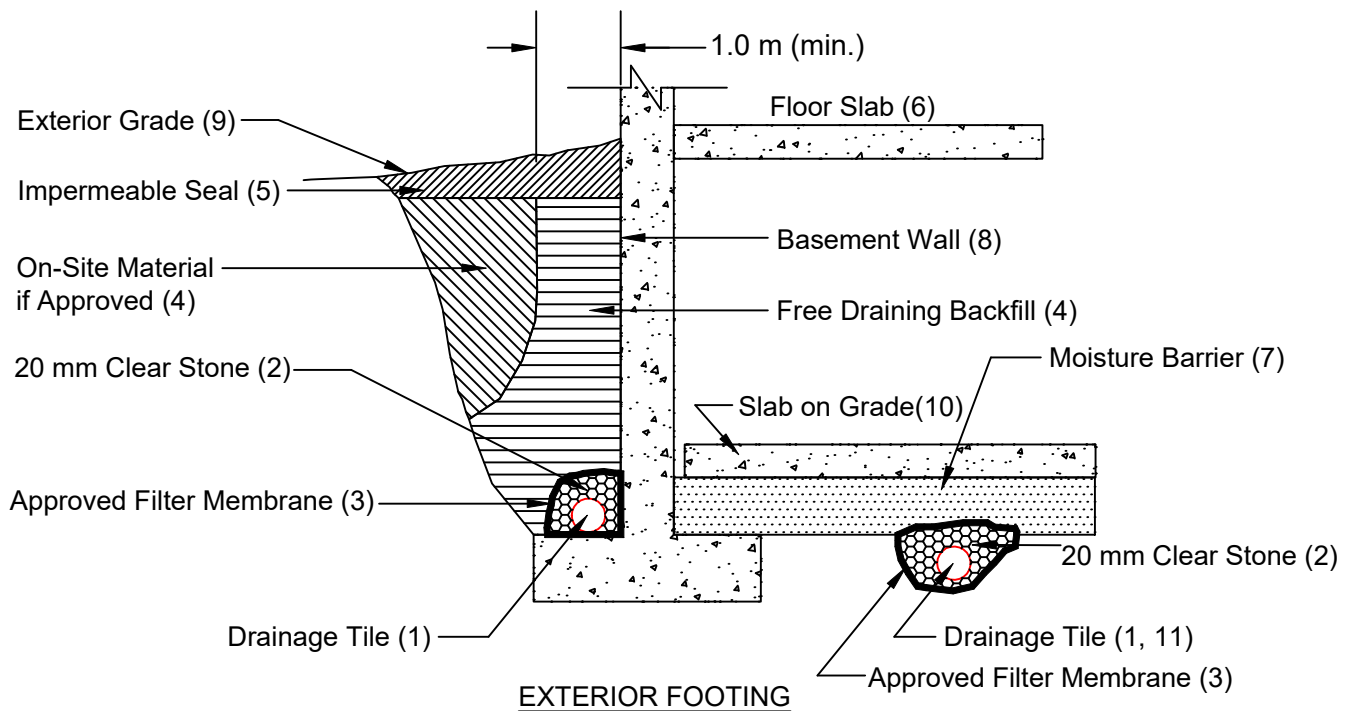


SOIL DATA								
	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●		BH21-1/SS6			14	30	16	CL
■		BH21-2/SS5			15	24	9	CL
▲		BH21-3/SS5			16	35	19	CL
◆		BH21-6/SS5			15	31	16	CL
▼		BH21-8/SS5			18	44	26	CL
*		BH21-9/SS5			17	39	22	CL
⊕		BH21-11/SS5			17	37	20	CL
⊕		BH21-13/SS5			17	41	24	CL
⊗		BH21-14/SS5			18	40	22	CL

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●		BH21-16/SS5			17	38	21	CL
■		BH22-2/SS6			18	37	19	CL
▲		BH22-1/SS6			17	22	5	CL-ML
◆		BH22-1/SS8			NP	21	NP	ML
▼		BH22-3/SS6			17	36	19	CL
*		BH22-1/SS19			18	21	3	ML
⊕		BH22-2/SS16			21	25	4	CL-ML
⊕		BH22-3/SS15			NP	NP	NP	ML



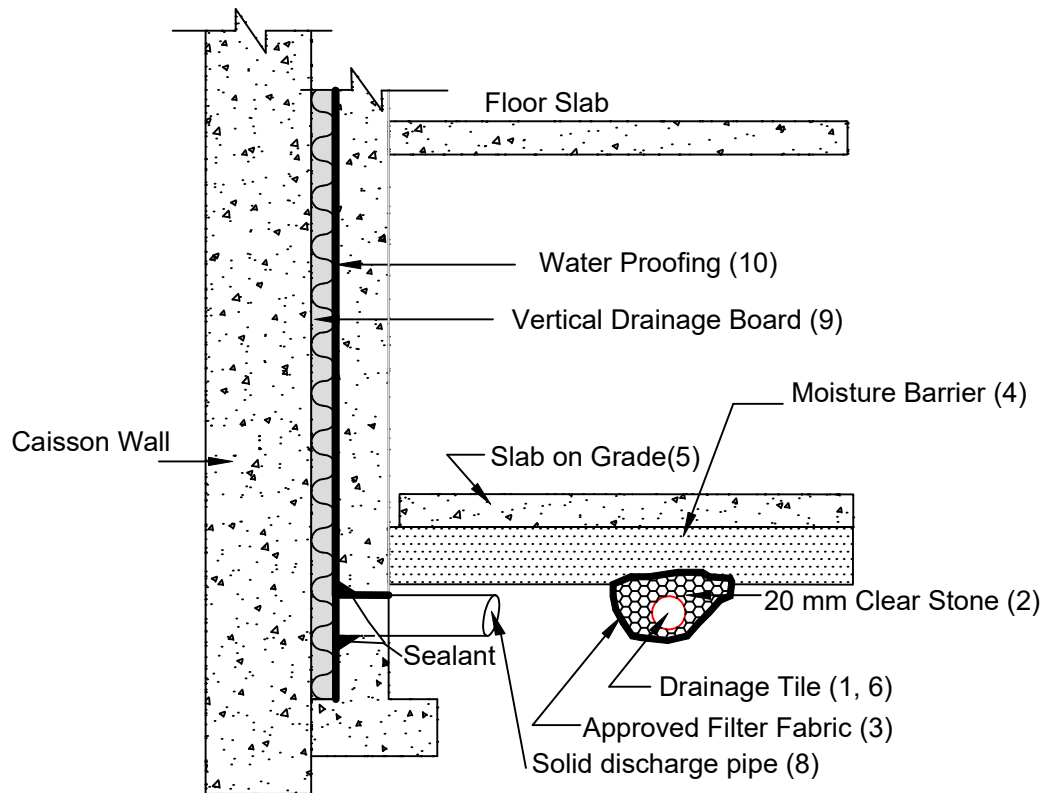
Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place 100 mm (4 inches) of stone below drain.
3. Wrap the clear stone with an approved filter membrane (Terrafix 270R or equivalent).
4. Free Draining backfill - OPSS Granular B or equivalent compacted to the specified density. Do not use heavy compaction equipment within 450 mm (18") of the wall. Use hand controlled light compaction equipment within 1.8 m (6') of wall. The minimum width of the Granular 'B' backfill must be 1.0 m.
5. Impermeable backfill seal - compacted clay, clayey silt or equivalent. If original soil is free-draining, seal may be omitted. Maximum thickness of seal to be 0.5 m.
6. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.
7. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
8. Basement wall to be damp proofed /water proofed.
9. Exterior grade to slope away from building.
10. Slab on grade should not be structurally connected to the wall or footing.
11. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab.
12. Drainage tile placed in parallel rows 6 to 8 m (20 to 25') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
13. The entire subgrade to be sealed with approved filter fabric (Terrafix 270R or equivalent) if non-cohesive (sandy) soils below ground water table encountered.
14. Do not connect the underfloor drains to perimeter drains.
15. Review the geotechnical report for specific details.

DRAINAGE AND BACKFILL RECOMMENDATIONS

Basement with Underfloor Drainage

(not to scale)



EXTERIOR FOOTING

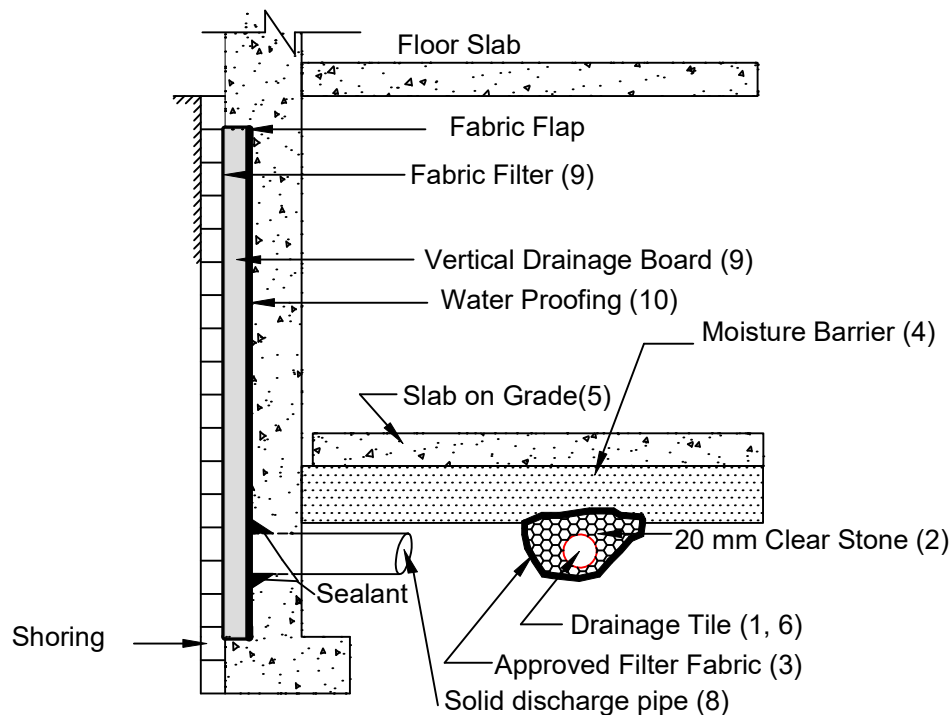
Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet, spaced between columns.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place 100 mm (4 inches) of stone below drain.
3. Wrap the clear stone with an approved filter membrane (Terrafix 270R or equivalent).
4. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
5. Slab on grade should not be structurally connected to the wall or footing.
6. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab.
Drainage tile placed in parallel rows 6 to 8 m (20 to 25') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
7. Do not connect the underfloor drains to perimeter drains.
8. Solid discharge pipe located at the middle of each bay between the soldier piles, approximate spacing 2.5 m, outletting into a solid pipe leading to a sump.
9. Vertical drainage board mira-drain 6000 or equivalent with filter cloth should be continuous from bottom to 1.2 m below exterior finished grade.
10. The basement walls must be water proofed using bentonite or equivalent water-proofing system.
11. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE RECOMMENDATIONS

Shored Basement wall with Underfloor Drainage System

(not to scale)



EXTERIOR FOOTING

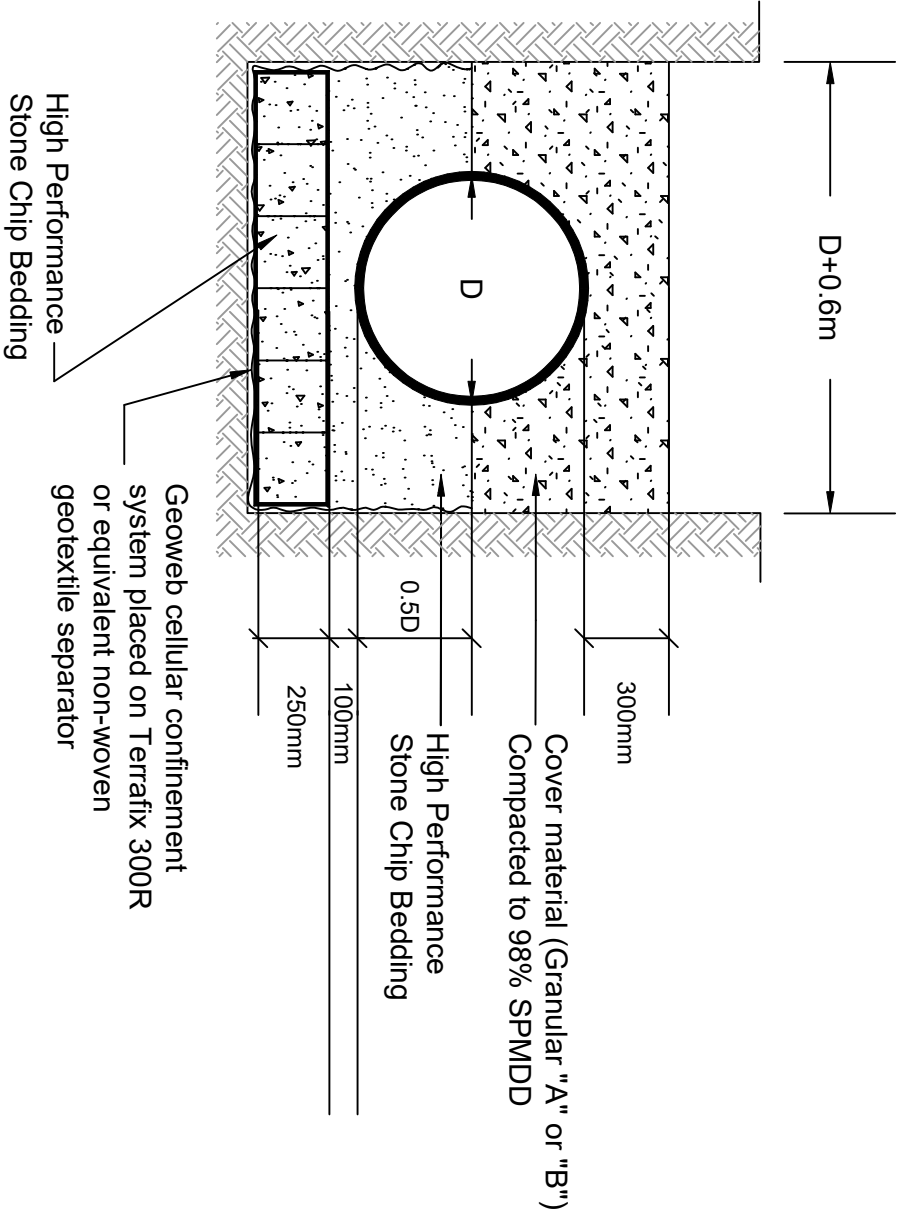
Notes

1. Drainage tile to consist of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet, spaced between columns.
2. 20 mm (3/4") clear stone - 150 mm (6") top and side of drain. If drain is not on footing, place 100 mm (4 inches) of stone below drain.
3. Wrap the clear stone with an approved filter membrane (Terrafix 270R or equivalent).
4. Moisture barrier to be at least 200 mm (8") of compacted clear 20 mm (3/4") stone or equivalent free draining material. A vapour barrier may be required for specialty floors.
5. Slab on grade should not be structurally connected to the wall or footing.
6. Underfloor drain invert to be at least 300 mm (12") below underside of floor slab.
Drainage tile placed in parallel rows 6 to 8 m (20 to 25') centers one way. Place drain on 100 mm (4") clear stone with 150 mm (6") of clear stone on top and sides. Enclose stone with filter fabric as noted in (3).
7. Do not connect the underfloor drains to perimeter drains.
8. Solid discharge pipe located at the middle of each bay between the soldier piles, approximate spacing 2.5 m, outletting into a solid pipe leading to a sump.
9. Vertical drainage board with filter cloth should be kept a minimum of 1.2 m below exterior finished grade.
10. The basement walls should be water proofed using bentonite or equivalent water-proofing system.
11. Review the geotechnical report for specific details. Final detail must be approved before system is considered acceptable.

DRAINAGE RECOMMENDATIONS

Shored Basement wall with Underfloor Drainage System

(not to scale)



DS CONSULTANTS LTD.
6221 Highway 7, UNIT 16
Vaughan, Ontario L4H 0K8
Telephone: (905) 264-9393
www.dsconsultants.ca

Project: **GEOTECHNICAL INVESTIGATION**

Title: **GEOWEB PIPE BEDDING**

Client:

PRIMONT HOMES

Approved By:

A.S

Drawn By:

S.Y

Date:

October 2018

Scale:

N.T.S

Project No:

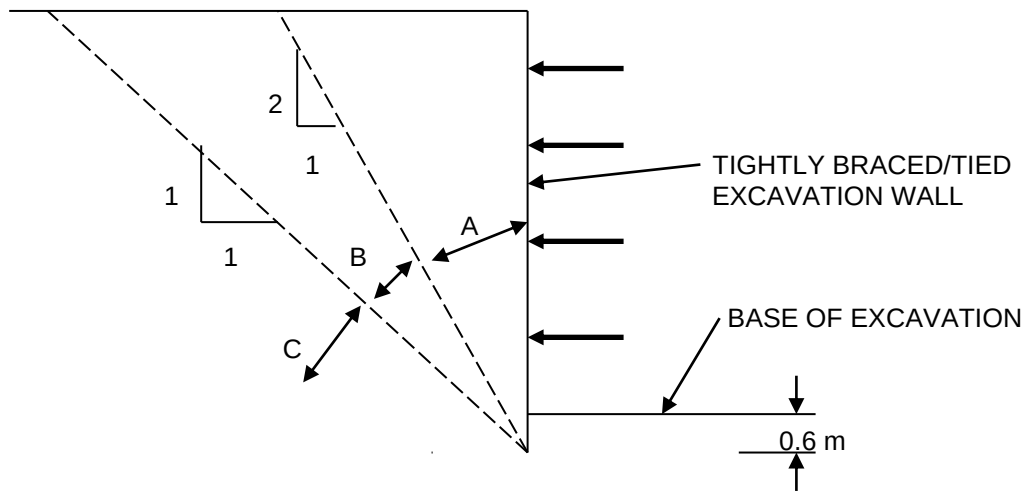
21-339-300

Figure No.

27

Guidelines for Underpinning in Soil and Excavation Support

Existing foundations located within Zone A normally require underpinning, especially for heavy structures. For some foundations in Zone A, it may be possible to eliminate underpinning and control foundation movement by tightly braced excavation walls, such as caisson walls.



- Zone A Foundations located within this zone normally require underpinning. Horizontal and vertical pressures on the excavation wall of non underpinned foundations must be considered
- Zone B Foundations located within this zone normally do not require underpinning. Horizontal and vertical pressures on the excavation wall of non underpinned foundations must be considered
- Zone C Underpinning to structures is normally founded in this zone. Lateral pressure from underpinning is not normally considered

(Reference: Figure 26.27 from Canadian Foundation Engineering Manual, 4th Edition)

Appendix A

ENGINEERED FILL GUIDELINES

GENERAL REQUIREMENTS FOR ENGINEERED FILL

Compacted imported soil that meets specific engineering requirements and is free of organics and debris and that has been continually monitored on a full-time basis by a qualified geotechnical representative is classified as engineered fill. Engineered fill that meets these requirements and is bearing on suitable native subsoil can be used for the support of foundations.

Imported soil used as engineered fill can be removed from other portions of a site or can be brought in from other sites. In general, most of Ontario soils are too wet to achieve the 100% Standard Proctor Maximum Dry Density (SPMDD) and will require drying and careful site management if they are to be considered for engineered fill. Imported non-cohesive granular soil is preferred for all engineered fill. For engineered fill, we recommend use of OPSS Granular 'B' sand and gravel fill material.

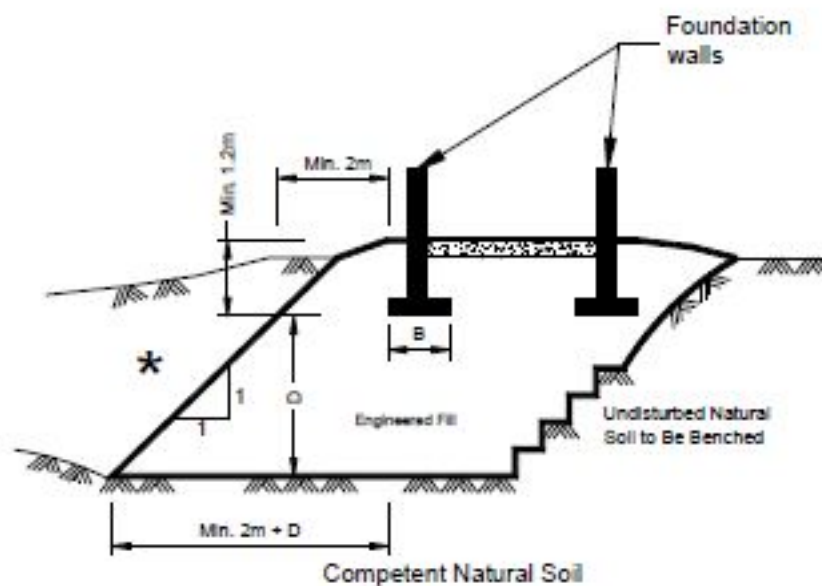
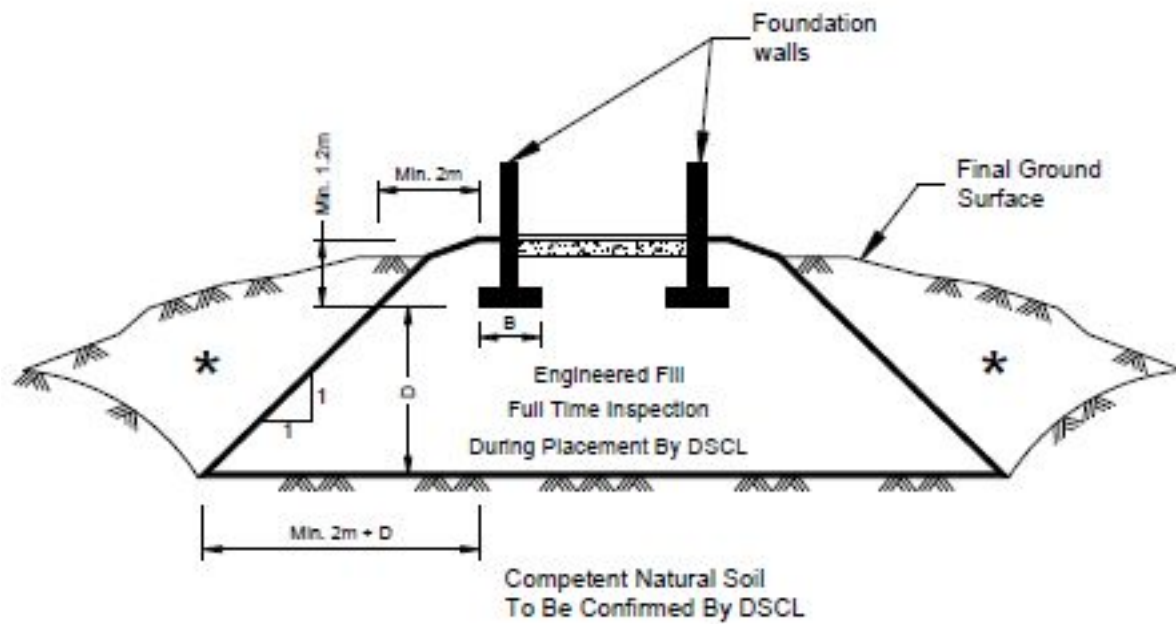
Adverse weather conditions such as rain make the placement of engineered fill to the required degree of density difficult or impossible; engineered fill cannot be placed during freezing conditions, i.e. normally not between December 15 and April 1 of each year.

The location of the foundations on the engineered fill pad is critical and certification by a qualified surveyor that the foundations are within the stipulated boundaries is mandatory. Since layout stakes are often damaged or removed during fill placement, offset stakes must be installed and maintained by the surveyors during the course of fill placement so that the contractor and engineering staff are continually aware of where the engineered fill limits lie. Excavations within the engineered fill pad must be backfilled with the same conditions and quality control as the original pad.

To perform satisfactorily, engineered fill requires the cooperation of the designers, engineers, contractors and all parties must be aware of the requirements. The minimum requirements are as follows; however, the geotechnical report must be reviewed for specific information and requirements.

1. Prior to site work involving engineered fill, a site meeting to discuss all aspects must be convened. The surveyor, contractor, design engineer and geotechnical engineer must attend the meeting. At this meeting, the limits of the engineered fill will be defined. The contractor must make known where all fill material will be obtained from and samples must be provided to the geotechnical engineer for review, and approval before filling begins.
2. Detailed drawings indicating the lower boundaries as well as the upper boundaries of the engineered fill must be available at the site meeting and be approved by the geotechnical engineer.
3. The building footprint and base of the pad, including basements, garages, etc. must be defined by offset stakes that remain in place until the footings and service connections are all constructed. Confirmation that the footings are within the pad, service lines are in place, and that the grade conforms to drawings, must be obtained by the owner in writing from the surveyor and DS Consultants Ltd (DS). Without this confirmation no responsibility for the performance of the structure can be accepted by DS. Survey drawing of the pre and post fill location and elevations will also be required.
4. The area must be stripped of all topsoil and fill materials. Subgrade must be proof-rolled. Soft spots must be dug out. The stripped native subgrade must be examined and approved by a DS engineer prior to placement of fill.

5. The approved engineered fill material must be compacted to 100% Standard Proctor Maximum Dry Density throughout. Engineered fill should not be placed during the winter months. Engineered fill compacted to 100% SPMDD will settle under its own weight approximately 0.5% of the fill height and the structural engineer must be aware of this settlement. In addition to the settlement of the fill, additional settlement due to consolidation of the underlying soils from the structural and fill loads will occur and should be evaluated prior to placing the fill.
6. Full-time geotechnical inspection by DS during placement of engineered fill is required. Work cannot commence or continue without the presence of the DS representative.
7. The fill must be placed such that the specified geometry is achieved. Refer to the attached sketches for minimum requirements. Take careful note that the projection of the compacted pad beyond the footing at footing level is a minimum of 2 m. The base of the compacted pad extends 2 m plus the depth of excavation beyond the edge of the footing.
8. A bearing capacity of 75 kPa at SLS (112.5 kPa at ULS) can be used provided that all conditions outlined above are adhered to. A minimum footing width of 500 mm (20 inches) is suggested and footings must be provided with nominal steel reinforcement.
9. All excavations must be done in accordance with the Occupational Health and Safety Regulations of Ontario.
10. After completion of the engineered fill pad a second contractor may be selected to install footings. The prepared footing bases must be evaluated by engineering staff from DS prior to footing concrete placements. All excavations must be backfilled under full time supervision by DS to the same degree as the engineered fill pad. Surface water cannot be allowed to pond in excavations or to be trapped in clear stone backfill. Clear stone backfill can only be used with the approval of DS.
11. After completion of compaction, the surface of the engineered fill pad must be protected from disturbance from traffic, rain and frost. During the course of fill placement, the engineered fill must be smooth-graded, proof-rolled and sloped/crowned at the end of each day, prior to weekends and any stoppage in work in order to promote rapid runoff of rainwater and to avoid any ponding surface water. Any stockpiles of fill intended for use as engineered fill must also be smooth-bladed to promote runoff and/or protected from excessive moisture take up.
12. If there is a delay in construction, the engineered fill pad must be inspected and accepted by the geotechnical engineer. The location of the structure must be reconfirmed that it remains within the pad.
13. The geometry of the engineered fill as illustrated in these General Requirements is general in nature. Each project will have its own unique requirements. For example, if perimeter sidewalks are to be constructed around the building, then the projection of the engineered fill beyond the foundation wall may need to be greater.
14. These guidelines are to be read in conjunction with DS Consultants Ltd report attached.

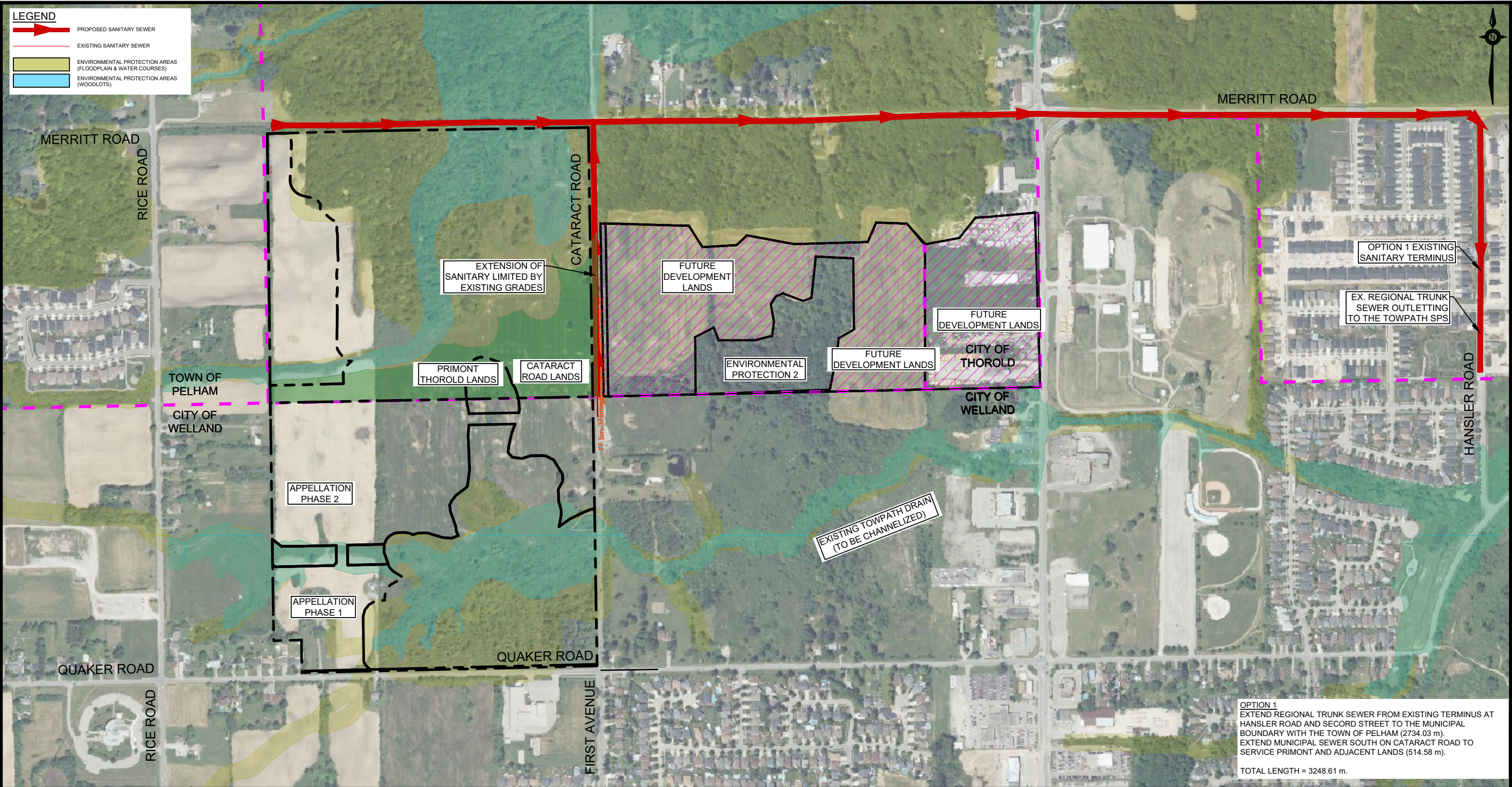


* Backfill in this area to be as per the DSCL report.

APPENDIX D

External Servicing Concepts

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PROJECT:
CATARACT ROAD LANDS

TITLE:
SANITARY CONCEPT PLAN - OPTION 1
EXTENSION OF REGIONAL SANITARY SEWER

REPRODUCTION OR DISTRIBUTION FOR PURPOSES OTHER THAN AUTHORIZED BY WALTERFEDY IS FORBIDDEN.
CONTRACTORS SHALL VERIFY AND BE RESPONSIBLE FOR ALL DIMENSIONS AND CONDITIONS ON THE JOB AND
REPORT ANY VARIATIONS FROM THE DIMENSIONS AND CONDITIONS SHOWN ON DRAWINGS TO WALTERFEDY.
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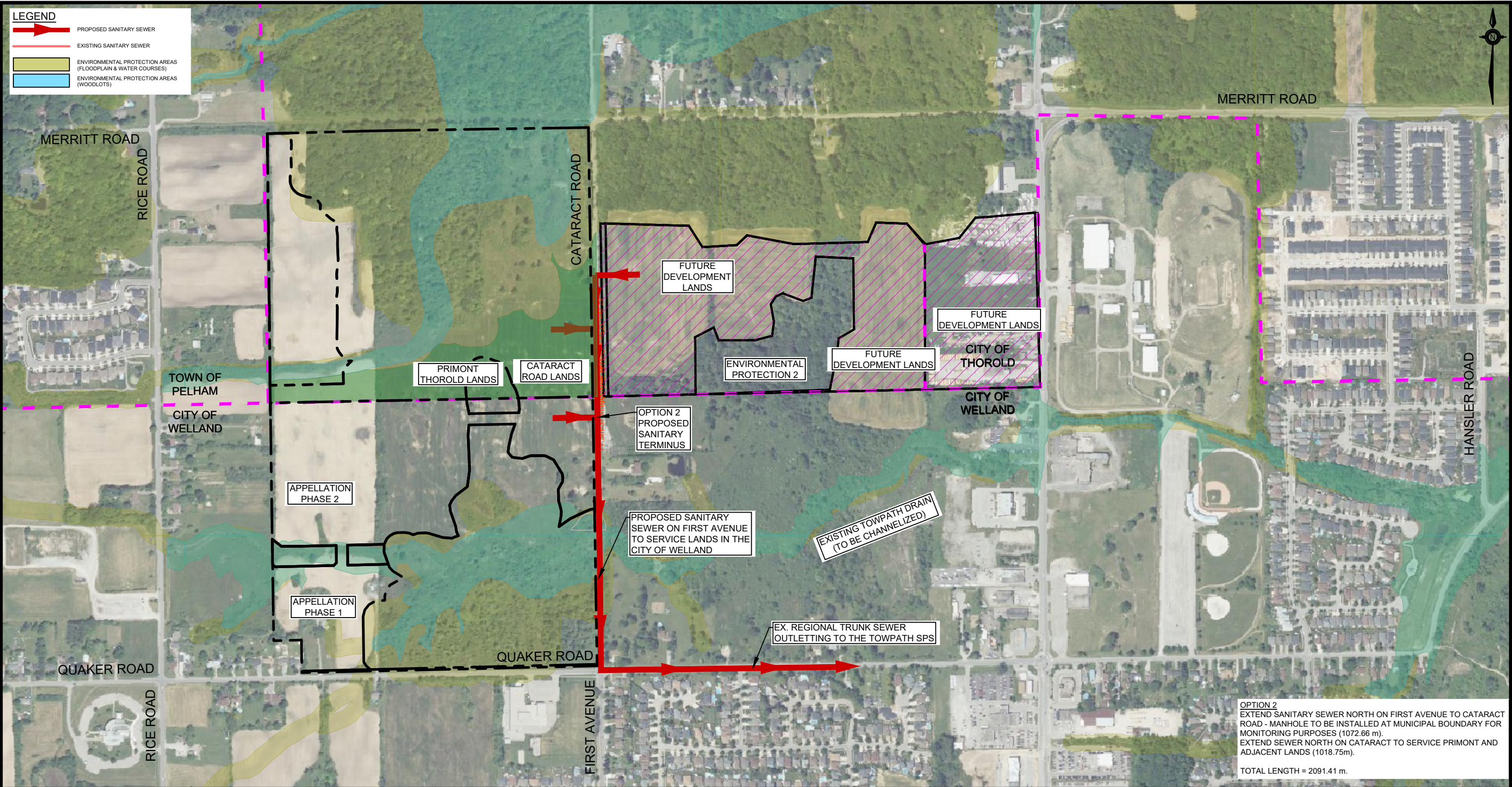
WALTERFEDY

KITCHENER OFFICE
675 Queen Street South, Suite 111, Kitchener, Ontario N2M 1A1
T: 519.576.2150 F: 519.576.5499 walterfedy.com

SCALE:	1:7000	DATE:	2026-01-20
DRAWN BY:	AM/JM	PROJECT NO.:	2022-0091-10
CHECKED BY:	ES	FILE:	2022-0091-10_SAN_Concept

SHEET NO.:
C802

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OPTION 2
EXTEND SANITARY SEWER NORTH ON FIRST AVENUE TO CATARACT ROAD - MANHOLE TO BE INSTALLED AT MUNICIPAL BOUNDARY FOR MONITORING PURPOSES (1072.66 m).
EXTEND SEWER NORTH ON CATARACT TO SERVICE PRIMONT AND ADJACENT LANDS (1018.75m).
TOTAL LENGTH = 2091.41 m.

PROJECT:
CATARACT ROAD LANDS

TITLE:
SANITARY CONCEPT PLAN - OPTION 2
EXTENSION OF REGIONAL SANITARY SEWER

REPRODUCTION OR DISTRIBUTION FOR PURPOSES OTHER THAN AUTHORIZED BY WALTERFEDY IS FORBIDDEN.
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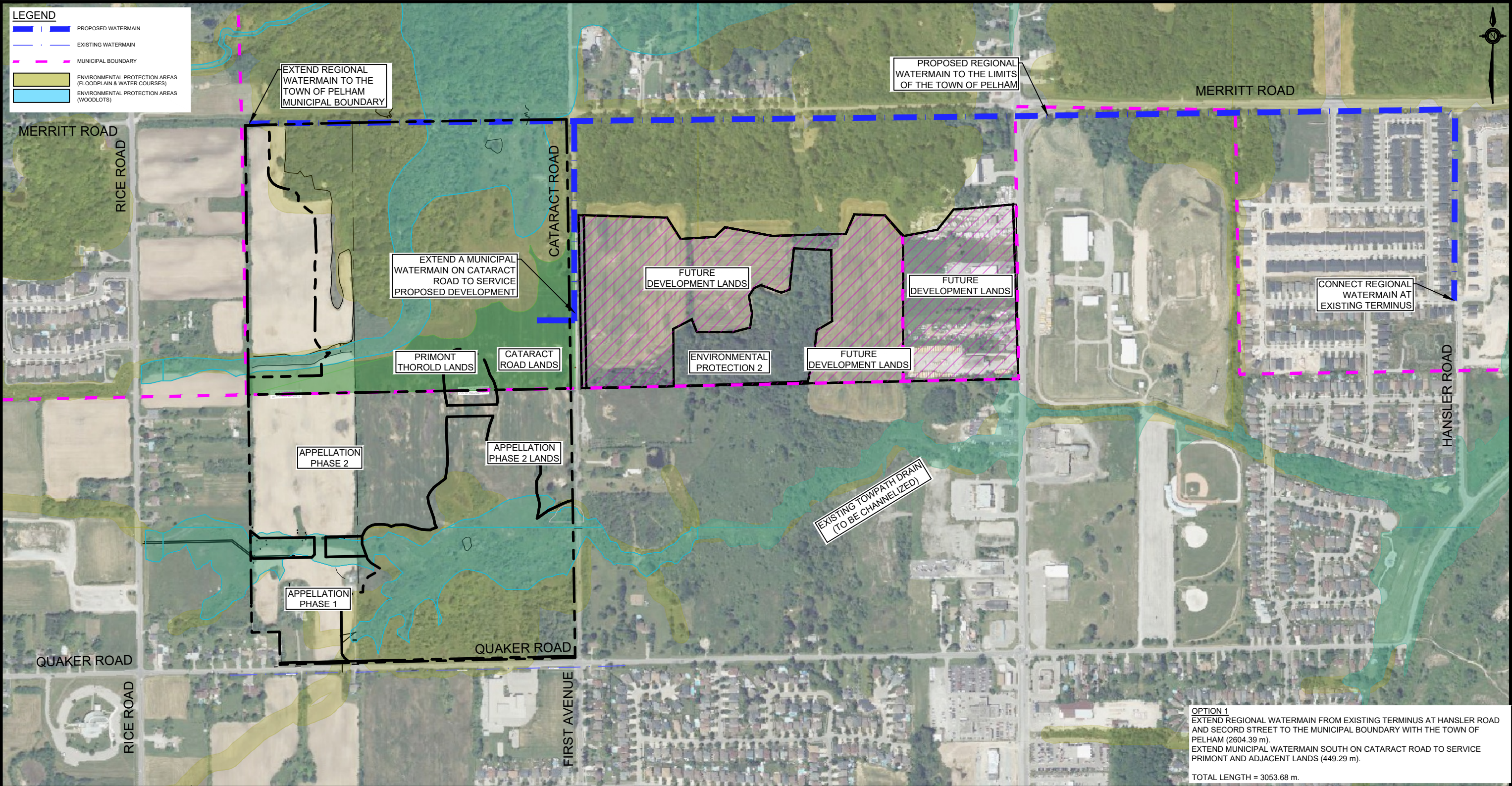
WALTERFEDY

KITCHENER OFFICE
675 Queen Street South, Suite 111, Kitchener, Ontario N2M 1A1
T: 519.576.2150 F: 519.576.5499 walterfedy.com

SCALE: 1:7000	DATE: 2026-01-20
DRAWN BY: AM/JM	PROJECT NO.: 2022-0091-10
CHECKED BY: ES	FILE: 2022-0091-10_SAN_Concept

SHEET NO.:
C803

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PROJECT:
CATARACT ROAD LANDS

TITLE:
WATERMAIN CONCEPT PLAN - OPTION 1
EXTENSION OF REGIONAL WATERMAIN

REPRODUCTION OR DISTRIBUTION FOR PURPOSES OTHER THAN AUTHORIZED BY WALTERFEDY IS FORBIDDEN.
CONTRACTORS SHALL VERIFY AND BE RESPONSIBLE FOR ALL DIMENSIONS AND CONDITIONS ON THE JOB AND
REPORT ANY VARIATIONS FROM THE DIMENSIONS AND CONDITIONS SHOWN ON DRAWINGS TO WALTERFEDY.
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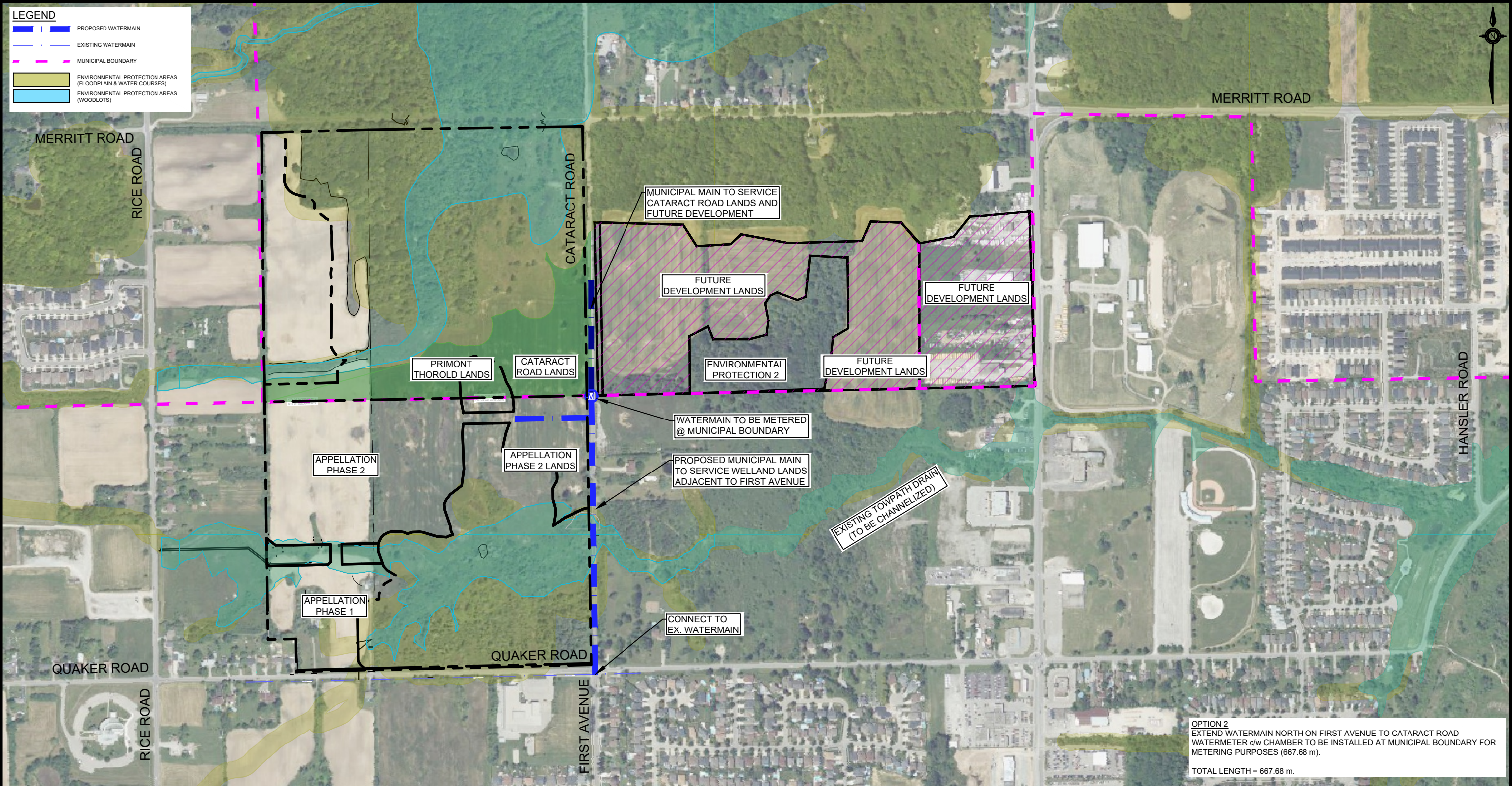
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PROJECT:
CATARACT ROAD LANDS

TITLE:
WATERMAIN CONCEPT PLAN - OPTION 2
EXTENSION OF REGIONAL WATERMAIN

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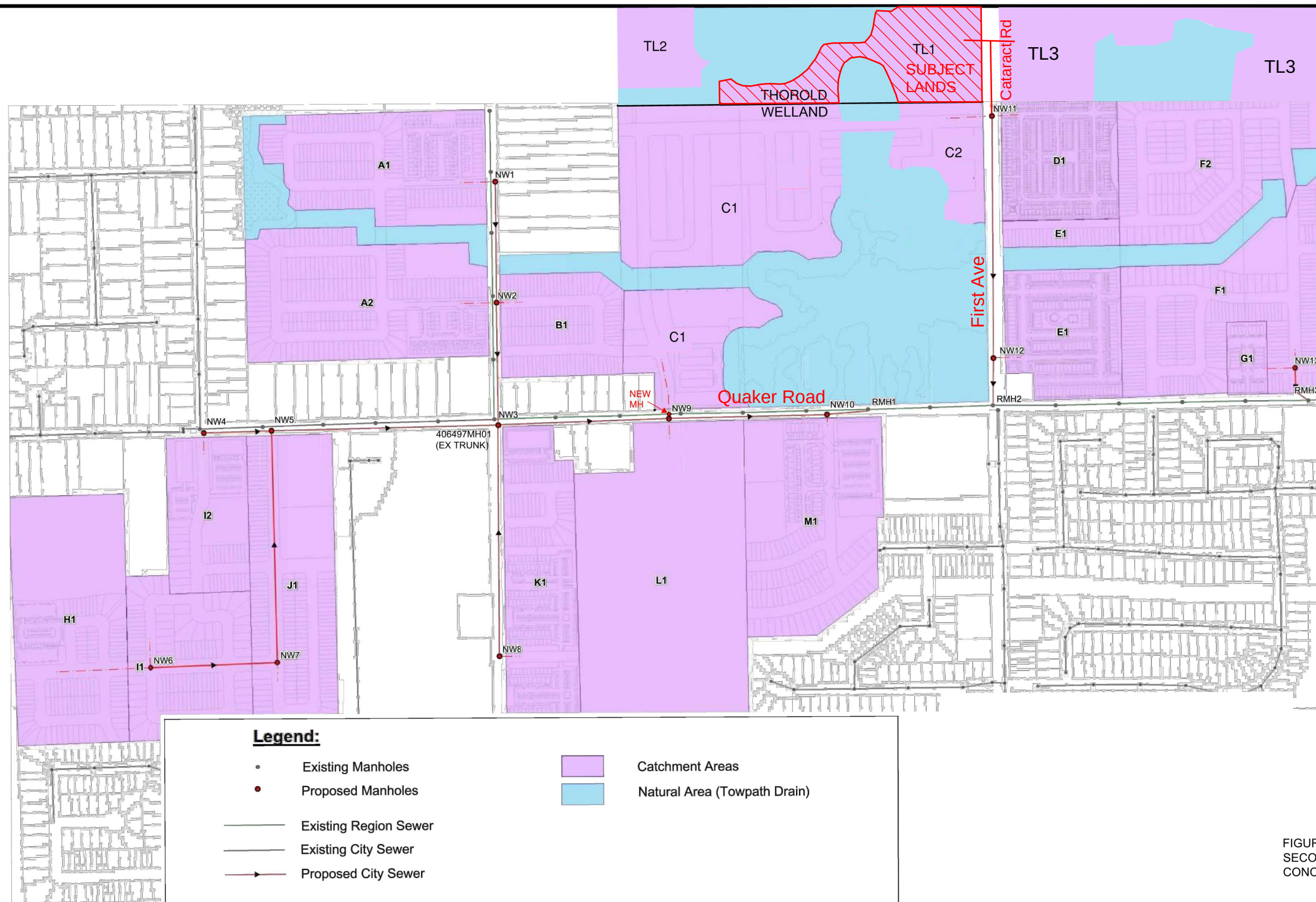
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C805

APPENDIX E

Sanitary Sewer Design Sheets for Quaker Road Trunk Sewer



PROJECT:
PRIMONT
436 QUAKER ROAD WELLAND

TITLE: NORTHWEST SECONDARY PLAN MUNICIPAL SERVICING
SANITARY SEWER DESIGN (WITH ADDITIONAL THOROLD LANDS)

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FIGURE 1

APPENDIX F

City of Welland Water Modelling



Issue Date:	August 25, 2025	Reference/Project No.:	2025-5893
To:	Tolga Aydin, C.E.T.	Previous Issue Date:	June 18, 2025
From:	Andrea LaPlante, P.Eng.		
Client:	City of Welland		
Project Name:	City of Welland - Modelling Assignments 2025		
Subject:	Water Modelling - 436 Quaker Road, Phase 1 Development, City of Welland (Assignment-006)		

1 INTRODUCTION

Associated Engineering (AE) was retained by City of Welland (City) to conduct hydraulic assessments for the development applications for the year 2025 on their behalf. In response to the City's request, this memo evaluates the municipal servicing requirements for the proposed development located at 436 Quaker Road – Phase 1 of a two-phase development. Phase 1 extends from the north side of the Towpath Drain channel block south to Quaker Road. Phase 2 will include the lands north of the Towpath Drain up to the Welland city limits. This assignment only covers the Phase 1 development. A proposed site layout for the proposed subdivision prepared by A.T. McLaren Limited is attached in **Appendix A**.

As indicated in the FSR prepared by WalterFedy, the subject land is proposed to be developed into a residential subdivision consisting of 155 single-detached dwellings, 155 street townhouses, and a 40-unit condominium townhouse block. Based on the draft plan prepared by A.T. McLaren Limited, the total area of the development is approximately 30.13 hectares.

This assignment is the fourth in the sequence of development applications received from the City in 2025 within the NWSP area and is referred to as Assignment-006. The objective of this assessment is to confirm the required pipe sizes for the major watermain loop, as well as the internal watermain sizing for Phase 1 of the development.

As part of the Northwest Welland Secondary Plan, a “Municipal Servicing Conceptual Design Report”¹ was prepared by AE in 2024. This report outlines a conceptual framework for the future NWSP area, detailing the proposed water service requirements and the necessary upgrades to support the NWSP development. The proposed development at 436 Quaker Road has been reviewed and assessed based on the information outlined in the Functional Servicing Report (FSR, February 2024) by WalterFedy.

Figure 1-1 shows the location of the proposed development along with the existing watermains surrounding the site.

¹ Northwest Welland Secondary Plan, Municipal Servicing Conceptual Design Report, AE, June 2024.



Memo To: Tolga Aydin, City of Welland

August 25, 2025

Page 2

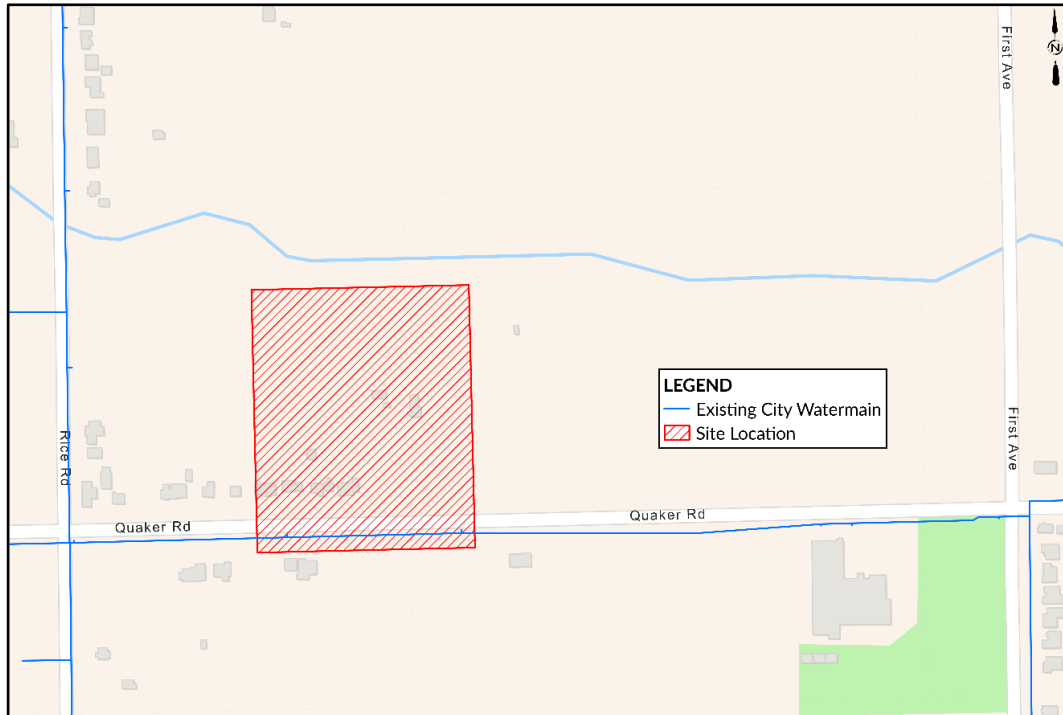


Figure 1-1 Site Location

2 BACKGROUND AND MODEL SET UP

2.1 Existing Distribution System and Model

The City's water distribution system receives potable water from the Regional Municipality of Niagara (the Region). The system includes the Welland Water Treatment Plant (WTP), Shoalt's Reservoir, Bemis Elevated Tank, and Hunter's Pointe Booster Pumping Station (BPS). The majority of the City's distribution network, including the proposed development at 436 Quaker Road is part of a single pressure zone, with system pressures regulated by the water level in the Bemis Tank, which has a maximum hydraulic grade line (HGL) of 219.1 m. A small portion of the City, located at higher elevations, receives boosted water via the Hunter's Pointe BPS. Additionally, the Welland distribution system extends beyond the City limits, providing water to the Town of Pelham (through the Shoalt's Pumping Station) and portions of Thorold (via the Hansler Road and Port Robinson West watermain connections).

The City's hydraulic model is maintained as an all-pipe InfoWater model for the water distribution system. AE recently updated the model prior to these assignments. The same model used for the 575 Quaker Road project (Assignment-005) was applied to this assignment and includes the recommended watermain infrastructure for the 469–509 Rice Road, 450 Rice Road, and 575 Quaker Road developments.



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August 25, 2025
Page 3

The City's InfoWater model includes both existing and future (interim and Full Buildout) average day and maximum day extended period simulation (EPS) scenarios. The interim and Full Buildout future scenarios incorporate known planned future growth in the City including NWSP. The future scenario model has been used to conduct the hydraulic analysis for the subject site.

2.2 Existing Site Servicing

The subject site is located in the northwestern quadrant of the intersection of Quaker Road and First Avenue, within the City of Welland. The lands are bounded by existing and future residential developments to the west, Quaker Road to the south, First Avenue to the east, and the municipal boundary between Welland and Thorold to the north.

2.3 Proposed Site Servicing

No pipe layout and sizes were provided by WalterFedy in the Functional Servicing Report. As per AE's "Municipal Servicing Conceptual Design" report for the NWSP, a 300mm diameter watermain is recommended through the subject site. To validate this recommendation against the most recent layout proposed by A.T. McLaren Limited, a 300mm diameter watermain was applied for the major loop through the subject land, with 200mm and 150mm diameters selected for internal watermains, as requested by the City. These proposed pipe sizes and alignments were added to the hydraulic model based on the site layout prepared by A.T. McLaren Limited included in FSR, dated February 2024.

Figure 2-1 shows the proposed watermain infrastructure and junctions within the subject site, along with the existing site infrastructure surrounding the site.

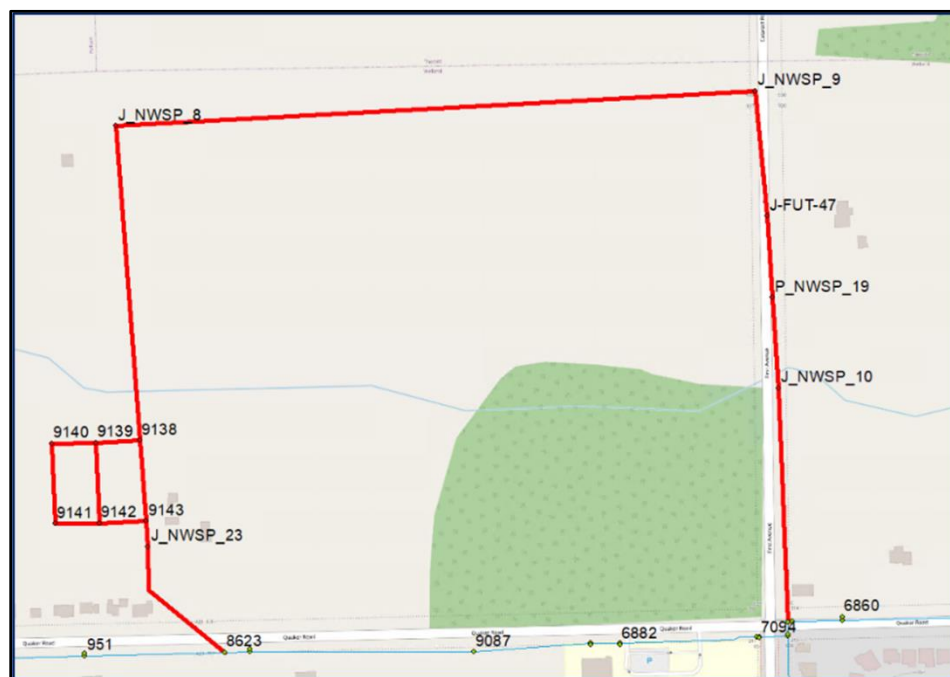


Figure 2-1 Proposed Pipe Layout and Junctions

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August 25, 2025

Page 4

All proposed watermain were assigned a C-Factor of 135 in the model. Junction elevations within the subject site were determined based on the surrounding elevations. Refer to Section 3.2 for the watermain sizing that were assessed as part of the analysis.

2.4 Site Water Demand

The FSR provided the total number of units and population for the full buildout of the subject land. To estimate the number of units located within the Phase 1 boundary, the draft plan prepared by A.T. McLaren Limited was reviewed. The total area of low-density residential blocks (Blocks 2-5, 12-19, 21-23, 25-27, 30, 31, and 34) is 6.812 hectares, with a total of 289 units. This results in a rate of approximately 43 units per hectare (289 units / 6.812 hectares), which was used to estimate the number of units within Phase 1.

Phase 1 includes Blocks 1 to 9, but only Blocks 2, 3, 4, and 5 are designated for residential use. Their areas and estimated number of units based on the rate of 43 units/hectare are as follows:

- Block 2 = 0.33 ha → 14 units
- Block 3 = 0.63 ha → 27 units
- Block 4 = 0.18 ha → 8 units
- Block 5 = 0.19 ha → 8 units

Total estimated units within the Phase 1 boundary = 57 units

In the Functional Servicing Report, WalterFedy used a per capita water demand of 320 L/capita/day to estimate average day demands. Peaking factors of 1.5 and 2.81 were applied for Maximum Day and Peak Hour demands, respectively (as shown in Table 6.1 of the FSR). This resulted in demand estimates of 3.01 L/s (ADD), 4.5 L/s (MDD), and 8.5 L/s (PHD). However, the City uses a lower per capita demand rate of 240 L/capita/day based on historical usage data. Therefore, the water demands for the 57 units were re-estimated using the City's design criteria, as outlined below.

- Populations were estimated assuming 2.75 persons/household
- Average day demands (ADD) were calculated using a per capita demand of 240 L/cap-day (as per a 2022 review of historic per capita demand rates for the City by land use type)
- Maximum day demands (MDD) were calculated using a peaking factor of 1.5 (as per a 2022 review of historic daily usage)
- Peak hour demands (PHD) were calculated using a peaking factor of 2.81 for residential units.

Table 2-1 below summarizes the estimated units within Phase 1 with the corresponding population along with their ADD, MDD and PHD demands. It is important to note that the demands calculated using the City's design criteria result in lower demands values compared to those proposed by WalterFedy in the Functional Servicing Report.

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August 25, 2025
Page 5

Table 2-1 Projected Future Demands

Development Site within Block 5	Proposed Development Units (as evaluated by AE)	Estimated Population	ADD (L/s)	MDD (L/s)	PHD (L/s)
Total Units	57	156	0.43	0.65	1.22

Proposed water demands were allocated in the model using closest junction. A summary of the allocated demands is provided in **Table 2-2** below.

Table 2-2 Model Demand Allocation

Development Site	Junction IDs	ADD (L/S)	MDD (L/S)	PHD (L/S)
Phase 1	9139	0.06	0.08	0.15
	9140	0.10	0.15	0.28
	9141	0.06	0.08	0.15
	9142	0.11	0.17	0.31
	J_NWSP_23	0.11	0.17	0.31
Total		0.43	0.65	1.21

A fire flow scenario was also assessed under MDD plus fire flow conditions to evaluate system capacity. As shown in the layout plan prepared by A.T. McLaren Limited (**Appendix A**), Blocks 2, 3, 4, and 5—located within Phase 1—are designated as low-density residential. If these blocks consist only of single-family or semi-detached homes, the minimum required fire flow would be 67 L/s, in accordance with City criteria. However, if they include townhouses or condominium units, a minimum fire flow of 133 L/s must be met. For the purposes of this memo, a fire flow requirement of 133 L/s was assumed.

3 HYDRAULIC ANALYSIS

3.1 Watermain Requirements

The following pressure requirements were used for the hydraulic analysis, as per City of Welland design standards and the MECF Design Guidelines for Drinking Water Systems:



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August 25, 2025

Page 6

- Preferred system pressure between 350 to 550 kPa (50 to 80 psi)
- Minimum system pressure during normal operating conditions to be greater than 275 kPa (40 psi)
- Maximum system pressure during normal operating conditions to be less than 700 kPa (100 psi)
- System pressure with 133 L/s or 67 L/s fire flow during MDD to be greater than 140 kPa (20 psi)
- Maximum velocity of 1.5 m/s during normal operations
- Maximum velocity of 3.5 m/s during emergency operations (including fire, under MDD conditions)

3.2 Servicing Scenarios

As outlined in Section 2.3, the initial water modeling followed the recommendations from AE's "Municipal Servicing Conceptual Design Report," which included implementing a 300mm watermain loop within the Phase 1 boundary to connect to the existing 300mm watermain on Quaker Road.

Three servicing scenarios (A, B, and C) were initially modeled as part of the preliminary assessment to evaluate system performance under various configurations. These scenarios were developed prior to the recent design criteria update.

Following the City's request to revise the maximum allowable velocity from 2.5 m/s to 3.5 m/s under emergency (fire flow) conditions, **Scenario A** and **B** were updated and reassessed using this new criterion.

- **Scenario A:** A 300mm watermain within the Phase 1 limits, with 200mm and 150mm watermains along the internal streets, as shown in **Figure 3-1**.

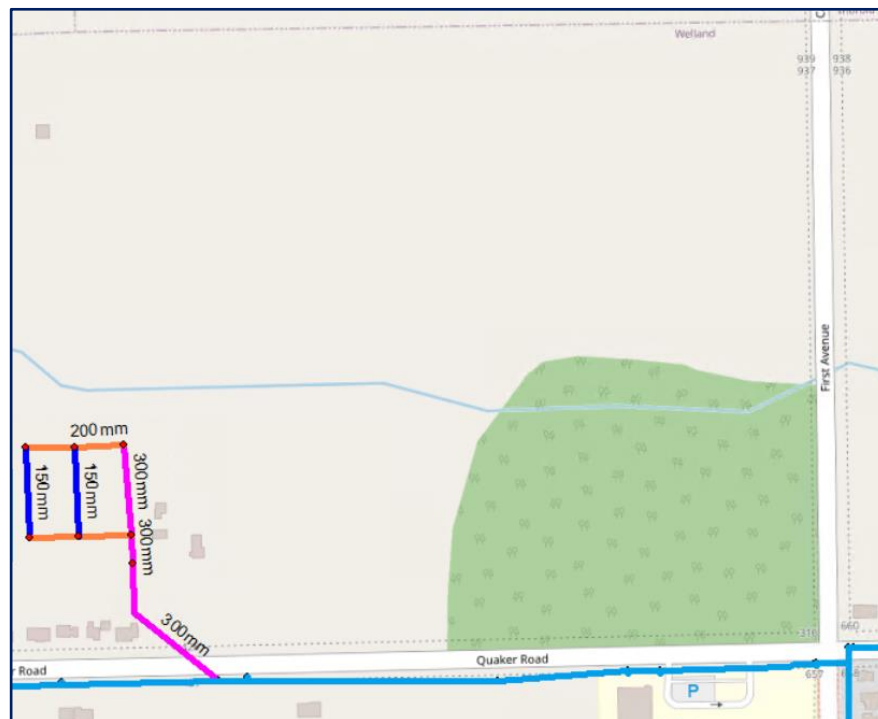


Figure 3-1

Proposed Watermain Sizing for Scenario A



Memo To: Tolga Aydin, City of Welland

August 25, 2025

Page 7

- **Scenario B:** Scenario A plus a 300 mm loop connecting to First Avenue and then to Quaker Road, as shown in Figure 3-2.

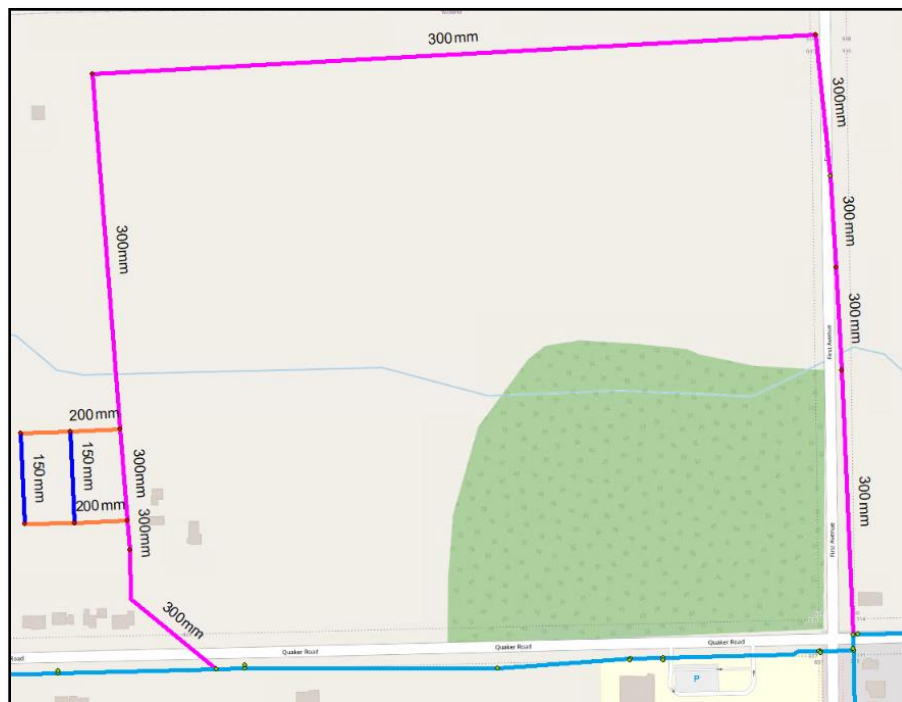


Figure 3-2 Proposed Watermain Sizing for Scenario B

3.3 Normal Condition Results

Refer to **Figure 2-1** for the locations of the junctions referenced in Table 3-1, 3-2 and 3-3, which are provided at the end of this section.

3.3.1 Average Day and Maximum day

Table 3-1, provided at the end of this section, summarizes the minimum pressures during ADD EPS within the proposed development at 436 Quaker Road (Phase 1) of the NWSP area for each of the servicing scenarios that were outlined in Section 3.2.

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August 25, 2025
Page 8

As shown, in both servicing Scenario A and B, the minimum pressures at nodes within the development meet the City's minimum design pressure criterion of 275 kPa under both ADD conditions.

3.3.2 Maximum day

Table 3-2, attached at the end of this section, summarizes the minimum pressures during MDD EPS within the proposed development site of the NWSP area for each of the servicing scenarios outlined in Sections 3.2.

As shown in Table 3-2, the nodes within the proposed development site at 436 Quaker Road (Phase 1) meets the minimum pressure criteria of 275 kPa in both servicing scenarios.

3.4 Fire Flow

Table 3-3 summarizes the available fire flow within the Phase 1 boundary of the proposed development site of the NWSP area for each of the servicing scenarios that were outlined in Section 3.2.

These values reflect the maximum achievable flow during Maximum Day Demand (MDD) conditions while maintaining a minimum residual pressure of 140 kPa (20 psi) and complying with the City's maximum velocity limit of 3.5 m/s. As shown in the table, all junctions within the Phase 1 limits achieve the minimum required fire flow of 133 L/s.

3.5 Watermain Velocity Review

A review of the velocities for the revised Scenario A and B were conducted to confirm the adequacy of the proposed watermain sizing for servicing the development. As per the City's updated design criteria, the maximum allowable velocity is 3.5 m/s during MDD and fire flow conditions.

In all scenarios, the maximum velocity during ADD conditions remained below the 1.5 m/s limit. Under MDD and fire flow conditions, all junctions achieved the minimum required fire flow of 133 L/s, with the resulting velocities remaining within the acceptable limit of 3.5 m/s.

Table 3-1 Minimum Pressure during ADD

Junctions	Scenario A Min Pressure (Kpa)	Scenario B Min Pressure (Kpa)
8623	336	334
J-NWSP-23	337	335
9138	332	330
9139	327	325



Memo To: Tolga Aydin, City of Welland

August 25, 2025

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Junctions	Scenario A Min Pressure (Kpa)	Scenario B Min Pressure (Kpa)
9140	327	325
9141	327	325
9142	327	325
9143	336	334
J-NWSP-8	-	315
J-NWSP-9	-	335
J-FUT-47	-	334
P-NWSP-19	-	336
J-NWSP-10	-	338
1404	-	343

Table 3-2 Minimum Pressure during MDD

Junctions	Scenario A Min Pressure (Kpa)	Scenario B Min Pressure (Kpa)
8623	324	321
J-NWSP-23	325	322
9138	320	317
9139	315	312
9140	315	312
9141	315	312
9142	315	312
9143	324	321
J-NWSP-8	-	302
J-NWSP-9	-	321
J-FUT-47	-	320



Memo To: Tolga Aydin, City of Welland

August 25, 2025

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Junctions	Scenario A Min Pressure (Kpa)	Scenario B Min Pressure (Kpa)
P-NWSP-19	-	322
J-NWSP-10	-	324
1404	-	329

Table 3-3 Available Fire Flow during MDD

Junctions	Scenario A (L/s)	Scenario B (L/s)
8623	237	322
J-NWSP-23	218	311
9138	203	301
9139	174	167
9140	151	149
9141	149	149
9142	163	166
9143	214	308
J-NWSP-8	-	279
J-NWSP-9	-	308
J-FUT-47	-	318
P-NWSP-19	-	329
J-NWSP-10	-	340
1404	-	415

4 CONCLUSIONS AND RECOMMENDATIONS

Scenario A and B were assessed for the proposed development at 436 Quaker Road (Phase 1) to determine the appropriate watermain sizing for future municipally owned infrastructure. These scenarios were reassessed based on the City's updated design criterion, which sets the maximum allowable velocity at 3.5 m/s under fire flow conditions.

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August 25, 2025
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The hydraulic analysis confirms that both Scenario A and Scenario B provide adequate system pressures above the City's minimum requirement of 275 kPa during normal operating conditions under both ADD and MDD. Under fire flow conditions, all junctions within the Phase 1 boundary achieve at least 133 L/s without exceeding the maximum velocity limit of 3.5 m/s. Based on the available fire flow results provided in **Table 3-3**, it is recommended to implement the internal street watermains sized at 200 mm and 150 mm as shown in **Figure 3-1**. The implementation of the main loop— either fully, as per Scenario B, or partially, as per Scenario A—depends on the required fire flow to be met; however, both scenarios satisfy the minimum requirements.

It is important to note that if all internal pipes are reduced to 150 mm, the system cannot achieve the minimum required fire flow of 133 L/s. As a result, that configuration was not presented as a viable servicing scenario.

Prepared by:

P.Hadipour August 25, 2025

Pegah Hadipour, P.Eng.
Civil Infrastructure Engineer
[PH/AL]

Reviewed by:



Andrea LaPlante, P.Eng.
Manager, Civil Infrastructure



Attachment: Appendix A – Site Layout and Phasing Plan



**Associated
Engineering**

*GLOBAL PERSPECTIVE.
LOCAL FOCUS.*

TECHNICAL MEMORANDUM

Memo To: Tolga Aydin, City of Welland

August 25, 2025

Page 12

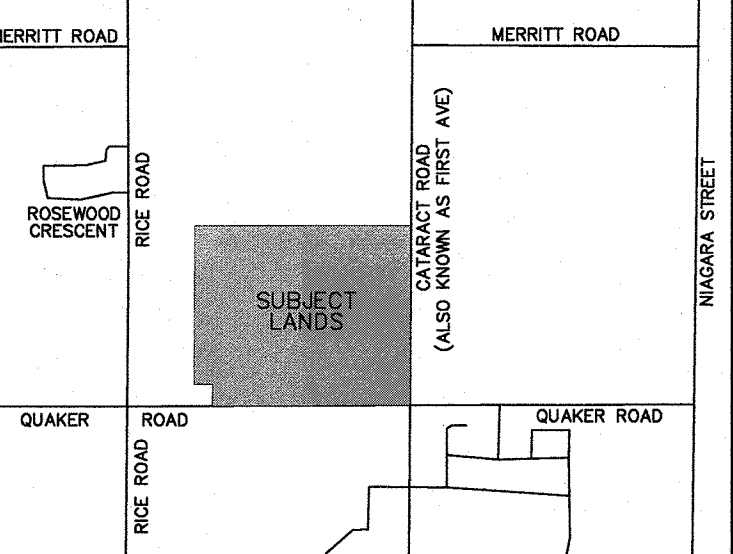
Appendix A

DRAFT PLAN
OF SUBDIVISION

PRIMONT
(THOROLD / WELLAND) INC.

PART OF TOWNSHIP LOTS 174 AND 228,
GEOGRAPHIC TOWNSHIP OF THOROLD,
IN THE CITY OF WELLAND, REGIONAL
MUNICIPALITY OF NIAGARA

SCALE 1:1000 METRIC



KEY MAP - NOT TO SCALE

INFORMATION REQUIRED
UNDER SECTION 54 (17) OF THE PLANNING ACT, R.S.O. 1990, c.P.13
AS AMENDED FEBRUARY 21, 2024

- (a) - AS SHOWN
(b) - AS SHOWN
(c) - AS SHOWN
(d) - AS LISTED BELOW
(e) - AS SHOWN
(f) - AS SHOWN
(g) - AS SHOWN
(h) - MUNICIPAL WATER
(i) - CLAY LOAM
(j) - AS SHOWN
(k) - MUNICIPAL SANITARY AND STORM SEWERS
(l) - AS SHOWN

SURVEYOR'S CERTIFICATE
I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LANDS TO BE
SUBDIVIDED ON THIS PLAN AND THEIR RELATIONSHIP TO THE
ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

SIGNED
ROB A. McLAREN O.L.S.
A.T. McLAREN LIMITED
DATE 30 JAN 2025

OWNER'S CERTIFICATE
I HEREBY CONSENT TO THE FILING OF THIS PLAN

SIGNED
JOE MONTESANO
DATE January 30, 2025

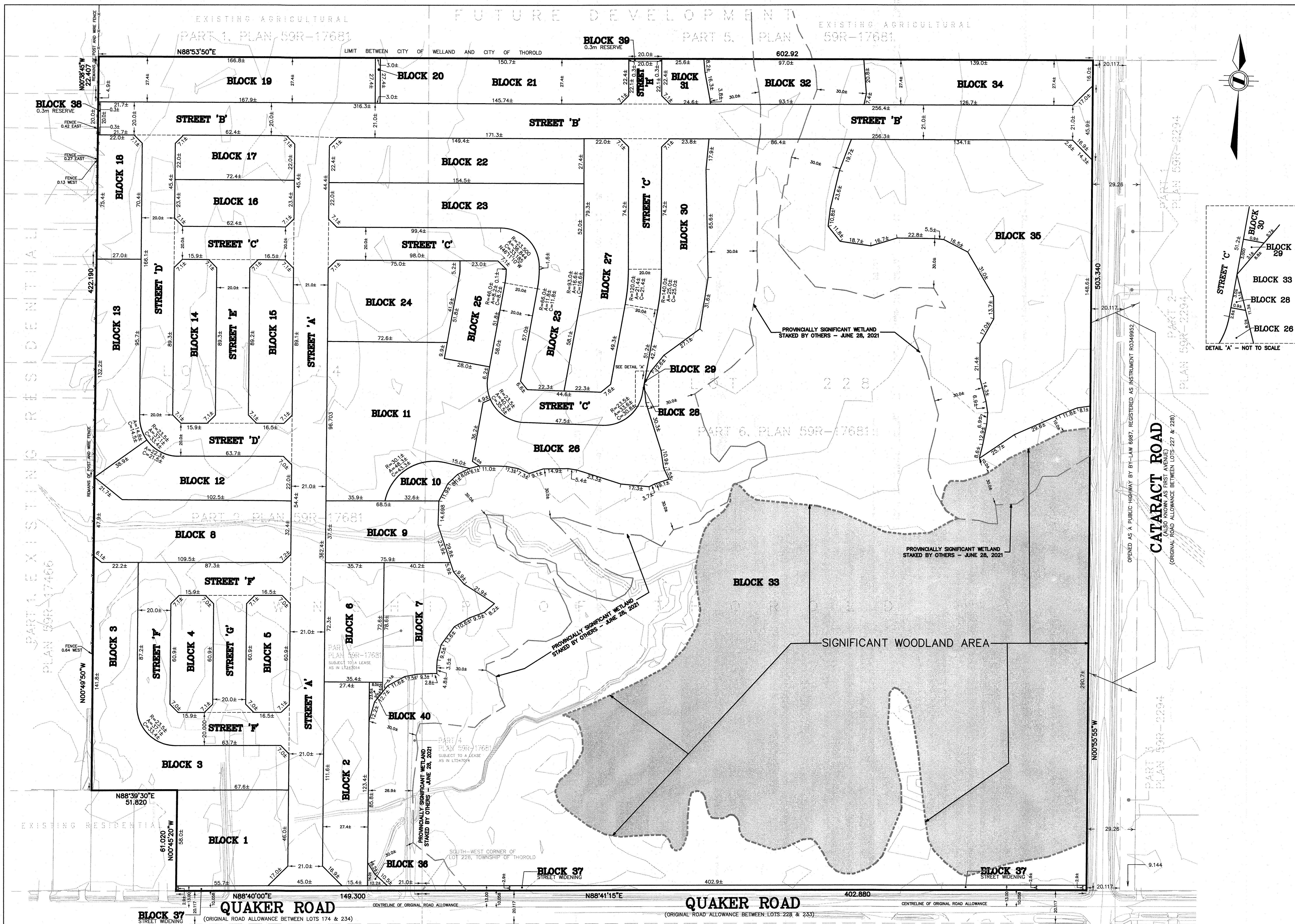
LAND USE SCHEDULE			
LAND USE	LOTS/BLOCKS	UNITS	AREA
LOW DENSITY RESIDENTIAL (FREEHOLD)	BLOCKS 2-5, 12-19, 21-23, 25-27, 30, 31 & 34	289±	6.812± Ha.
MEDIUM DENSITY RESIDENTIAL (CONDOMINIUM)	BLOCK 35	70-300±	1.678± Ha.
PARK LAND / PARKETTE	BLOCKS 1, 20, 24, 28 & 29		0.759± Ha.
OPEN SPACE & BUFFER	BLOCKS 7, 10, 36, & 40		0.410± Ha.
STORM WATER MANAGEMENT	BLOCKS 6 & 11		1.019± Ha.
ENVIRONMENTAL AREA	BLOCKS 32 & 33		13.833± Ha.
CHANNEL	BLOCKS 8 & 9		0.725± Ha.
ROADS, RESERVES & WIDENINGS	STREETS A, B, C, D, E, F, G, & H AND BLOCKS 37, 38 & 39		4.880± Ha.
TOTAL		359-589±	30.126± Ha.

No.	DESCRIPTION	DATE	BY
5	REVISED BLOCK 35 AND SCHEDULE	JAN 27, 2025	KM
4	REVISED TO MATCH NEW CONCEPT	DEC. 18, 2024	KM
3	ADDED WETLAND/WOODLAND	JULY 11, 2024	KM
2	UPDATED STORMWATER BLOCKS	JUNE 13, 2024	KM
1	ORIGINAL DRAWING	MAR. 15, 2024	KM

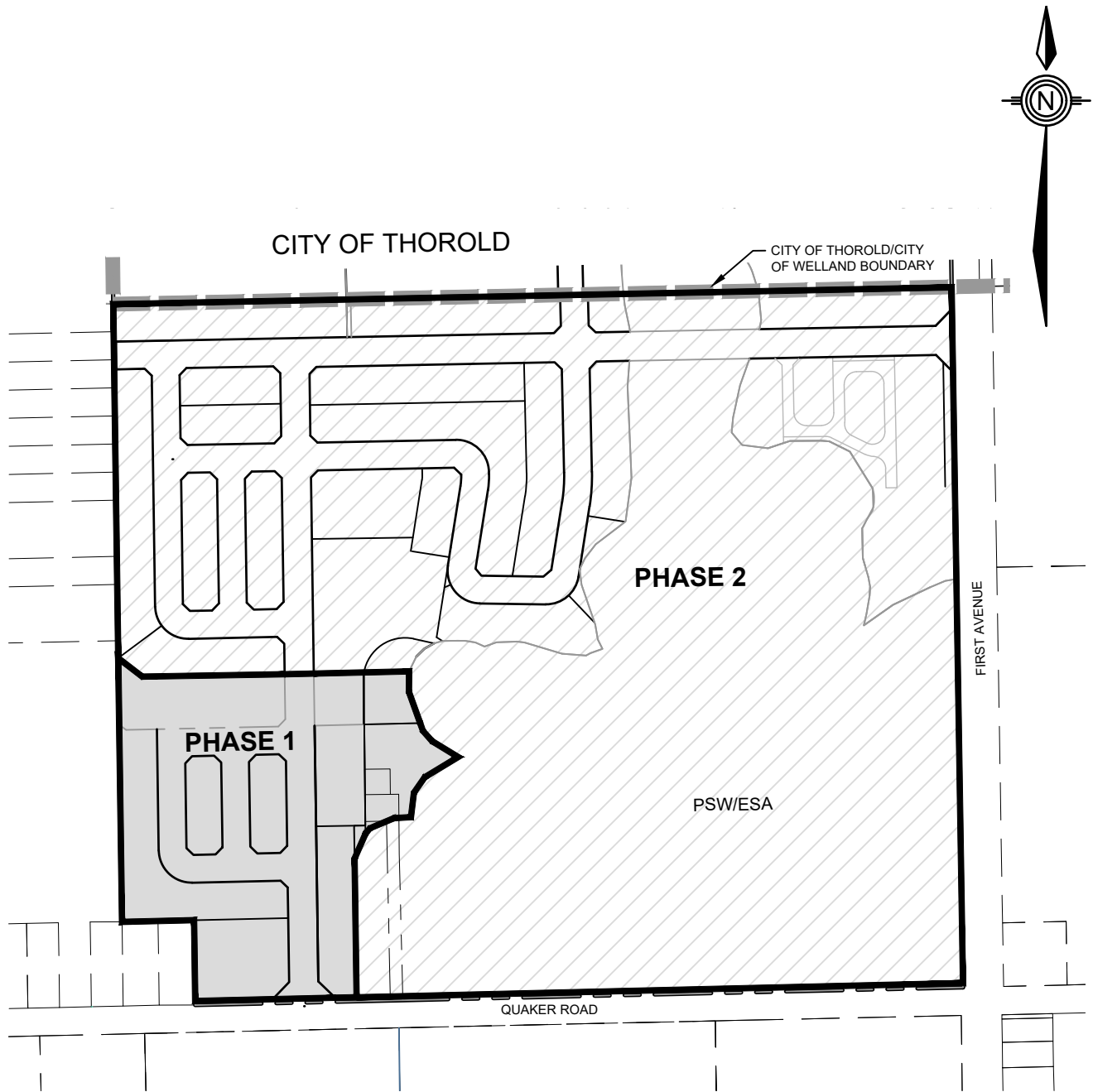
REVISIONS

A.T. McLaren Limited
LEGAL AND ENGINEERING SURVEYS
69 JOHN STREET SOUTH, SUITE 230
HAMILTON, ONTARIO, L8N 2B5
PHONE (905) 527-8559 FAX (905) 527-0032
Drawn: KM, Created: RBW, Drawn: SV, Scale: 1:1000, Drawn: KM, 36820-0P

METRIC NOTE:
DISTANCES SHOWN ON THIS PLAN ARE IN
METRES AND CAN BE CONVERTED TO FEET
BY DIVIDING BY 0.3048



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LEGEND

-  PHASE BOUNDARY
-  CITY OF THOROLD/CITY OF WELLAND BOUNDARY
-  PHASE 1
-  PHASE 2



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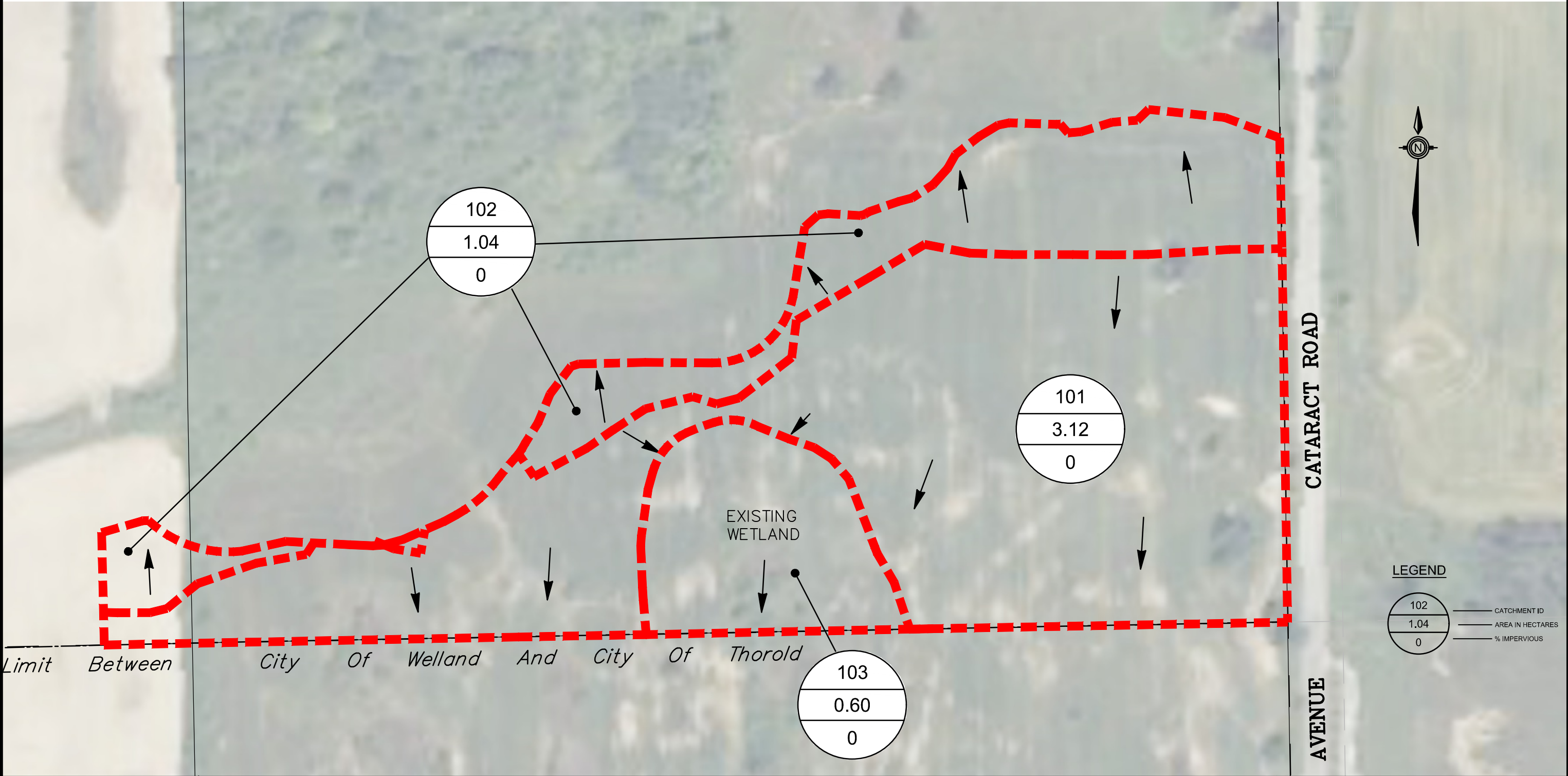
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CHECKED BY: RB	FILE: 2022-0091-10_PH_PLT
SHEET NO.:	

FIG.A

APPENDIX G

Pre-Development Storm Drainage Area Plan

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PROJECT:
CATARACT ROAD
THOROLD

TITLE:
PRE-DEVELOPMENT STORM DRAINAGE AREA PLAN
THOROLD

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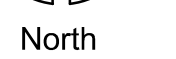
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CHECKED BY: JO	FILE: 2022-0091-10 SDAP PRE-1

SHEET NO.:
DAP1

DRAWINGS

C101 Existing Conditions Plan



DATE	ISSUANCE	NO.

	BOREHOLE No.		EXISTING BOREHOLE LOCATION
			EXISTING TREE DRIPLINE AND/OR VEGETATION LINE
			EXISTING CONTOURS
			DEVELOPABLE BOUNDARY
			ENVIRONMENT AREA
			OVERLAND FLOW ROUTE ARROW
			PROPERTY LINE LIMITS

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SCALE: 1:1250	SHEET NO.: C101
DATE: 2026-02-18	
PROJECT NO.: 2022-0091-10	
DRAWN BY: BG	
CHECKED BY: RB	

