Updated Hydrogeological Assessment, Water Balance Assessment and Source Water Protection Analysis, Erin Fairways Subdivision, 5525 Eighth Line, Town of Erin, Ontario

Prepared for:

EC (Erin) GP Inc., 125 Villarboit Crescent Vaughan, ON L4K 4K2

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September 19, 2023

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Re: Updated Hydrogeological Assessment, Water Balance Assessment and Source Water Protection Analysis, Erin Fairways Subdivision, 5525 Eighth Line, Town of Erin, ON

Dear Mr. Lefas,

EXECUTIVE SUMMARY

The Erin Fairways Subdivision is proposed for development at the Erin Heights Golf Course. A water level monitoring network of groundwater monitoring wells, and downgradient monitors of wetlands, surface water and shallow groundwater have been in operation since mid-2021 to document pre-development conditions over a period of 24 months. Site design can (i) accommodate water balance maintenance for the downgradient Provincially significant wetlands, and (ii) the protection of the nearby municipal supply well.

1.0 Introduction and Background Information

Terra-Dynamics Consulting Inc. (Terra-Dynamics) respectfully submits this updated study (previously submitted as Terra-Dynamics Consulting Inc., 2022) of the proposed Erin Fairways Subdivision (the Site, Figure 1) providing additional monitoring data and responding to comments from government review agencies (Town of Erin, 2022). This study includes (i) a Hydrogeological Assessment, (ii) a Water Balance Assessment and (iii) a Source Protection Analysis. The Site is part of a golf course and is approximately 13.9 hectares in size. The Erin Fairways Subdivision will be a municipally serviced residential development (Armstrong, 2021).

2.0 Scope of Work

A background review of available information was completed that included, but was not limited to:

1. West Credit Subwatershed Study, Characterization Report (Credit Valley Conservation (CVC), 1998);

2. Integrated Water Budget Report – Tier 2, Credit Valley Source Protection Area (AquaResource Inc., 2009);

3. WHPA Delineation and Vulnerability Assessment (Blackport Hydrogeology Inc. and Golder Associates Ltd., 2010);

4. Highly Vulnerable Aquifer Delineation, Groundwater Quality Vulnerability Analysis (CTC Source Protection Region, 2010);

5. Existing Conditions Report, Phase 1 – Environmental Component, Erin Servicing and Settlement Master Plan (CVC et al, 2011);

6. Ontario Geological Survey (OGS) surficial geology (OGS, 2003) and OGS 3-D modelling of surficial deposits (Burt and Dodge, 2016); and

7. Stormwater Management Criteria, Credit Valley Conservation (2012).

In addition, on-site investigations have been reviewed including geotechnical (DS Consultants Inc., 2021) geomorphic (GEO Morphix, 2020) and ecological (WSP, 2022).

2.1 Hydrogeological Assessment

A hydrogeological assessment was completed generally following the Conservation Authority Guidelines for Hydrogeological Assessments (Conservation Ontario, 2013) as required by the CVC (Vandermeulen, 2021). The hydrogeological assessment includes (i) a description of existing conditions, (ii) an impact assessment and (iii) recommended mitigation measures.

Downgradient features discussed in detail include:

(i) Two Provincially significant swamp wetland areas (MNRF, 1995); and

(ii) Two watercourses associated with Subwatershed 15 of the Erin Branch of the West Credit River (AquaResource Inc., 2009) with the main tributary classified as a cold-water fishery (CVC et al, 2011).

As requested by CVC (Salsberg, 2021), Subwatershed 15 West Credit River study recommendations (1998) were also considered.

2.2 Water Balance Assessment

A water balance assessment was completed as required for development of the Site (Salsburg, 2021).

Credit Valley Conservation (CVC) have specified that a “*Site-specific and features-based water balance will be required… Low Impact Development (LID) features be incorporated in the design to achieve a neutral water balance given the site is located within …* (a) *Significant Groundwater Recharge Area* (SGRA)“. Also, given the Site is almost entirely mapped as an SGRA, a “*Site specific water balance* (is) *required to identify pre-development groundwater recharge rates and distribution as well as hydrologic and ecologic functions*” (CVC, 2012).

Our water balance assessment used existing long-term modelling results of the Site completed for CVC (AquaResource Inc., 2009) with some adjustments reflecting soil conditions documented during the geotechnical investigation (DS Consultants, 2021), i.e. providing a “*more detailed hydrogeological characterization*” (CVC, 2012).

A Wetland Risk Evaluation (TRCA, 2017) was also completed.

2.3 Source Water Protection Analysis – Municipal Groundwater Supply

Development of the Site includes consideration of source water protection policies given the Town of Erin's Municipal Well E8 is located northwest of the Site, and the associated municipal wellhead protection areas (WHPAs) extend into the Site. The source water protection policies concern water quality, not water quantity (Salsburg, 2021). WHPA water quality considerations include:

A. A Section 59 Notice evaluation, i.e. as the Site includes a municipal WHPA, this requires review by the source water protection risk management officer/investigator;

B. Significant threat management discussion, specifically meeting the Town of Erin/Source Water Protection requirements for:
    i. Higher construction and operational standards for sanitary sewers and related pipes near the municipal supply well; and
    ii. Stormwater management facilities and outlets located in such a way as to prevent negative impacts to the municipal supply well;

C. Consideration of road salt and snow storage management; and

D. Reporting on existing transport pathways and any transport pathways to be created.

3.0 Physical Setting Summary

The Site is located within the Guelph Drumlin Field within a glacial outwash plain spillway area, immediately north of an area that is mapped as till plain (Chapman and Putnam, 1984, and CVC, 1998).

The Site is located within Subwatershed 15 of the West Credit River watershed (AquaResource Inc., 2009). Site topography generally slopes to the north from an elevation of 424 metres above sea level (m ASL) to 397 m ASL, with the downgradient Erin Branch of the West Credit River tributary at/below 394 m ASL (Figure 2).

3.1 Surface Water

No surface watercourses are mapped at the Site.

The Erin Branch of the West Credit River is located downgradient, and about 50 m northwest, of the Site. It has perennial flow and is classified as cold water (Credit Valley Conservation et al, 2011). It is noted that downstream of the golf course on the Erin Branch, the thermal regime is historically reported as cool water (Credit Valley Conservation et al, 2011). The river bed material in the area of the Site is reported as sand, and in some riffles, sand and gravel, with watercress noted as phreatophytes or evidence of groundwater inputs. The reach is also noted as having a low gradient and an average bankfull depth of 1 m (GEO Morphix Ltd., 2020). Surface water levels were monitored at staff gauge station SW-2 on the Erin Branch, which was responsive to precipitation events (Appendix A). Surface water flows have also been measured at SW-2 as well as downstream at SW-3 in spring, summer and fall and the results discussed in the next Section.

A tributary of the West Credit River is also located along the east side of the Site, paralleling the Site boundary at a distance of close to, but slightly greater than, 30 m. This tributary may have been created between 1954 and 1980, and has a bankfull depth of 0.45 m (GEO Morphix Ltd., 2020). A staff gauge (ID SW-1) was installed in summer 2021, but was destroyed during the fall season of 2021 as part of a washout of the tributary, and the station re-installed in spring season of 2022 and re-equipped with a water level datalogger. It is currently presumed that this tributary intersects the shallow groundwater table adjacent to the Site. The pre-development portion of the Site was calculated to be draining to this tributary is shown on Figure 5. Site golf course operations have an Irrigation Pond that receives discharge from this tributary (Figure 2). This Irrigation Pond is subject to a Ministry of the Environment, Conservation and Parks (MECP) Permit To Take Water (7370-A8YL4P) which allows for a maximum daily taking of 909,000 Litres/day from the pond. During the August 25, 2021 site visit it was observed that the pond water level was lower than the outlet pipe to the Erin Branch of the West Credit River.

3.1.1 Baseflow

Baseflow analysis was completed for the Erin Branch of the West Credit River at the upgradient Water Survey of Canada (WSC) stream gauge station 02HB020 (Figure 1) as part of the Tier 2 Water Budget (AquaResource Inc., 2009). An average baseflow of 0.33 m^3/s was calculated, including a mean flow of 0.47 m^3/s and a high baseflow component of 71%. It was also noted that low flow issues are sometimes a problem later in summer:

> "*Monthly variations in streamflow are not very large, and summer baseflow remains sustained…the 90th percentile exceedance flow does tend to decrease over the summer months into September which suggests that low flow issues are sometimes a problem later in the summer.*" (AquaResource Inc., 2009)

Historic baseflow measurements of the West Credit River immediately downgradient of the Site indicate this reach can be both an area of groundwater discharge (1.68 $L/sec/km^2$, August 1992) as well as an area of groundwater recharge (-9.1 $L/sec/km^2$, November 1995) (CVC 2011 et al):

> "*The gaining and losing portions of the West Credit River through the Erin Village area is variable and recharge/discharge conditions are more complex than previously interpreted.*" (CVC et al, 2011)

Earlier CVC reports (1998) have also indicated "*Much of the baseflow lost in the lower reaches of the northern tributaries of the West Credit appears to be related to the change in surficial geology from till to sands and gravel*". We note that Municipal Well E8 began operation in 1993, between these two sets of baseflow measurements referenced above, and that the water level at Municipal Well E8 changes on average from artesian or flowing/above ground surface (0.7 m) to approximately 4.6 m below ground surface during operation (OCWA, 2021). However, it is acknowledged that reporting on the 1993 municipal well testing stated "*there was no direct connection or impact of groundwater discharge to the West Credit River or adjacent wetlands*" (Blackport Hydrogeology and Golder Associates, 2010).

Manual surface water flow measurements from 2021 to 2023 have been completed at SW-1, SW-2 and SW-3, to include two sets of measurements in the spring, summer and fall seasons. The dates of these measurements include: (i) August 25, 2021, (ii) November 10, 2021, (iii) April 5, 2022, (iv) August 4, 2022, (v) November 10, 2022, and (vi) May 19, 2023. The results (discussed below) generally showed the Erin Branch of the West Credit River between Stations SW-2 and SW-3 as a gaining reach, with the exception of April 5, 2022.

1. No measurable precipitation occurred for 8 days prior to the August 25, 2021 measurements (Environment Canada Station 6142400, Shand Dam) meeting the 7-day criteria for baseflow measurements (MacViro, 2009). The approximate baseflow at the tributary (Station SW-1) was approximately 0.75 L/s and a temperature measured of 17.6°C (maximum day temperature of 28°C at Shand Dam). The measured baseflow in the Erin Branch of the West Credit River increased from 214 to 225 L/s between Stations SW-2 and SW-3, respectively.

2. Precipitation of 5.4 mm occurred the day before the November 10, 2021 measurements, with no measurable precipitation for the 8 days prior. The flow at the tributary (Station SW-1) was approximately 1.2 L/s. The measured flow, which may represent baseflow, in the Erin Branch of the West Credit River increased from 278 to 433 L/s between Stations SW-2 and SW-3, respectively.

3. Precipitation of 7.2 mm (partly snow) occurred during the week prior to the April 5, 2022 measurements. The flow at the tributary (Station SW-1) was approximately 14 L/s. The measured flow, which may represent baseflow, in the Erin Branch of the West Credit River decreased from 729 to 562 L/s between Stations SW-2 and SW-3, respectively.

4. Precipitation was 26 mm the day before flow measurements on August 4, 2022, although precipitation had been less than 3.5 mm the 9 days prior to that. The approximate flow at the tributary (Station SW-1) was estimated as 0.5 L/s. The measured flow in the Erin Branch of the West Credit River increased from 131 to 205 L/s, between stations SW-2 and SW-3, respectively.

5. No precipitation was measured 5 days prior, or less than 3 mm over the 10 days prior to the flow measurements on November 10, 2022. The approximate baseflow at the tributary (Station SW-1) was 0.26 L/s. The measured baseflow in the Erin Branch of the West Credit River increased from 229 to 242 L/s, between Stations SW-2 and SW-3, respectively.

6. No precipitation was measured for 11 days prior to the flow measurements of May 19, 2023. The approximate baseflow at the tributary (Station SW-1) was 0.59 L/s. The measured baseflow in the Erin Branch of the West Credit River increased from 459 to 691 L/s between stations SW-2 and SW-3, respectively.

The surface water measurements indicated the West Credit reach between SW-2 and SW-3 was generally a gaining reach, i.e. groundwater discharge increased surface water flows, however, it can also be a losing reach upon occasion, i.e. groundwater recharge decreases surface water flows.

3.2 Soils

The Site soils are mapped as Hillsburgh Fine Sandy Loam (OMAFRA, 2021). These permeable soils were developed on fine to medium outwash sands (Hoffman, Matthews and Wicklund, 1963). Infiltration rates were calculated as per CVC's methodology (2012, CVC Figure B11) from the shallowest grain-size analysis (DS Consultants Ltd., 2021) based upon hydraulic conductivity calculations (Appendix C, Devlin, 2015) at each borehole.

All calculated potential infiltration rates were greater than 7.6 mm/hour as expected for hydrologic soil group A (USDA, 1986), and none were less than 15 mm/hour, i.e. all suitable for recharge measures, with the highest rates in the central portion of the Site at boreholes BH21-3, BH21-6, BH21-7 and BH21-8 (Table 1, Figure 2) which consists of silty sand fill, sand or sand and gravel at surface.

Table 1 - Calculated Infiltration Rates

Calculated Infiltration Rates	Borehole Locations
>50 mm/hour	BH21-3, BH21-6, BH21-7 and BH21-8
15 to 50 mm/hour	MW21-1, MW21-2, BH21-4, BH21-5, BH21-9 and MW21-10

3.3 Surficial Geology

The surficial geology for the Site is regionally mapped as "*gravel and gravelly sand, frequently overlain by several feet of sand or silt*" (OGS, 2003). The 2021 geotechnical investigation (DS Consultants Ltd., 2021), confirmed this classification in the central portion of the Site at boreholes 6, 7 and 8 (Figure 2), however lower permeability silty sand and silt were identified at-surface in most remaining boreholes (Appendix B, Section 3.4.1). Overall, the thickness of the surficial permeable soils, above the underlying silty sand till, had average and median thicknesses of 3.6 m and 2.8 m, respectively.

A local hydrogeologic cross-section summarizes the Site setting, with the overburden thickness above bedrock decreasing from 40 m to less than 10 m towards the northwest and the West Credit River (Figure 3). This cross-section for the Site matches the general conceptual model in the area of (i) sand and gravel, underlain by (ii) sandy silt (*to silty sand*) till, underlain by (iii) the bedrock aquifer as shown below in Figure 4 (Credit Valley et al, 2011).

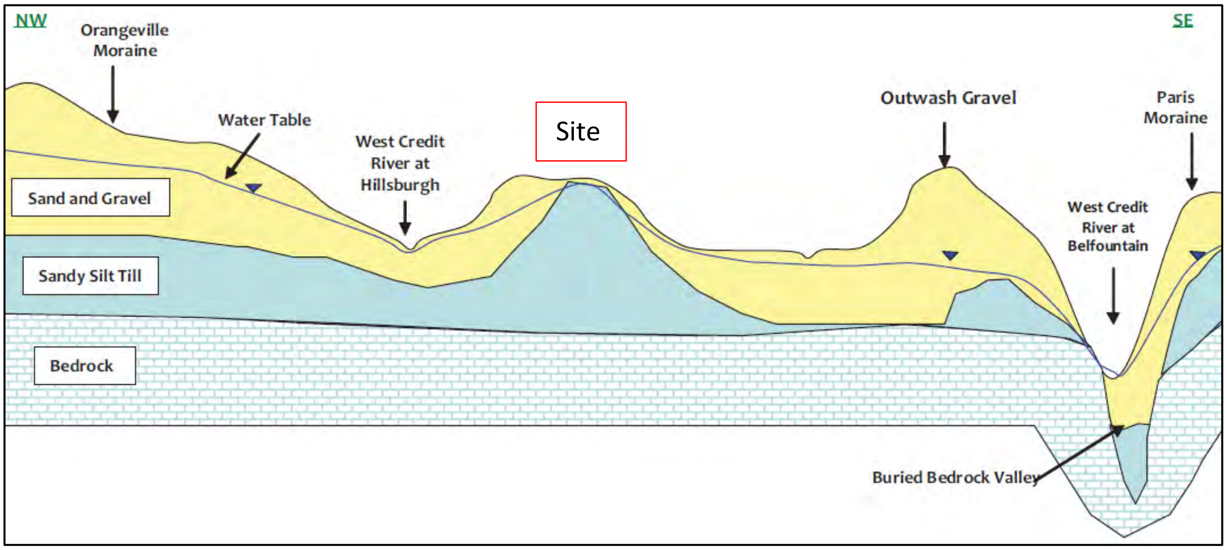

Figure 4 – Hillsburgh and Erin Schematic Cross-Section (Credit Valley et al, 2011)

3.4 Overburden Groundwater

3.4.1 Hydraulic Conductivity

The hydraulic conductivity of overburden materials was investigated using a combination of (i) hydraulic conductivity testing of on-site monitoring wells and (ii) grain-size analyses from the geotechnical investigation.

Shallow Soil Grain-Size Analyses

Hydraulic conductivities were calculated from grain-size analyses (DS Consultants Ltd., 2021) according to the methodology of Devlin (2015). Shallow (0.3 to 1.1 mBGS) soil sample results, from highest hydraulic conductivity to lowest, are listed below grouped by material (Appendix C):

1. Sand and gravel (boreholes BH21-6, BH21-7): 10^{-4} m/s
2. Gravelly sand (borehole BH21-8): 10^{-5} m/s
3. Silty Sand Fill (borehole MW21-3): $7x10^{-6}$ m/s
4. Silty Sand and Silty Sand Fill (boreholes MW21-2, BH21-4 and BH21-5): 10^{-6} m/s
5. Silt and Sand (borehole MW21-1): $5x10^{-7}$ m/s
6. Silty Sand Fill (boreholes BH21-9 and MW21-10): $1x10^{-7}$ to $6x10^{-8}$ m/s

While the calculated hydraulic conductivity results appear low for some of the reported shallow borehole log geology (MECP, 2006), the amount of ‘fines’ lowered the calculated hydraulic conductivities (Appendix C) for the at-surface samples at boreholes MW21-1, MW21-2, MW21-3, BH21-5, BH21-9 and MW21-10. For example, the grain-size classification of the 0.3 m sample from borehole BH21-9 is “poorly sorted sandy silt with fines”. Lower hydraulic conductivities that are below the range used for the CVC Model uppermost glaciofluvial outwash layer of $5x10^{-4}$ to $5x10^{-6}$ m/s were identified for approximately 28% of the Site (AquaResource Inc., 2009), e.g. $1x10^{-7}$ m/s at BH21-9 is the same as reported by the MECP for sandy/silty diamicton (2006).

Monitoring Well Testing

Monitoring well hydraulic conductivity testing was completed on August 2, 2023. A bail-down/ rising-head approach was used at the four on-site monitoring well locations (MW21-1, MW21-2, MW21-3 and MW21-10).

The hydraulic conductivity test results were analyzed using a Bouwer and Rice analysis (Bouwer, 1989) as recommended when the water level is within the screen (Bair, 2005) which occurred in some cases. The analyses were completed in Aqtesolv™ and are presented in Appendix C. The results are listed below with the hydraulic conductivity assigned to the most permeable geologic unit screened at each well, e.g. MW21-20 is screened across silty sand and silty sand till, however the hydraulic conductivity of $2x10^{-5}$ m/s is assigned to the silty sand. It is noted that the results for the silty sand varied within the minimum to maximum expected published range of 10^{-5} to 10^{-7} m/s (Fetter, 1995).

a) Silty Sand (MW21-3) $5x10^{-5}$ m/s
b) Silty Sand (MW21-10) $2x10^{-5}$ m/s
c) Silty Sand (MW21-2) $3x10^{-7}$ m/s
d) Silty Sand Till (MW21-1), $2x10^{-7}$ m/s

The geometric mean value for the silty sand is $6x10^{-6}$ m/s.

The silty sand till value of $2x10^{-7}$ m/s is comparable to published ranges for this material (Fetter, 1995, AquaResource Inc., 2009). It should be noted that groundwater control pumping methods are "*not feasible and may not be necessary*" for granular soils with hydraulic conductivities of 10^{-7} m/s or less (Preene, 2020). For example, an excavation 250 m wide and 5 m deep into the saturated silty sand till would be expected to generate less than 3,000 Litres/day based upon a Darcy flow calculation (Fetter, 1995).

3.4.2 Shallow Overburden Groundwater Flow On-Site

In April 2021, four monitoring wells were constructed on-site as part of the geotechnical investigation (DS Consultants, 2021). Three monitoring wells were screened in the surficial silty sand and upper silty sand till (MW21-2, MW21-3 and MW21-10), from 4.6 to 7.6 m BGS, 4.6 to 7.6 m BGS and 1.3 to 4.3 m BGS, respectively (Appendix B). A fourth deeper monitoring well (MW21-1) was also constructed in only the underlying silty sand till from 7.6 to 10.6 m BGS. DS Consultants have completed manual and datalogger monitoring at these locations since Spring 2021 and continue measurements in 2023. The data collected for greater than two years exceeds the Town's requirement for "*a minimum of 12 months to confirm the seasonally high groundwater table*" (Town of Erin, 2022). The water level plots and manual measurements are presented in Appendix A.

The greater than two years of groundwater monitoring have captured the spring season high water levels in 2022 and 2023. Above average March precipitation was observed in both those years compared to climate normals for the Shand Dam Environment Canada Station, i.e. 125% and 214% of average, respectively for 2022 and 2023 (Table A-1). An extensive period of below average precipitation was also captured from the spring to fall seasons of 2022, e.g. the April to November, 2022 precipitation was 69% of average.

On-site groundwater level measurements are summarized in Table 2, with the following observations:

a) Spring groundwater levels less than 1 m BGS were observed at MW21-2 (0.3 m BGS) and MW21-10 (0.1 m BGS);
b) Water table levels were generally in the silty sand till in the southern/upland portion of the Site and in the overlying sand in the northern/downgradient portions of the Site. This divide roughly follows the top of till at 410 m ASL;
c) An upward vertical gradient was generally observed between MW21-1 and MW21-10 at the southern upland area of the Site;
d) The average water table change/variation from fall season to spring season was an increase of 2.1 m; and
e) Groundwater levels regularly fluctuate at MW21-2 on the order of 0.5 m, which may be related to operation of municipal well E8 that is approximately 65 metres away.

Table 2 - Groundwater Level Measurements

Location	**Spring 2022**	**Fall 2022**	**Spring 2023**	**Spring 2022**	**Fall 2022**	**Spring 2023**	**Spring/Fall 2022**	**Fall 2022/ Spring 2023**
	Elevation (m ASL)			**Depth (m BGS)**			**Variation (m)**	
WATER TABLE								
MW21-2	398.5	396.3	398.4	0.3	2.5	0.4	2.2	2.1
MW21-3	400.2	398.8	400	5.5	6.9	5.7	1.4	1.2
MW21-10	418.7	416.1	419	0.4	3	0.1	2.6	2.9
UNDERLYING SILTY SAND TILL								
MW21-1	419.6	414.2	419.7	3.2	8.6	3.1	5.4	5.5

Shallow overburden groundwater flow mimics the topography with flow generally towards the north-northwest (Figure 5), as previously identified by CVC, *"…gravelly soils….allow water to percolate…and make its way slowly to the river…..*" (CVC, 1998). A hydraulic gradient of 0.061 m/m is calculated from Figure 5. With respect to shallow groundwater flow it has been previously reported that:

> "*…an extensive low permeability till unit underlying the sand and gravel … much of the groundwater will not move to depth and likely discharge as baseflow to a local surface water feature…*" (CVC et al 2011).

This is reasonable for the Site given the top of the silty sand till parallels that of the ground surface dipping to the northwest, north and northeast (Figure 3). It is noted that the Spring/April 2022 high groundwater level shown on Figure 3 is generally 1 m higher than that visualized on Figure 5 for December 2021, except near the northern part of the Site which was relatively the same elevation.

3.4.3 Shallow Overburden Groundwater Flow Off-Site/Downgradient

In August, 2021, shallow drive-point piezometers and staff gauges were installed to monitor (a) shallow groundwater at the two wetland polygons (GW-1 and GW-2), (b) surface watercourses (SW-1 Tributary and SW-2 Erin Branch of the West Credit River), (c) wetland surface water levels (WET-1 and WET-2) and (d) shallow groundwater adjacent the surface watercourses (GW-3 and GW-4) (Figure 2). The shallow groundwater monitors (GW-1, GW-2, GW-3 and GW-4) were installed approximately 1 m deep, while the wetland and surface water monitors (SW-1, SW-2, WET-1, and WET-2) were installed between 0.2 and 0.4 m deep, and water level datalogging pressure transducers were installed in each. The hydrographs for these are shown in Appendix A and described below. During the monitoring period precipitation conditions were (i) above average from August, 2021 to April, 2022, (ii) below average from May, 2022 to November, 2022 and (iii) above average from December, 2022 to July, 2023 (Table A-1).

1. Water levels in the SWM3-2 poplar swamp (WET-1/GW-1): (a) water levels at the wetland varied 30 cm (WET-1) and varied 70 cm at the drive-point piezometer (GW-1) from dry conditions (e.g. summer 2022) to wet conditions (e.g. spring 2022 and 2023), (b) water levels were generally below ground surface except during fall season of 2021 and spring season of 2022 during a period of above average precipitation (Table A-1), and (c) the vertical gradient was generally downwards, however upward gradients did occur in response to precipitation and during the 2023 spring season high water level conditions. Groundwater levels at monitoring well MW21-2 were generally lower than GW-1 except during spring, meaning generally a downgradient gradient in the shallow system.

2. Water levels in the SWM4-1 cedar swamp (WET-2/GW-2) were (a) below ground surface during the two years of monitoring, (b) at the wetland staff gauge (WET-2) generally 30 cm below ground surface and at the drive-point piezometer 45 cm, (c) a downward vertical gradient was observed between the wetland staff gauge (WET-2) and the deeper drive-point piezometer (GW-2) and (d) the groundwater levels at GW-2 showed some responsiveness to precipitation events. To further characterize groundwater conditions near the cedar swamp two additional monitoring wells (MW-2-00 and MW-6-00), up- and down-gradient of the wetland, were installed with water level loggers in November, 2022 and November, 2021, respectively. The monitoring wells are 4.1 and 2.8 m BGS deep. The average monitoring well groundwater levels up-gradient of the wetland were about 3 m BGS (MW-2-00) and downgradient of the wetland 1 m BGS (MW-6-00), suggesting an overall downward vertical gradient from the wetland to the groundwater table.

3. Shallow groundwater levels adjacent the west tributary (GW-3) were (a) generally 40 to 60 cm below of ground surface until 2023 when backflow from the Irrigation Pond elevated levels sometimes above ground surface, and (b) since deepening the drive-point piezometer in April, 2022 upward gradients compared to surface water station SW-1. The water level depth at SW-1 was generally less than 10 cm until the summer season of 2023 when back flow into channel from the Irrigation Pond was noted.

4. Shallow groundwater levels adjacent to the Erin Branch of the West Credit River (GW-4) were (a) generally within 20 cm of ground surface, (b) responsive to precipitation events, and (c) had a fairly consistent upward vertical gradient compared to nearby surface water gauge SW-2.

3.5 Bedrock Aquifer

The bedrock aquifer underlying the Site is the Amabel Formation, "…*a highly transmissive bedrock aquifer*" (AquaResource Inc., 2009). As shown on the Site cross-section (Figure 3), the confined aquifer bedrock groundwater levels (Section 3.4.1) are above ground surface under static conditions at the Erin

Branch of the West Credit River. Regional groundwater flow in the bedrock aquifer is towards the east in the area of the Site (Credit Valley Conservation et al, 2011).

3.5.1 Municipal Well E8

Municipal Well E8 is located at 5555 Eighth Line, northwest of the Site (Figure 2). Further details regarding the bedrock supply well include:

> *"Municipal well E8, was constructed to a depth of 46 metres in 1991, and has been in production since 1993. Bedrock was encountered at 6.6 metres below ground surface (m BGS) but the upper bedrock zones were sealed to 16.8 m BGS by pressure-grouting to minimize potential connection to surface water. The well is artesian with a static level about 6.4 m above ground surface.*
> (Credit Valley Conservation et al, 2011)

Water levels provided by the Ontario Clean Water Agency (2021) indicated that daily maximum water levels at Municipal Well E8 continue to be generally artesian in nature or above ground surface.

3.5.2 Well Head Protection Area (WHPA) Mapping

Well Head Protection Areas (WHPAs) were mapped for Municipal Well E8 as part the 2006 County of Wellington Groundwater Protection Study (Golder Associates Ltd., 2006). Bedrock aquifer vulnerability scoring of the modelled WHPAs was completed in 2010 (Blackport Hydrogeology Inc. and Golder Associated Ltd.). Underlying the Site, the intrinsic susceptibility index (ISI) of the bedrock aquifer vulnerability was modelled as 'medium' closer to Municipal Well E8 and 'low' further upgradient (Appendix D).

The WHPAs at the Site include (Appendix D):

a) Well Head Protection Area (WHPA)-A: a 100-metre circle around the Municipal Well E8, with a vulnerability score of 10, and covers 0.64 hectares or 5% of the Site.
b) WHPA-B: the 2-year time of travel to Municipal Well E8, with vulnerability scores of 8 and 6 (because of lower natural vulnerability mapped to the southeast), and covers 4.15 hectares or 29% of the Site.
c) WHPA-C: the 5-year time of travel to municipal well E8, with a vulnerability score of 4, and covers 1.3 hectares or 9% of the Site.

Due to the age of the WHPAs, they may be remodelled in the future, which may change their size and location. However, it is our understanding that funding for WHPA updates has not been confirmed, and it would likely take on the order of three years to complete the modelling and update the source protection assessment report and plan policies.

3.6 Highly Vulnerable Aquifer Mapping

The delineation of Highly Vulnerable Aquifers (HVAs) was completed as part of a modelling effort (CTC Source Protection Region, 2010) separate from the earlier WHPA modeling (Section 3.5.2). During the

HVA modelling project, Municipal Well E8 was still classified as being in a 'medium' vulnerability physical setting whereby the bedrock aquifer is "*overlain by aquitard material*".

However, most of the Site (10.9 hectares or 78%) was regionally classified as an HVA (Appendix D) because of (i) surficial geology mapping of sand and gravel, and (ii) off-site water well records suggesting that the on-site sand and gravel thickness is greater than 2 metres on-site. The HVA in this case is the at-surface surficial sediments, not the underlying municipal bedrock aquifer. Based upon the CTC Source Protection Region (2010) criteria using the on-site investigations, the entire Site could be mapped as an HVA; however, this unit is not a potable water supply aquifer on-site, nor immediately downgradient and so does not function as an aquifer. HVAs are assigned a vulnerable score of 6 based upon source water protection technical rules.

3.7 Wetlands

Downgradient of the Site are three swamp polygons of Provincially Significant Wetland (PSW) associated with the West Credit River Wetland Complex (Figure 2, MNRF, 1995, Appendix D). Ecological Land Classifications (ELC) of these swamps are (WSP, 2022): (i) cedar hardwood organic mixed swamp SWM4-1 and (ii) poplar conifer mineral mixed swamp SWM3-2 (Figure 2). These wetlands occur at ground elevations that are approximately below or lower than the 400 m ASL contour line, similar to the Tributary that is mapped east of the Site (Figure 2).

Soil hand-augering completed for installation of the wetland water level monitoring stations noted (i) 0.65 metres of clay and silt at the SWM4-1 cedar swamp over sand (WET-2, SWM4-1, polygon 4a), and (ii) 0.75 m clay and silt over silty sand at the SWM3-2 poplar swamp (WET-1, SWM3-2, polygon 5a). This is not unexpected as OMAFRA has mapped "muck", or hydrologic soil group D, for much of the poplar swamp (Appendix D) and the OGS has mapped a portion of the poplar swamp as bog deposits. These lower permeability soils correlate with the expected higher soil water holding capacity at swamps than is expected at the Site, i.e. 350 mm versus 50-100 mm (AquaResource Inc. and NPCA, 2009). Perched conditions were commonly noted at both wetlands as shown by the shallow water level monitoring (Section 3.4.3).

Topographic contours through the wetlands indicate gentle slopes of between 3% (cedar swamp) and 4% (poplar swamp) towards the West Credit River. However, most of the poplar swamp is within the West Credit River floodplain while the cedar swamp is upgradient of the floodplain (Figure 5).

As discussed in Section 3.4.3, water level monitoring has been on-going since late August, 2021 and includes a measure of the vertical gradient. Based upon the water level monitoring:

a) The SWM3-2 poplar swamp (WET-1/GW-1) was generally under recharge conditions however, groundwater discharge could occur (e.g. spring season of 2022). Wetland water levels were very shallow, on average 7 cm below ground surface in the clay and silt, and the shallow groundwater levels were also shallow averaging 30 cm below ground surface.

b) The SWM4-1 cedar swamp (WET-2/GW-2) was under recharge conditions as water levels were generally 30 cm below ground surface in wetland silt and clay and the shallow groundwater levels 45 cm below ground surface.

The wetlands are a combination of three types, as visualized below in Figure 6: (ID (a)) surface water depression, (ID (c)) groundwater depression and (ID (d)) groundwater slope wetlands as reported by Mitsch and Gosselink (2007). The relevant portions of the definitions of these groundwater flow schematics are also presented below. This combination model is proposed as (i) the wetlands are underlain by a low permeability layer allowing some perched to mounded conditions, (ii) the ground surface gently slopes, (iii) at the SWM4-1 cedar swamp the water table is below ground surface under recharge conditions and at the SWM3-2 poplar swamp the water table is usually below ground surface but groundwater discharge can occur and (iv) a shallow depth to groundwater allows for root uptake of groundwater (McBean, Rovers and Farquhar, 1995).

Surface Water depression wetlands (ID (a)): *"…little groundwater outflow due to a layer of low-permeability soils…where the wetland is separated from the water table by an unsaturated zone"*

Groundwater depression wetlands (ID (c)): *"…groundwater discharge wetlands…in a depression low enough to intercept the local groundwater table… can occur in coarse-textured glaciofluvial deposits…Water-level fluctuations….less dramatic than… surface flow….because of the relative stability of the groundwater levels"*

Groundwater slope wetlands (ID (d)): "*Wetlands often develop on slopes …Groundwater flow into these wetlands can be …seasonal….*"

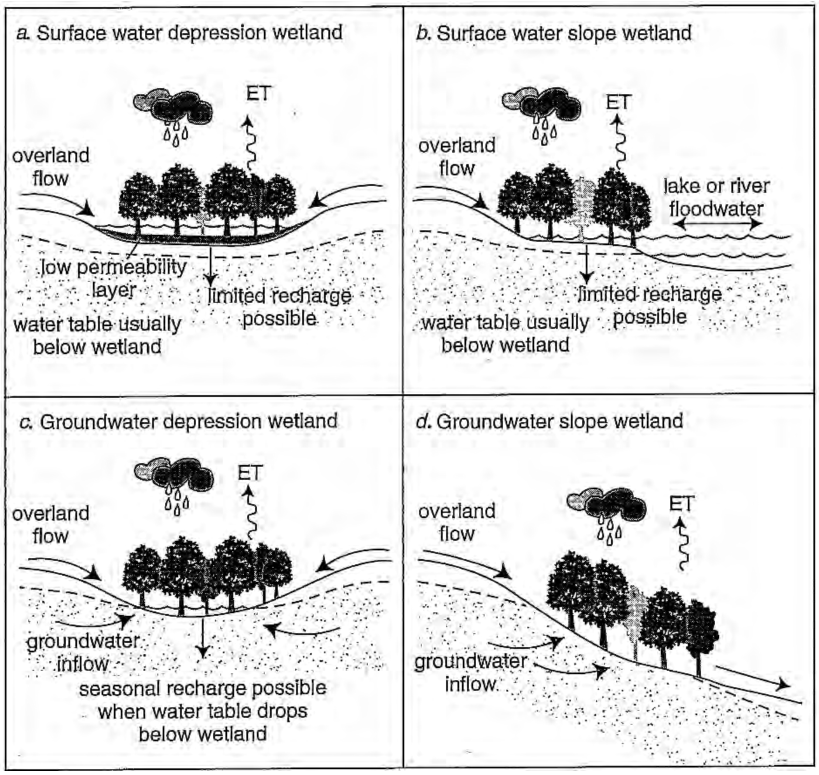

Figure 6 – Groundwater flow patterns for wetlands (Mitsch and Gosselink, 2007)

The upgradient catchment areas for each wetland were calculated using topographic contours and are 2.16 and 7.56 hectares for the cedar (SWM4-1, 4a wetland polygon) and poplar (SWM3-2, 5a wetland polygon) swamps, respectively (Table 3, Figure 5). The cedar and poplar swamps are 1.2 and 1.0 hectares approximately in size, respectively, with upgradient wetland catchment drainage areas of 1.38 and 6.05 (Table 3, Figure 5). It should be noted that 0.78 ha (Cedar wetland) and 1.51 ha (Poplar wetland) can remain unchanged between the Site and the wetlands to both (i) receive direct precipitation recharge and (ii) transmit subsurface recharge.

It is worth noting that previous reporting by CVC (1998) appears to comment on this reach of the West Credit River in the area of the Site, with respect to the effect of wetlands on upgradient infiltrated groundwater, "*…because of the wetland vegetation, most this cool groundwater is used up and transpired by the vegetation before reaching the stream or warms up as it passes through the wetland soils*…" which is reflected in the change from cold to cool of the West Credit River (Section 3.1).

Table 3 – Wetland Catchment Areas

Wetland	ELC	Size (ha)	Upgradient Catchment (ha)	Upgradient Catchment Within Site (ha)	Unchanged Upgradient Area (ha)
Cedar - 4a	SWM4-1	1.2	2.16	1.38	0.78
Poplar - 5a	SWM3-2	1.0	7.56	6.05	0.51

It is also noted that there is an existing Irrigation Pond adjacent/downgradient of the cedar hardwood organic mixed swamp SWM4-1 (Figure 2). This pond may not be in operation following residential development of the Site. Consequently, this would benefit wetland hydrology, as the Irrigation Pond would not be drawn down for irrigation purposes during the growing season.

There is also small polygon (5d, Figure 2) of poplar swamp located north of the Site (WSP, 2022). This has not been investigated for impacts as there is already substantial municipal infrastructure for Municipal Well E8 between the Site and this wetland.

4.0 Water Balances and Groundwater Recharge

4.1 West Credit Subwatershed Study (CVC, 1998)

It has been noted by CVC for Subwatershed 15 of the West Credit River that:

> "*Not all the recharge to the subwatershed discharges to the West Credit River. The average annual precipitation within the subwatershed is 850 mm per year, and average infiltration within the subwatershed is estimated to be 338 mm per year. The average infiltration contributing to baseflow is estimated to be 294 mm per year* (35% of precipitation)*. The difference is approximately 13%, meaning that this water would discharge outside the West Credit Subwatershed to the main Credit River, within Subwatershed 18."*

4.2 Tier 2 Source Water Protection Water Budget (AquaResource Inc., 2009)

Water Survey of Canada (WSC) surface water flow gauge 02HB020 (Figure 1), is located on the Erin Branch of the West Credit River upstream of 8th Line and the Site. Surface water balance analyses of the 1961-2004 dataset provided the following water balance results in mm per year: (i) Precipitation 894, (ii)

Evapotranspiration 437 (49% of precipitation), (iii) Runoff 139 (16% of precipitation) and (iv) Recharge 319 (36% of precipitation). Of the precipitation noted at the Shand Dam Weather Station (Environment Canada Station 6142400), 15% of precipitation is snowfall, or 125 mm, and this station is considered representative of climatic conditions west of the Niagara Escarpment.

AquaResource Inc. modelling of average groundwater recharge was completed for the period 1960-2005. The results for the Site in mm per year were: (i) Precipitation 897, (ii) Evapotranspiration 402-408, (iii) Runoff 114-122 and (iv) Recharge 368-381. An average area-weighted value for the Site of 340 mm/year recharge (38% of precipitation) was calculated after (a) incorporating values for the lower permeability soils identified for 28% of the Site (Section 3.4.1) which were assigned a recharge rate of 302 mm/year pro-rated from AquaResource Inc. modelling for similar soils west of the Site, and (b) including a limited existing impervious area of 4%. This equates to an annual recharge volume of 47,368 m^3/year. However, it should be noted that these modelled results remain significantly in excess of typical MECP groundwater recharge rates (Table 4).

Table 4 - Typical Groundwater Recharge Rates (MECP, 1995)

Soil Texture	Groundwater Recharge Rate (mm/year)
Coarse sand and gravel	>250
Fine to medium sand	200-250
Silty sand to sandy silt	150-200
Silt	125-150
Clayey silt	100-125
Clay	<100

4.3 Significant Groundwater Recharge Areas

The CTC Source Protection Committee/Region choose to delineate Significant Groundwater Recharge Areas (SGRAs) as those areas modelled as having 115% greater than the overall average watershed recharge rate of 230 mm/year, for a criterion of 265 mm/year. This value of 265 mm/year is within the expected range for coarse sand and gravel (Table 4, MECP, 1995). Consequently, given a CVC modelled recharge rate of 374 mm/year for the Site (Section 3.6.2), the Site is mapped almost entirely as an SGRA (95%).

4.4 Maintenance of the Site Water Balance

A daily precipitation analysis was completed for Environment Canada Shand Dam Station 6142400 for the period 2013-2021 and summarized in Table 5. The analysis was completed to determine a precipitation infiltration threshold to maintain pre-development levels of groundwater recharge. This threshold can then be a criterion for design of stormwater management low impact development (LID) infiltration facilities.

The analysis indicated that annual daily 10 mm or less precipitation events ranged between 386 to 488 mm/year (Table 5). These values exceed the modelled Site pre-development recharge rate of 340 mm/year, with an average '*10 mm or greater precipitation*' value of 425 mm/year exceeding the modelled recharge by 25%. However, a larger amount of precipitation abstraction is required for the Site as driveway and road runoff cannot be included because of potential water quality concerns (e.g. road salt) to features such as wetlands (CVC, 2012).

The pre-development Site recharge rate will be maintained to 80% or greater, if (a) 20 mm, or less, precipitation events are infiltrated from “clean” impervious surface roof runoff and (b) fill is of loam quality or higher infiltration rate (Table 6). If a higher recharge rate is required more permeable soils than loam could be specified for fill areas. Table 6 is further explained below:

(a) Infiltration of ‘clean’ runoff from 3.86 hectares of impervious areas (i.e. multiplied by 727 mm/year for capture or precipitation events from 1 to 15 mm) via a 3rd pipe system to infiltration areas at the stormwater management facilities resulting in an estimated annual recharge volume of 28,062 m^3/year; and

(b) 4.90 hectares of continuing recharge for the permeable areas of lots, the park and the stormwater management areas.

  a. 3.10 hectares multiplied by 138 mm/year (representing an average rate for loam soils to be placed at the Site) for an annual recharge volume of 4,278 m^3/year.
  b. 1.80 hectares multiplied by 302 mm/year (representing areas where native soils will be at-surface not fill) for an annual recharge volume of 5,436 m^3/year. This was calculated in the southern portion of the Site to include areas of less than 2 m of excavation.

The eastern infiltration area will provide groundwater recharge to, and discharge to, the eastern tributary and the eastern wetland (Figure 5).

It is also noted that recent annual precipitation amounts are generally above the 1980-2010 climate normal of 946 mm/year. It is noted that climate change modelling by the Grand River Conservation Authority has indicated future winters are expected to have less snow and greater precipitation and increase in winter groundwater recharge (Shifflett, 2014).

Table 5 - Daily Precipitation Summary*

Year	Annual Precipitation (mm/% of average)	Days with 1-10 mm	Depth Sum of 1-10 mm Days (mm)	Days with 1-15 mm	Depth Sum of 1-15 mm Days (mm)	Days with 1-20 mm	Depth Sum of 1-20 mm Days (mm)
2013	1,199 (127%)	152 (42%)	395	175 (48%)	686	184 (50%)	840
2014	1,102 (116%)	152 (42%)	407	174 (48%)	677	177 (48%)	731
2015	866 (92%)	138 (38%)	386	149 (41%)	523	156 (43%)	643
2016 (Leap)	1,032 (109%)	138 (38%)	420	151 (41%)	588	160 (44%)	740
2017	1,110 (117%)	160 (44%)	488	175 (48%)	678	185 (51%)	853
2018	953 (101%)	146 (40%)	456	155 (42%)	564	166 (45%)	753
2019	Shand Dam and nearby meteorological stations had too many data gaps						
2020 (Leap)	1,017 (108%)	123 (34%)	423	139 (38%)	622	147 (40%)	765
2021	878 (93%)	144 (39%)	428	150 (41%)	498	151 (41%)	516
2022	808 (85%)	145 (40%)	426	159 (44%)	597	159 (44%)	706
Average	996 (105%)	144 (39%)	425	159 (43%)	604	165 (45%)	727

Year	Annual Precipitation (mm/% of average)	Days with 1-10 mm	Depth Sum of 1-10 mm Days (mm)	Days with 1-15 mm	Depth Sum of 1-15 mm Days (mm)	Days with 1-20 mm	Depth Sum of 1-20 mm Days (mm)
Median	1,025 (109%)	145 (40%)	422	153 (42%)	605	163 (45%)	720

Note: * - Shand Dam (Station 6142400) 1981-2010 Average Precipitation of 946 mm/year, 20 km away

Table 6 – Annual Estimated Site Recharge Rates

	Area (hectares)	Recharge (mm/year)	Volume (m^3/year)
Pre-development	13.86	340	**47,081**
Post-development	3.86 (clean impervious roof areas via 3rd pipe to infiltration systems)	727	28,062
	3.10 (pervious areas fill)	138	4,278
	1.80 (pervious areas native)	302	5,436
		SUM	**37,776**

4.5 Wetland Water Balance Analysis

Credit Valley Conservation (CVC) (AquaResource Inc., 2009), through the source water protection water budgeting exercise, have calculated average water balance results per CVC climatic zone, soil type and land use type. The wetlands downgradient of the Site are in Climatic Zone 1, with a #3 slope category (i.e. slope 3.01 degrees or greater), and hydrologic soil group "organic" based upon the site investigations (Section 3.7). The CVC reported annual results in mm/year were: (i) Precipitation 897, (ii) Evapotranspiration 578, (iii) Recharge 152 and (iv) Runoff 167. These results reflect the lower permeability of the uppermost soils of the wetlands as observed during installation of wetland monitoring locations.

A monthly water balance for the swamps was completed using the U.S. Geological Survey (USGS) Monthly Water Balance Model (McCabe and Markstrom, 2007), which considers direct precipitation only, not runoff to the wetland. For temperature and precipitation climate normal inputs, Environment Canada weather station, Shand Dam Station, ID 6142400 (Environment Canada, 2022) was used. The calculated annual surplus (Precipitation minus Evapotranspiration) of 401 mm/year was higher than that modelled by CVC, and may be a result of the more detailed CVC 1-hour modelling time steps. The monthly modelling wetland results (Table 7) are summarized below.

1. Potential evapotranspiration exceeded precipitation for June and July, i.e. soil water utilization occurred;
2. Swamp soil water holding capacities were less than saturated for the summer months, i.e. June through September; and
3. Soil water recharge occurred in September.

Table 7 – Monthly Wetland Water Balance (mm)

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Precipitation (mm)	68	56	60	74	87	84	89	97	93	77	93	69
Potential (mm) Evapotranspiration	8	10	18	36	67	98	113	91	54	29	15	9
Soil Moisture (mm)	350	350	350	350	350	**332**	**305**	**306**	**340**	350	350	350
Soil Water Depletion (mm)						18	45	44	10			

4.6 Maintenance of the Wetland Water Balance

The water balances for the wetlands can be maintained post-development (Tables 8a/8b) and excess/increased recharge can continue to flow in the subsurface downgradient of the wetlands. The details presented in Tables 8a/8b details explained below:

1. Direct precipitation will continue to the wetlands.

2. Pre-development groundwater recharge rates will be maintained immediately upgradient of the wetlands because development is set-back from the wetlands, i.e. 0.78 ha for Wetland 4a (SWM4-1) and 1.51 ha for Wetland 5a (SWM3-2).

3. Stormwater management infiltration of clean roof runoff will occur at two proposed infiltration facilities upgradient of the wetlands providing infiltration of events up to 20 mm (Urbantech, 2023a).

4. Uncontrolled drainage areas will provide recharge as well as discharge from impervious areas.

5. Lot-level infiltration will occur in pervious areas upgradient on-site.

Table 8a – Annual Estimated Upgradient Wetland Recharge

East SWM4-1 Cedar Wetland 4a Catchment	**Area – on and off-site (hectares)**	**Recharge (mm/year)**	**Volume (m^3)**
Pre-development	2.16	374	**8,078**
Post-development	0.60 (clean roof runoff infiltrated at SWM)	727	4,362
	0.78 (preserved off-site upgradient buffer area)	374	2,917
	0.53 (uncontrolled drainage area recharge)	138	729
	0.14 (uncontrolled drainage area discharge)	996	1,394
	0.17 (pervious drainage upgradient on-site)	138	229
		SUM	**9,631**

Table 8b – Annual Estimated Upgradient Wetland Recharge

West SWM3-2 Poplar Wetland 5a Catchment	**Area – on and off-site (hectares)**	**Recharge (mm/year)**	**Volume (m^3)**
Pre-development	7.56	359	**27,140**
Post-development	3.26 (clean roof runoff infiltrated at SWM)	727	23,700
	1.51 (preserved off-site upgradient buffer area)	374	5,647
	0.89 (uncontrolled drainage area recharge)	138	1,227
	0.11 (uncontrolled drainage area discharge)	996	1,084
	1.03 (pervious drainage upgradient on-site)	138	1,421
		SUM	**33,079**

4.7 Wetland Risk Evaluation

4.7.1 Magnitude of Hydrological Change

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

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

"*The highest magnitude category with one or more criteria satisfied determines the potential magnitude of change*" (TRCA, 2017).

(1)(2) The upgradient groundwater catchments for the downgradient PSW wetlands will be reduced, as well as their associated recharge areas as there will be "*replacement of existing soils with significantly less permeable materials*". The Wetland 4a catchment will be reduced from 2.16 ha to 0.78 ha (64% reduction) and the Wetland 5a catchment will be reduced from 7.56 ha to 1.51 ha (80% reduction). These changes meet the criteria for high magnitude of hydrological change as they are greater than 25%. However, this is without consideration of SWM LID mitigation measures, or consideration of on-site recharge (Section 4.6).

(3) Future impervious cover in for the Site is 73% (Urbantech, 2023a) which meets the criteria for a high magnitude of hydrological change as it is greater than 25%. However, this is without consideration of SWM infiltration mitigation measures.

(4) Active construction dewatering is not expected to be required (Section 6.0).

4.7.2 Sensitivity of the Wetlands

The risk assignment is also to consider the type of wetland and their hydrological sensitivity (TRCA, 2017), downgradient of the Site:

(i) Wetland 4a is mapped as cedar hardwood organic mixed swamp (SWM4-1) which has a High Hydrological Sensitivity; and

(ii) Wetland 5a is mapped as poplar conifer mineral mixed swamp (SWM3-2) which has a Medium Hydrological Sensitivity.

4.7.3 Risk Assignment

The cedar hardwood organic mixed swamp (SWM4-1) receives a High-Risk assignment, having a high hydrological sensitivity and a high magnitude of hydrological change (Figure 6). However, the poplar conifer mineral mixed swamp SWM3-2 receives a Medium Risk assignment because of having a medium hydrological sensitivity although having a high magnitude of hydrological change (Figure 6).

The recommended study, modelling and mitigation requirements are similar for high and medium risks, i.e. similar levels of effort for considering Wetlands 4a and 5a:

(i) Pre-development monitoring is required as outlined in the Wetland Water Balance Monitoring Protocol (TRCA, 2016).
  - Years of monitoring both wetlands began in August, 2021.

(ii) Continuous hydrological modelling is required at daily aggregated to weekly resolution.
  - Existing annual HSP-F modelling (completed at 1-hour time steps) completed for CVC was utilized for this report (AquaResource Inc., 2009). This existing work could be re-visited to extract the weekly results, however it is unclear the direct benefit of doing so at this time.

(iii) Design of a mitigation plan to maintain the wetland water balance, in some cases an interim mitigation plan may also be required.
  - This has already been prepared as briefly outlined herein and presented in detail in Urbantech (2023a).

(iv) Additional emphasis placed on characterization of groundwater interaction [High Risk only, i.e. Wetland 4a]
  - Additional monitoring was implemented adding water level dataloggers to monitoring wells located up- and down-gradient of the wetland confirming an overall downwards vertical gradient at the Cedar wetland, with no groundwater discharge observed at the wetland monitoring stations Wet-2/GW-2.

(v) Integrated hydrological model may be required where groundwater interaction is high [High Risk only, i.e. Wetland 4a]
  - Groundwater interaction is not considered high at the Cedar wetland and was under recharge conditions during the two years of monitoring which included both dry and wet precipitation periods. However, it is acknowledged that shallow groundwater levels were measured within a metre of surface. The existing CVC FEFlow model (AquaResource Inc., 2009) could be used if required, however it is unclear of the benefit of doing so as the conceptual model appears well understood and appropriate mitigation have been designed.

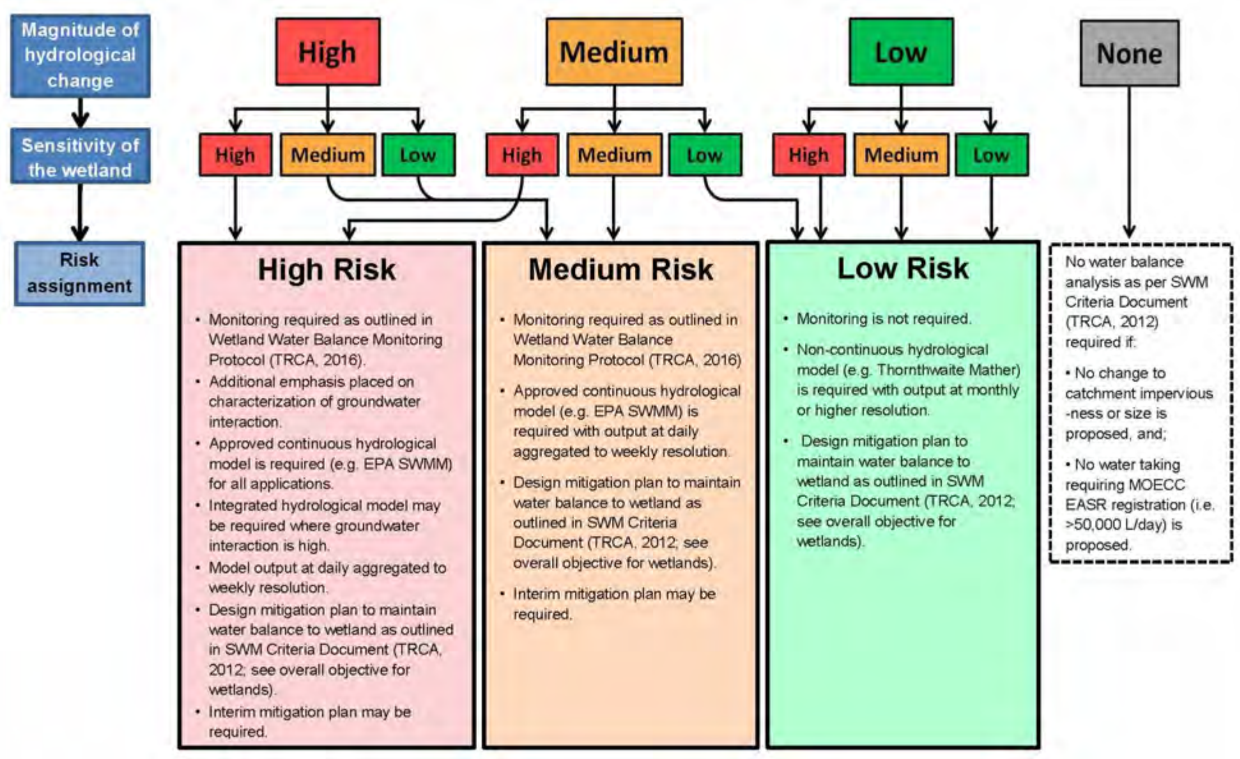

Figure 6 - Wetland Risk Evaluation Decision Tree

5.0 Source Water Protection Policy Implementation

5.1 Section 59 Notice Evaluation

Site development will include a Section 59 notice evaluation by Wellington County source water protection risk management staff. The '*Section 59 process*' is a review process to ensure that the Site design complies with the required source water protection policies. The policies requiring compliance concern the prevention of significant water quality threats to Municipal Well E8 serving the Town of Erin.

5.2 Significant Threat Management

Source Water Protection Policies SWG-13/SWG-14: Sanitary sewer pipes proposed within the WHPA-A require higher than normal construction and operational standards in order that potential leakage is not a significant municipal drinking water threat. Source Water Protection Policies SWG-13 and SWG-14 do not require these standards outside the WHPA-A, however such standards may be requested outside the WHPA-A. Parklands are currently proposed for the portion of WHPA-A within the Site. However, it is expected that the sanitary main will be located along 8th Line right-of-way and therefore pass through the WHPA-A and require additional standards for implementation such ensuring a closed system such as extra-flange protectors to prevent potential leakage.

Source Water Protection Policies SWG-11(1)/SWG-12(1): Stormwater management facilities, including outlets and infiltration are prohibited within the WHPA-A. One of the water quality concerns for the municipal well is road salt contamination of the municipal water supply. Source Water Protection

Policies SWG-11(1) and SWG-12(1) do not require these standards outside the WHPA-A. However, it is noted CVC (2012) has stated that "*infiltration from "clean" water sources such as roof runoff…will be encouraged in these areas*".

5.3 Road Salt and Snow Storage Management

Road salting, road salt storage, and snow storage are drinking water threats that are associated with urban/developed areas. However, the water quality threat level classification (significant, moderate or low) of these activities is based upon the vulnerability zone (and associated vulnerability score) and activity details as will be explained below.

Road salting and road salt storage are calculated as low water quality threats for the Site, given the area of the WHPA-A is planned to be a park (Armstrong, 2021) without roadways or road salt storage. Snow storage would also be a low threat within WHPA-B for snow storage areas between 0.01 and 0.5 hectares in size; however, snow would not be expected to be stored at the park as it would have to be moved across the stormwater management facility.

Source Water Protection Policy SAL-10: this policy concerns application of road salt and is a '*have-regard-to*" policy not an enforceable policy. This policy advocates development of a salt management plan for the development of the Site including "*directing stormwater discharge outside of vulnerable areas where possible*". Town Planning and Wellington Source Water Protection have asked to be providing a Salt Management Plan (Town of Erin, 2022). The Town of Erin was contacted by e-mail in July, 2023 to receive a copy of their plan, however no response was received. However, the Town of Erin previously shared that their approach is a 5% salt/95% sand mix except during freezing rain events whereby 10%salt/90% sand is applied. We would propose a similar approach for the Site. In addition the bedrock aquifer will be protected via a third-pipe system whereby only clean runoff will be infiltrated on-site. This is a reasonable approach given the bedrock aquifer supplying the municipal well is not highly vulnerable and previous study has concluded that the municipal well is not under the influence of surface water.

Wellington Source Water Protection have also asked that the at-surface/above-ground stormwater management facility "*have an impervious liner to avoid recharge of water containing contaminants, particularly sodium and chloride, back to the aquifer*" (Wellington Source Water Protection, 2023).

5.4 Existing Transport Pathways and Creation of Transport Pathways

Transport pathways are existing, man-made features that could promote 'transport' of contaminants to a water supply aquifer, e.g. unused water supply or monitoring wells.

There is an existing water supply well at the Site, MECP water well record 6700766 (Figure 2) which is listed on the Permit to Take Water as the Club House Well. This well will be decommissioned by an Ontario-licensed water well driller once no longer required for golf course operations.

There are monitoring wells located on the Site which will be decommissioned by an Ontario-licensed water well driller once they are no longer required for monitoring purposes.

5.5 Water Quantity

As stated by Wellington County source water protection risk management staff (Vandermeulen, 2021), "*There are currently no Clean Water Act requirements related to the management of the water quantity*…". However, recharge at the Site will be maintained to at least 80%, and maintained to pre-development rates to the downgradient wetlands.

6.0 Dewatering Considerations

Responding to the comments on the first submission for development of the Site (Town of Erin, 2022), construction dewatering was considered and is not predicted to require an MECP Environmental Activity and Sector Registry (EASR) or Permit to Take Water (PTTW). This is because of:

a) The large amount of fill required for development of the Site limiting the amount of construction below the water table (Urbantech, 2022); and

b) Where the excavations are anticipated to be below the water table which generally correspond with the water table being at, or within the, lower permeability silty sand till, (i.e. the southern/upland areas of the Site, even compared to the spring season of 2022 high water table).

The deepest excavations are associated with the installation of sanitary sewers (Urbantech 2023b). These depths were compared to the top of the silty sand till and the associated water table in order to determine areas where the more permeable overlying sand may require dewatering.

1. In the northern/downgradient part of the Site, sanitary sewer excavations are above, or at, the high spring season of 2022 water table elevations because of the large amount of fill are being added to the existing surface of the Site. Consequently, construction dewatering is not predicted.

2. In the southern/upland areas of the Site where excavations are anticipated to generate very little need for dewatering, if any, because of the low permeability of the silty sand till (Section 3.4.1).

3. Where the water table could be within the permeable silty sand in some upland/southern areas during higher water table conditions. This is not expected to generate greater than 50,000 L/day of dewatering. For example, if 3 m of silty sand along a 250 m northeast-southwest trench required dewatering during the April high water table, the calculated Darcy flow is less than 25,000 L/day (Fetter, 1995). This is based upon a hydraulic gradient of 0.061 m/m (Section 3.4.2), and a hydraulic conductivity of $6x10^{-6}$ m/s (Section 3.4.1).

No negative impacts are predicted to the tributary east of the Site as active dewatering is not predicted to be required.

Post-construction dewatering is not an expected concern due to the amount of fill proposed for the Site combined with the low permeability of the underlying silty sand till. It is acknowledged that there is removal of soils in the southern part of the Site as part of the cut/fill plan (Urbantech, 2023c), however this removes the most permeable overlying soils in an area where the water table is generally lower (e.g. in the underlying silty sand till).

7.0 Conclusions and Recommendations

7.1 Conclusions

The following conclusions are provided:

1. There are no watercourses at the Site.

2. Downgradient of the Site is the Erin Branch of the West Credit River, which has perennial flow and a cold-water regime. Analyses of West Credit River flows, upstream of the Site and Municipal Well E8, indicated a baseflow/groundwater discharge component of 71%. Pre-development baseflow measurements downgradient of the Site have indicated both groundwater discharge and groundwater recharge conditions.

3. Calculated on-site soil infiltration rates were greater than 15 mm/hour, including areas of >50 mm/hour making lot-level infiltration implementable

4. Surficial geology ranged from gravel and gravelly sand, to silty sand and silt, with a general thickness of approximately 3 metres above the underlying silty sand to sandy silt till aquitard.

5. Shallow groundwater flow follows the site topography with flow from the south-southeast to the north-northwest.

6. Bedrock groundwater levels at the Erin Branch of the West Credit River are artesian or above ground surface when Municipal Well E8 is not operating.

7. The natural vulnerability of the bedrock aquifer supplying Municipal Well E8 is medium to low beneath the Site because of overlying aquitard material.

8. Municipal Well E8 wellhead protection areas (WHPAs) extend beneath the Site. Policies requiring compliance at the Site concern the WHPA-A, which covers 0.64 hectares of the northwest corner of the Site. This area is proposed to be a park in order to protect the water quality of the municipal well.

9. Highly Vulnerable Aquifer mapping of the Site is related to the overlying sand and gravel, which is not a potable water supply on-site, and the sand and gravel is also not a potable water supply immediately downgradient of the Site and consequently this designation should not apply.

10. Credit Valley Conservation annual water balance modelling results for the Site were precipitation (897 mm/year), evapotranspiration (402 to 408 mm/year), runoff (114 to 122 mm/year) and recharge (368 to 381 mm/year). Considering soil conditions at the Site and existing impervious areas, the pre-development recharge rate for the Site was calculated as 340 mm/year.

11. Annual precipitation on average totals (i) 422 mm/year for precipitation events of 1 to 10 mm, (ii) 605 mm/year for precipitation events of 1 to 15 mm and (iii) 747 mm/year for events of 1 to 20 mm.

12. The pre-development recharge rate can be maintained to 80% during post-development with a combination of (a) infiltration of 'clean' runoff from precipitation events of 20 mm or less, and (b) permeable area recharge.

13. Provincially significant wetlands, located downgradient of the Site, are identified as mixed swamp cedar hardwood organic (4a SWM4-1), and poplar conifer mineral (5a SWM3-2) (Figure 5). These wetlands have high and medium hydrological sensitivity, respectively.

14. Two years of wetland and nearby water level monitoring have indicated:

    a. The SWM3-2 poplar (west) swamp was generally under recharge conditions with very shallow wetland water levels on average 7 cm below ground surface in clay and silt, with shallow groundwater levels on average 30 cm below ground surface.

    b. The SWM4-1 cedar (east) swamp was under recharge conditions and water levels were generally 30 cm below ground surface in wetland silt and clay with shallow groundwater levels 45 cm below ground surface.

15. Credit Valley Conservation wetland annual water balance modelling rates for the types of wetlands identified at the Site were precipitation (897 mm/year), evapotranspiration (578 mm/year), runoff (167 mm/year) and recharge (152 mm/year).

16. A pre-development monthly water balance for the wetlands indicated that soil water holding capacities are expected to be less than saturated during the summer season months of June to September.

17. Post-development Groundwater recharge rates upgradient of the wetlands can be maintained from infiltration of (a) clean roof runoff at SWM facilities, (b) preserved buffer areas, (c) uncontrolled area recharge and discharge and (c) upgradient pervious areas.

18. The develop risk assignment is high for Wetland 4a SWM4-1 cedar, and medium for Wetland 5a SWM3-2 poplar. The Wetland Risk Evaluation requirements have been met: (i) pre-development monitoring, which has been completed for 2 years, (ii) continuous hydrological modelling, which already exists and has been used in this report, and (iii) design of a mitigation plan which has been completed. For the Wetland 4a, given the high-risk assignment, (i) additional groundwater characterization was completed that included two additional monitoring wells up- and down-gradient of the wetland.

19. Sanitary infrastructure required within the Municipal Well E8 WHPA-A, requires a higher than standard construction/monitoring requirements to ensure a closed system, such as implementing extra flange protection.

20. Stormwater management facilities are prohibited within the Municipal Well E8 WHPA-A; however, CVC's stormwater management criteria (2012) state that "*infiltration from "clean" water sources such as roof runoff...will be encouraged in these areas*". This has been incorporated into Site planning and design.

21. Construction is not predicted to require groundwater control pumping methods for dewatering or an MECP EASR or PTTW.

7.2 Recommendations

The following recommendations are provided:

1. Submit our updated report to the Town of Erin and the Credit Valley Conservation;

2. Discontinue the surface water and groundwater monitoring program once Site Plan Approval is received from the Town of Erin, Credit Valley Conservation and Wellington Source Water Protection.

3. The fil material to be imported or relocated on Site should be permeable loam or a material with a higher infiltration rate than the underlying native silty sand till.

4. Implement a salt management plan for the Site based upon the Town of Erin approach which required a 5% salt/95% sand mix except during freezing events where 10% salt/90% sand is applied.

5. All existing private water supply wells and monitoring wells should be decommissioned by a licensed Ontario water well contractor in compliance with the Ontario Water Resources Act Regulation 903.

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

D D Slaine

LICENSED PROFESSIONAL ENGINEER
Sept 18, 2023
J. D. CAMPBELL
J.D. Campbell
PROVINCE OF ONTARIO

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

David D. Slaine, M.Sc., P. Geo.
Principal Hydrogeologist & President

cc. Cesare Pittelli, Senior Planner, Project Manager, Armstrong Planning & Project Management

Attachments
Figure 1 – Location of Subject Lands
Figure 2 – Site Details
Figure 3 – Geological Cross-Section A-A'
Figure 5 – Surface water/Groundwater Flow
Appendix A - Hydrographs
Appendix B – Borehole logs
Appendix C – Hydraulic Conductivity Analyses
Appendix D – Provincial Maps

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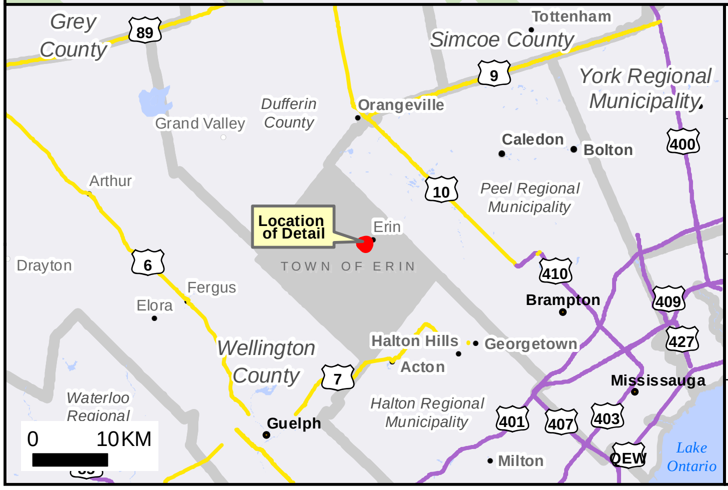


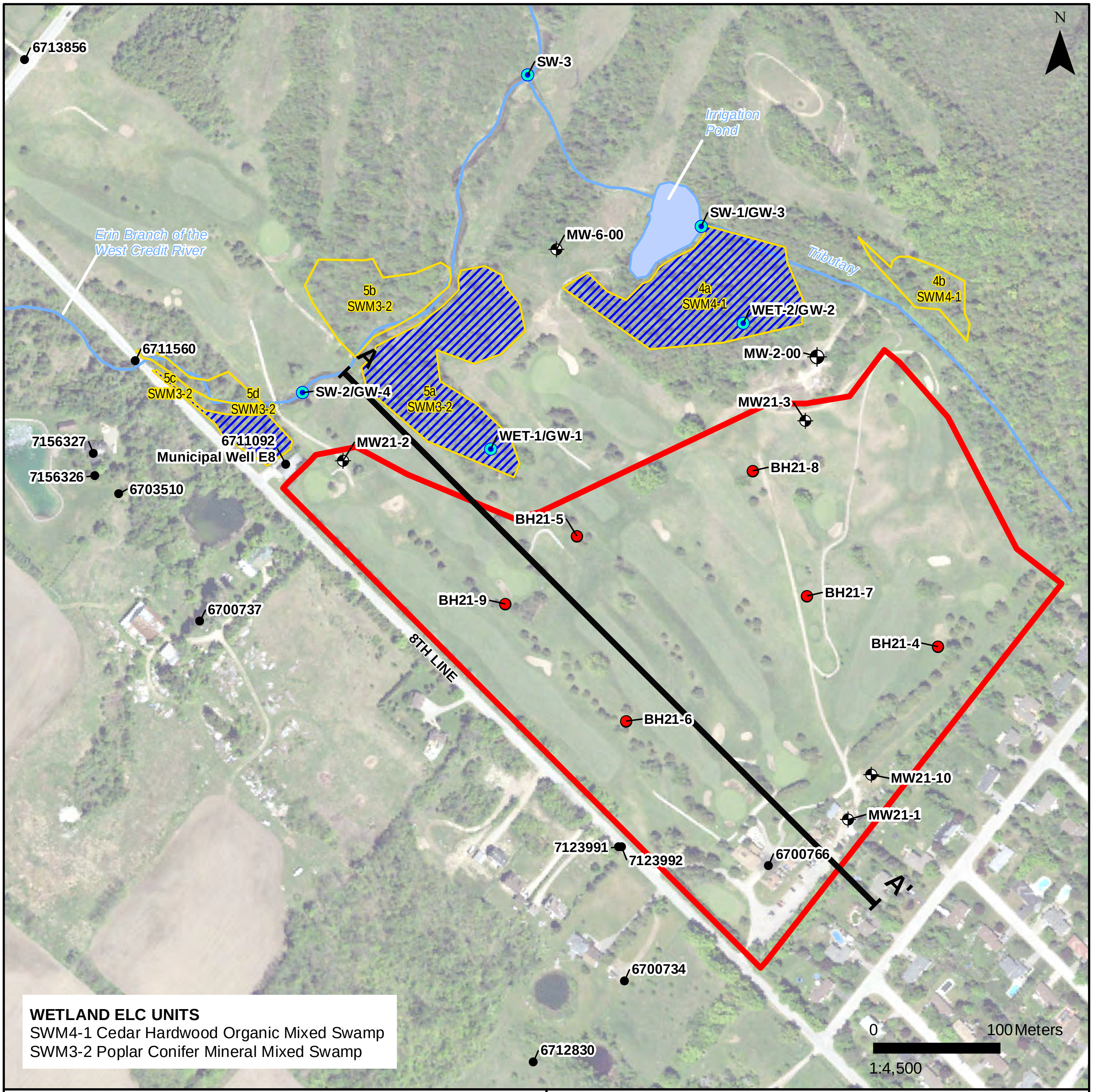
Site Location

Erin Fairways Subdivision
5525 8th Line, Town of Erin, ON
EC (Erin) GP Inc.

TDC Terra-Dynamics Consulting Inc.

Figure 1

Path: H:\TERRA_DYNAMICS\9511 - TD Empire Erin\gis\mxd\Figure 1 Location of Subject Lands.mxd Revised: January 21, 2022



WETLAND ELC UNITS
SWM4-1 Cedar Hardwood Organic Mixed Swamp
SWM3-2 Poplar Conifer Mineral Mixed Swamp

▭ Subject Lands
▨ Wetlands
■ Irrigation Pond
▭ Ecological Land Classification
━ Geologic Cross-section Location
— Ground Surface Contour (5m)
— Watercourse
● Geotechnical Borehole
⌖ Monitoring Well
• Water Well Record (MECP)
◉ Drive-point Piezometers and Staff Gauges

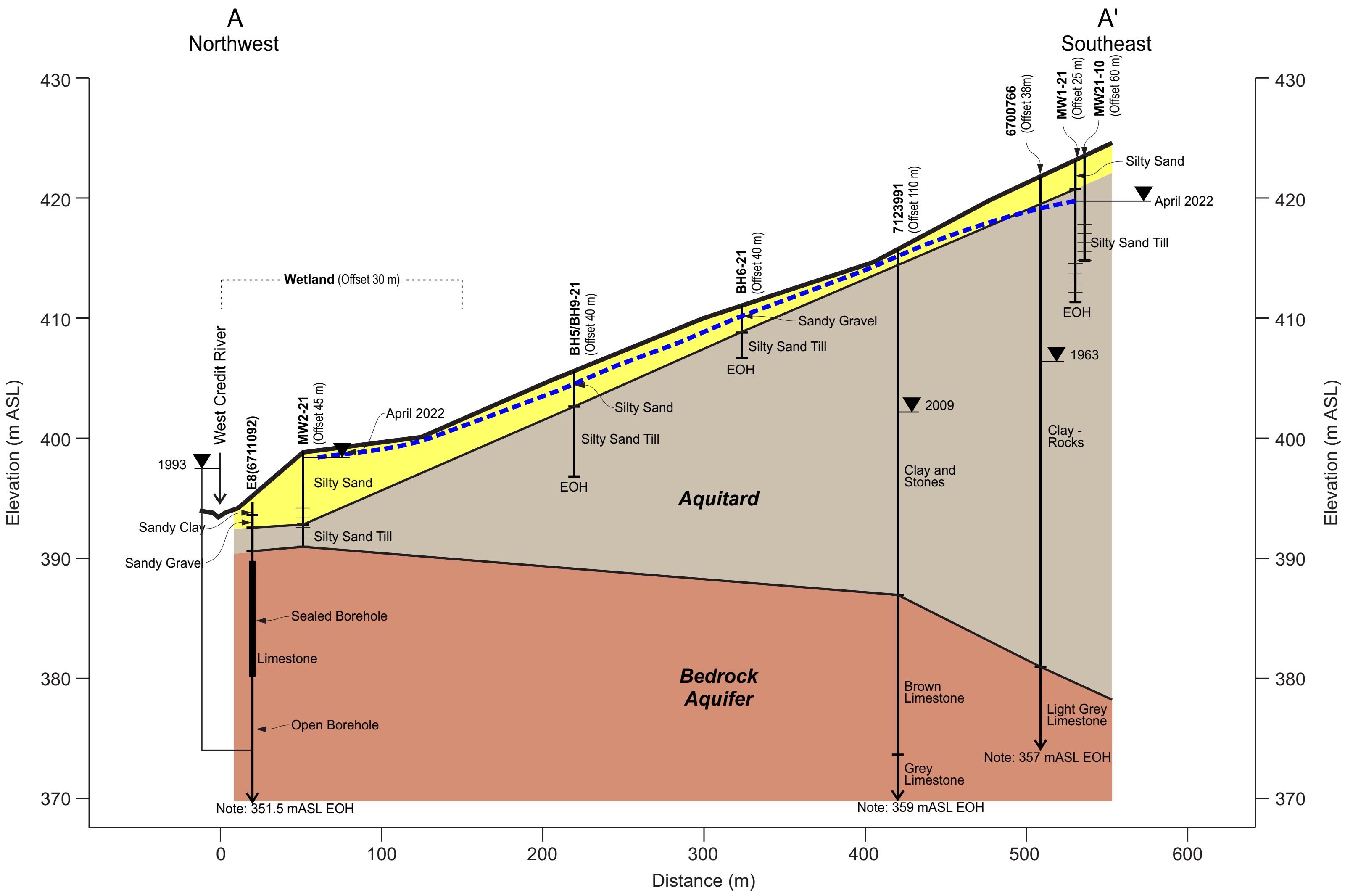
Site Details

Erin Fairways Subdivision
5525 8th Line, Town of Erin, ON
EC (Erin) GP Inc.

TDC Terra-Dynamics Consulting Inc.

Figure 2

Path: H:\TERRA_DYNAMICS\9511 - TD Empire Erin\gis\mxd\Figure 2 Site Details.mxd Revised: September 5, 2023



⊥	Borehole	🟨	Sand/Gravel
☰	Well Screen	▨	Silty Sand Till
EOH	End of Hole	🟫	Bedrock
▼	Water Level		
- - -	High Water Table April 2022		

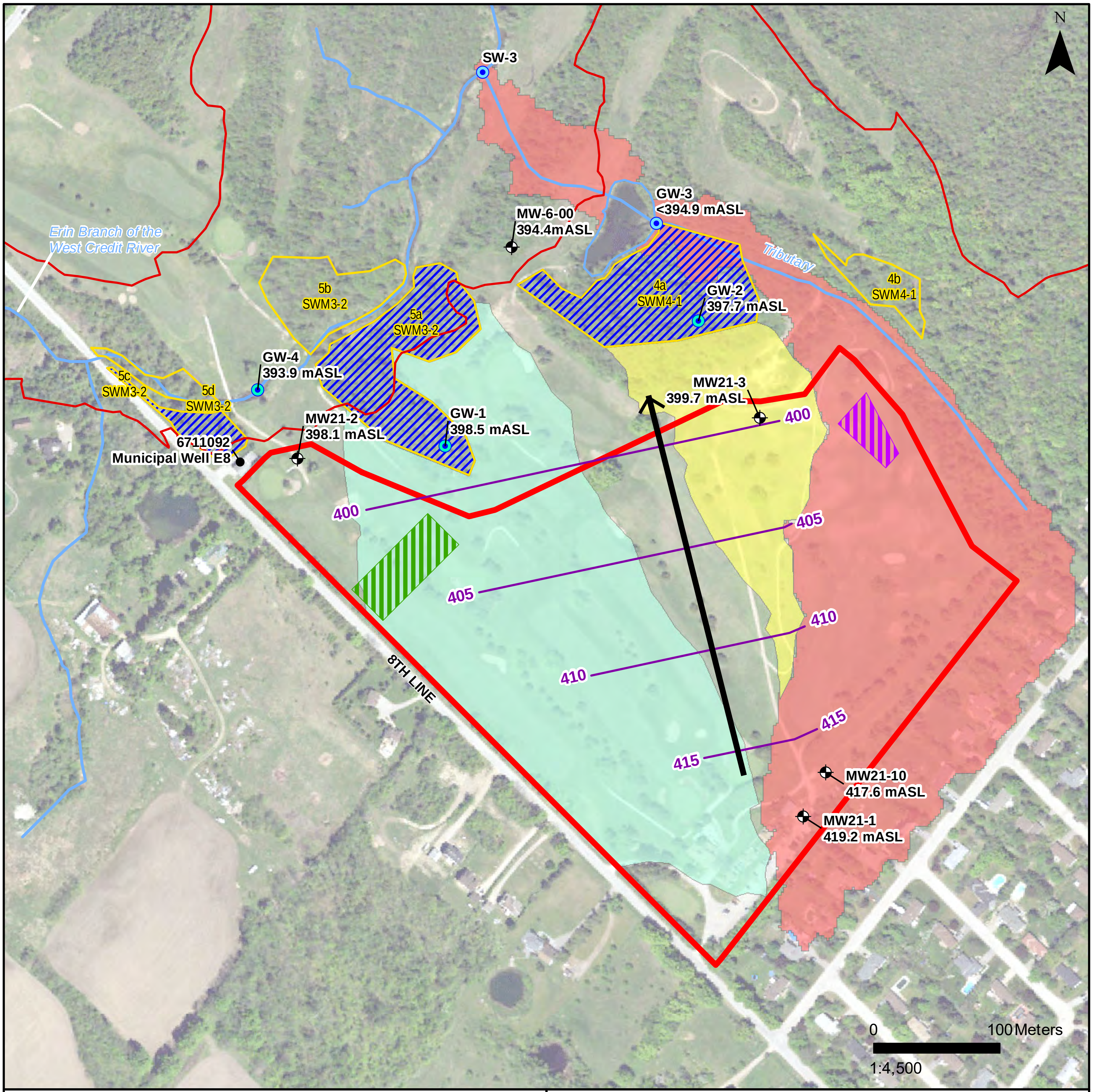
Geologic Cross-section A-A’

Erin Fairways Subdivision
5525 8th Line, Town of Erin, ON
EC (Erin) GP Inc.

TDC Terra-Dynamics Consulting Inc.

Figure 3

H:\TERRA_DYNAMICS\9511 - TD Empire Erin\corel\Figure 3 Geologic Cross-section A-A'.cdr Revised: September 18, 2023



🟥 Subject Lands

▨ Wetlands

— Watercourse

☐ Ecological Land Classification

🟩 Area for Infiltration of Clean Water

🟪 Surface Infiltration Gallery

⌖ Monitoring Well

● Water Well Record (MECP)

◉ Drive-point piezometers – groundwater levels November 10, 2021

— Shallow Groundwater Flow Contour (December 14, 2021)

→ Shallow Groundwater Flow Direciton

Catchment Areas

🟨 Wetland 4a

🟩 Wetland 5a

🟥 Tributary

Surface Water / Groundwater Flow

Erin Fairways Subdivision
5525 8th Line, Town of Erin, ON
EC (Erin) GP Inc.

TDC Terra-Dynamics Consulting Inc.

Figure 5

Path: H:\TERRA_DYNAMICS\9511 - TD Empire Erin\gis\mxd\Figure 5 Surfacewater Groundwater flow.mxd Revised: September 18, 2023

Appendix A

Hydrographs

TABLE A-1
PRECIPITATION ANALYSES

Year	**2021**									
Month	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Precipitation (mm)	36.6	54.5	25.2	105.4	92.7	54.6	162.5	100.5	54.6	94.2
Average Precipitation (mm)	60	74	87	84	89	97	93	77	93	69
% Difference	61%	74%	29%	125%	104%	56%	175%	131%	59%	137%
3-Month %			55%	76%	86%	95%	112%	121%	121%	109%

Year	**2022**											
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Precipitation (mm)	43.6	125.4	75.1	55.1	62.8	59.4	46.5	119.1	35.1	43.2	63.4	83.7
Average Precipitation (mm)	68	56	60	74	87	84	89	97	93	77	93	69
% Difference	64%	224%	125%	74%	72%	71%	52%	123%	38%	56%	68%	121%
3-Month %	86%	142%	138%	141%	91%	72%	65%	82%	71%	72%	54%	82%
					Period of below-average precipitation							

Year	**2023**						
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**
Precipitation (mm)	76.8	73.8	128.3	79.2	38.2	98.5	140.9
Average Precipitation (mm)	68	56	60	74	87	84	89
% Difference	113%	132%	214%	107%	44%	117%	158%
3-Month %	101%	122%	153%	151%	122%	89%	106%

Note: The climate station used for the precipitation values is Fergus Shand Dam, Ontario.
The climate station had a missing precipitation value on December 23, 2022.
Therefore, the precipitation value for that day was taken from the Georgetown WWTP, Ontario climate station.

Table A-2
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)	Depth at Staff Gauge (m)	Water Level Elevation (m ASL)
GW-1	398.66	0.90	399.56	1.74	0.84	25-Aug-21	Dry	Dry	-	Dry
						10-Nov-21	1.03	0.13	-	398.53
						5-Apr-22	0.89	-0.01	-	398.67
						4-Aug-22	Dry	Dry	-	Dry
						10-Nov-22	Dry	Dry	-	Dry
						19-May-23	0.97	0.07	-	398.59
						2-Aug-23	1.14	0.24	-	398.42
GW-2	398.16	1.10	399.26	2.37	1.27	25-Aug-21	Dry	Dry	-	Dry
						10-Nov-21	1.60	0.50	-	397.66
						5-Apr-22	1.52	0.42	-	397.74
						4-Aug-22	Dry	Dry	-	Dry
						10-Nov-22	1.62	0.52	-	397.64
						19-May-23	1.46	0.36	-	397.80
						2-Aug-23	1.46	0.36	-	397.80
GW-3	395.91	0.92	396.83	2.05	1.13	5-Apr-22	1.86	0.94	-	394.97
						4-Aug-22	Dry	Dry	-	Dry
						10-Nov-22	1.67	0.75	-	395.16
						19-May-23	Dry	Dry	-	Dry
						2-Aug-23	1.35	0.43	-	395.48
GW-4	394.04	1.09	395.13	1.74	0.65	25-Aug-21	Dry	Dry	-	Dry
						10-Nov-21	1.28	0.19	-	393.85
						5-Apr-22	1.86	0.77	-	393.27
						4-Aug-22	1.50	0.41	-	393.63
						10-Nov-22	1.38	1.38	-	393.76
						19-May-23	1.35	0.26	-	393.78
						2-Aug-23	Dry	Dry	-	Dry

Table A-2
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)	Depth at Staff Gauge (m)	Water Level Elevation (m ASL)
Wet-1	398.66	0.72	399.38	0.99	0.27	25-Aug-21	Dry	-	Dry	Dry
						10-Nov-21	Dry	-	Dry	Dry
						5-Apr-22	0.70	-	0.03	398.68
						4-Aug-22	Dry	-	Dry	Dry
						10-Nov-22	Dry	-	Dry	Dry
						19-May-23	Dry	-	Dry	Dry
						2-Aug-23	Dry	-	Dry	Dry
Wet-2	398.16	0.56	398.72	0.99	0.43	25-Aug-21	Dry	-	Dry	Dry
						10-Nov-21	Dry	-	Dry	Dry
						5-Apr-22	Dry	-	Dry	Dry
						4-Aug-22	Dry	-	Dry	Dry
						10-Nov-22	Dry	-	Dry	Dry
						19-May-23	Dry	-	Dry	Dry
						2-Aug-23	Dry	-	Dry	Dry
SW-1	394.51	0.73	395.24	0.99	0.26	25-Aug-21	0.70	-	0.04	394.55
						10-Nov-21	NA	NA	NA	NA
As Apr 5, 2022	~394.92	0.30	395.22	0.79	0.49	5-Apr-22	0.24	NA	0.06	394.99
						4-Aug-22	0.24	-	0.03	394.98
						10-Nov-22	0.23	-	0.04	394.99
						19-May-23	0.25	-	0.02	394.97
						2-Aug-23	-0.02	-	0.24	395.24
SW-2	393.51	0.64	394.15	0.80	0.16	25-Aug-21	0.48	-	0.14	393.67
						10-Nov-21	0.38	-	0.22	393.77
						5-Apr-22	0.36	-	0.22	393.80
						4-Aug-22	0.45	-	0.17	393.70
						10-Nov-22	0.43	-	0.21	393.72
						19-May-23	0.42	-	0.22	393.73
						2-Aug-23	0.42	-	0.23	393.73

Table A-2
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)	Depth at Staff Gauge (m)	Water Level Elevation (m ASL)
SW-3	392.76	1.25	394.01	NA	NA	25-Aug-21	NA	-	0.46	~392.46
						10-Nov-21	0.36	-	0.62	393.65
						5-Apr-22	0.42	-	0.61	393.59
						4-Aug-22	0.73	-	0.18	393.28
						10-Nov-22	0.64	-	0.32	393.37
						19-May-23	0.61	-	0.23	393.41
						2-Aug-23		-	0.23	394.01
MW-6-00	395.15	0.87	396.02	3.62	2.75	10-Nov-21	1.69	0.81	-	394.34
						5-Apr-22	1.61	1.61	-	394.41
						4-Aug-22	2.37	2.37	-	393.65
						10-Nov-22	2.09	1.22	-	393.93
						19-May-23	1.96	1.08	-	394.07
						2-Aug-23	1.82	0.95	-	394.20
MW-2-00	401.40	0.61	402.01	397.32	396.71	10-Nov-22	4.29	3.68	---	397.72
						19-May-23	3.41	2.80	---	398.60
						2-Aug-23	3.67	3.06	---	398.34

Note:

MW=Monitoring well; SG=Staff gauge; TOC= Top of Casing; m ASL=metres above sea level; * - Depth at staff gauge

On April 5, 2022 GW-3 was shifted deeper by 0.17 m

On April 5, 2022 SW-1 was re-installed

Project No.: 21-129-300
Water Level Monitoring
Erin Heights Golf Course, Erin, ON

Summary of Groundwater Monitoring Data

		Date	2021-04-28 (Loggers installed)			2021-08-11			2021-12-14			2022-01-12		
Well ID	Ground Elevation	Stickup	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation
	masl	mags	T.O.P	mbgs	masl	T.O.P	mbgs	masl	T.O.P	mbgs	masl	T.O.P	mbgs	masl
BH 21-1	422.8	0.00	5.0	5.00	417.80	3.81	3.81	418.99	3.63	3.63	419.17	*	*	*
BH 21-2	398.8	0.94	2.1	1.18	397.62	2.68	1.74	397.06	1.65	0.71	398.09	1.87	0.93	397.87
BH21-3	405.7	0.95	7.3	6.33	399.37	7.81	6.86	398.84	6.94	5.99	399.71	6.97	6.02	399.68
BH 21-10	419.1	0.93	2.6	1.69	417.41	3.22	2.29	416.81	2.39	1.46	417.64	2.66	1.73	417.37

		Date	2022-02-16			2022-03-21			2022-04-28			2022-07-25		
Well ID	Ground Elevation	Stickup	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation
	masl	mags	T.O.P	mbgs	masl	T.O.P	mbgs	masl	T.O.P	mbgs	masl	T.O.P	mbgs	masl
BH 21-1	422.8	0.00	*	*	*	*	*	*	3.70	3.70	419.10	5.77	5.77	417.03
BH 21-2	398.8	0.94	2.22	1.28	397.52	1.59	0.65	398.15	1.52	0.58	398.22	2.82	1.88	396.92
BH21-3	405.7	0.95	7.29	6.34	399.36	6.48	5.53	400.17	6.74	5.79	399.91	7.67	6.72	398.98
BH 21-10	419.1	0.93	3.00	2.07	417.03	1.47	0.54	418.56	2.52	1.59	417.51	3.49	2.56	416.54

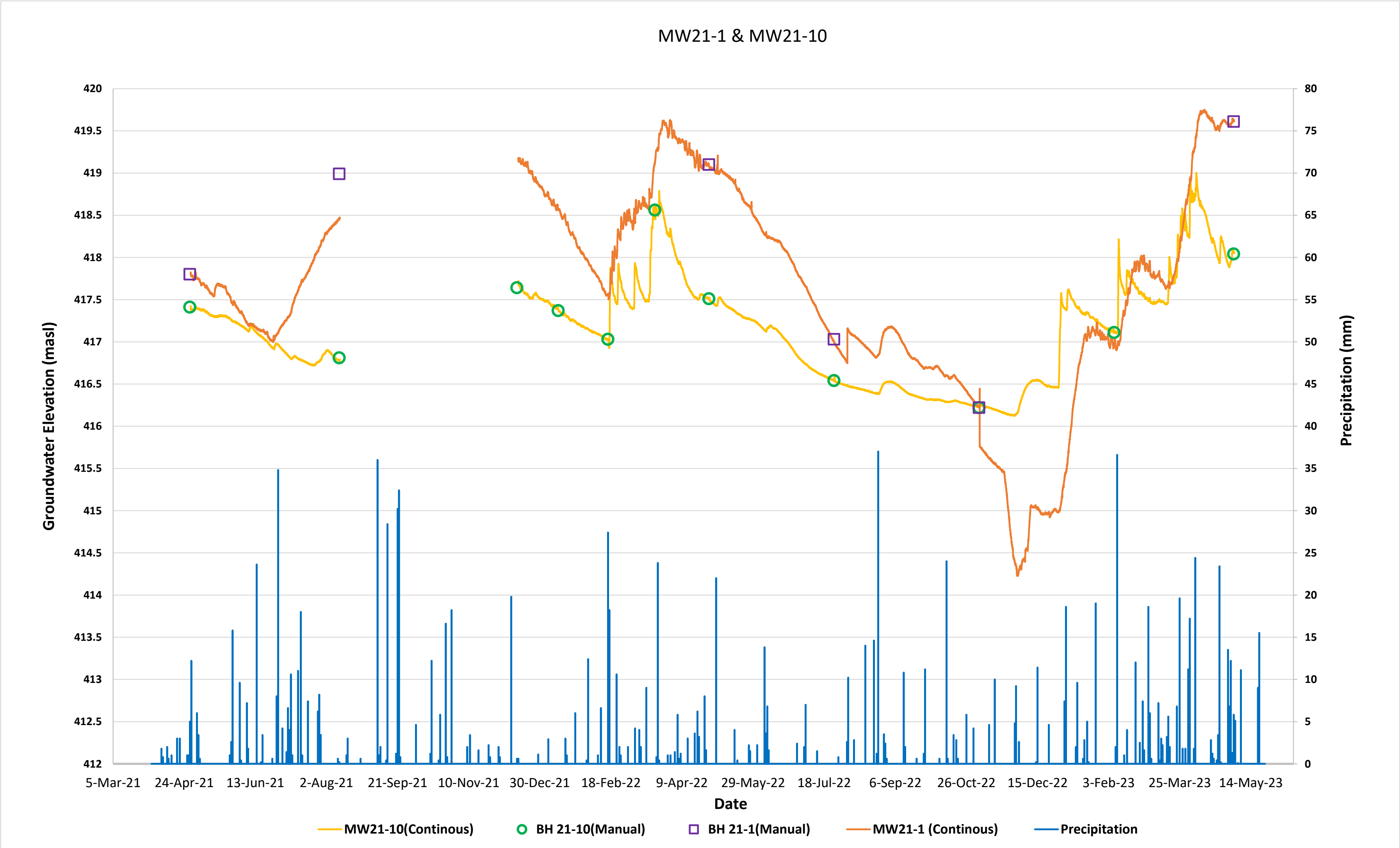
		Date	2022-11-04			2023-02-06			2023-05-02		
Well ID	Ground Elevation	Stickup	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation	Water Level	Water Level	Water Elevation
	masl	mags	T.O.P	mbgs	masl	T.O.P	mbgs	masl	T.O.P	mbgs	masl
BH 21-1	422.8	0.00	6.58	6.58	416.22	*	*	*	3.19	3.19	419.61
BH 21-2	398.8	0.94	3.35	2.41	396.39	3.17	2.23	396.57	1.56	0.62	398.18
BH21-3	405.7	0.95	7.83	6.88	398.82	7.65	6.70	399.00	6.73	5.78	399.92
BH 21-10	419.1	0.93	3.81	2.88	416.22	2.92	1.99	417.11	1.99	1.06	418.04

Note:

* BH21-1 was not accessible due to snow/ice cover

DS Consultants Ltd.
April, 2022

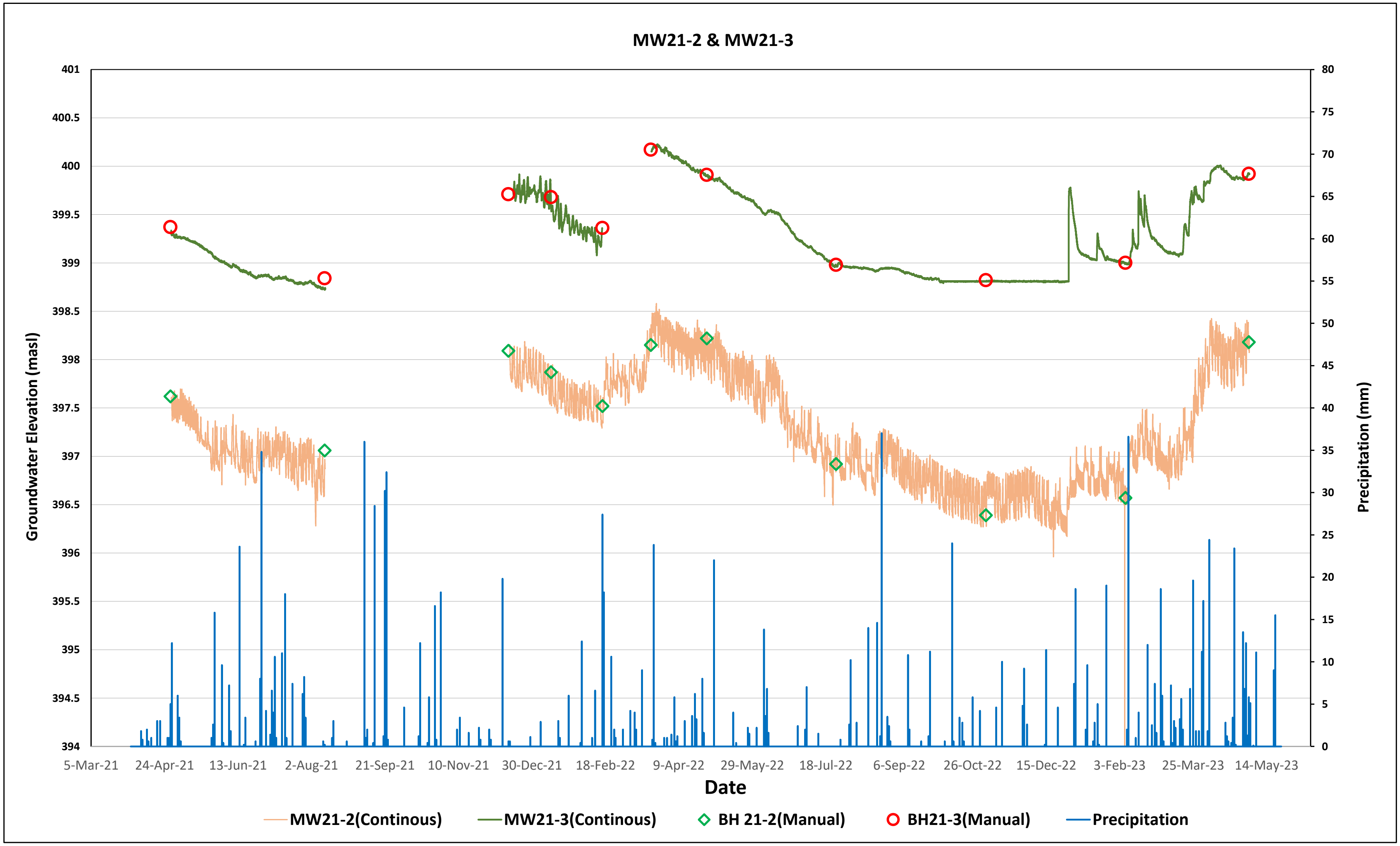
WATER LEVEL HYDROGRAPH



DS CONSULTANTS LTD.
Geotechnical • Environmental • Materials • Hydrogeology

Erin Heights Golf Course, Erin, ON
HYDROGRAPH
Baseline Groundwater and Surface Water Monitoring
April 2021 - Nov 2022

WATER LEVEL HYDROGRAPH



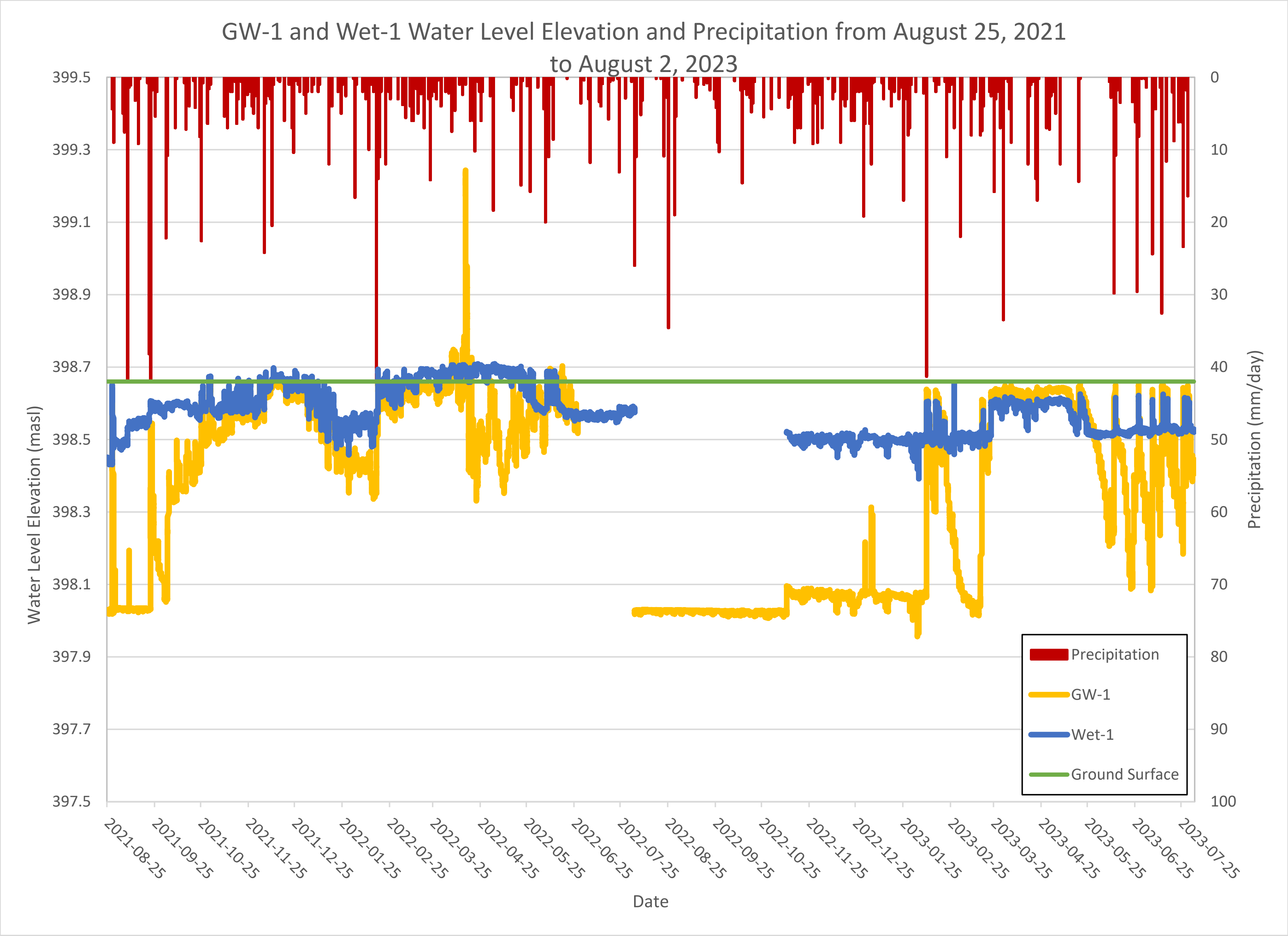
DS CONSULTANTS LTD.
Geotechnical • Environmental • Materials • Hydrogeology

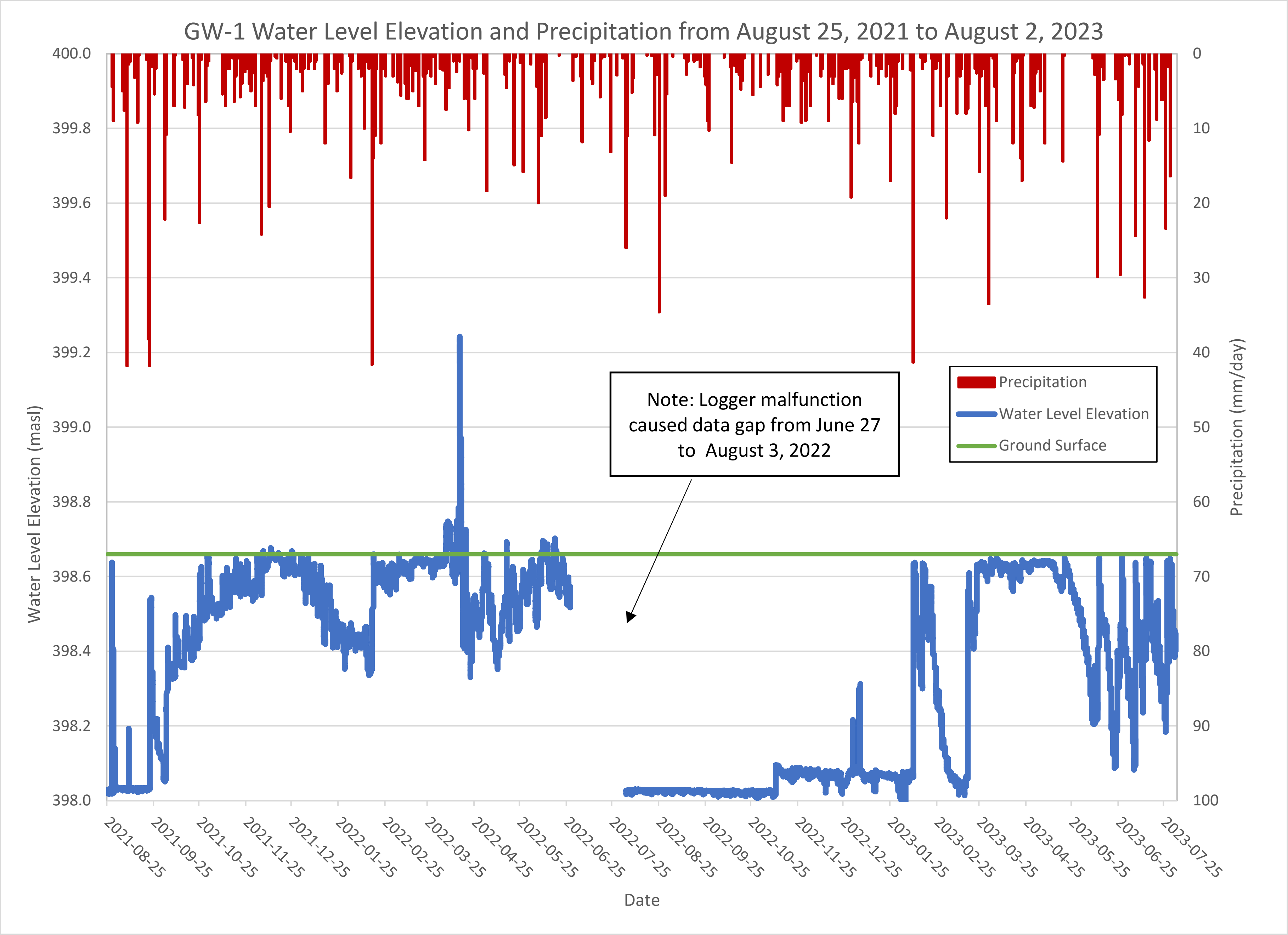
Erin Heights Golf Course, Erin, ON

HYDROGRAPH

Baseline Groundwater and Surface Water Monitoring

April 2021 - Nov 2022


GW-1 and Wet-1 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
399.5
399.3
399.1
398.9
398.7
398.5
398.3
398.1
397.9
397.7
397.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date
Precipitation
GW-1
Wet-1
Ground Surface


GW-1 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
400.0
399.8
399.6
399.4
399.2
399.0
398.8
398.6
398.4
398.2
398.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Note: Logger malfunction caused data gap from June 27 to August 3, 2022
Precipitation
Water Level Elevation
Ground Surface
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
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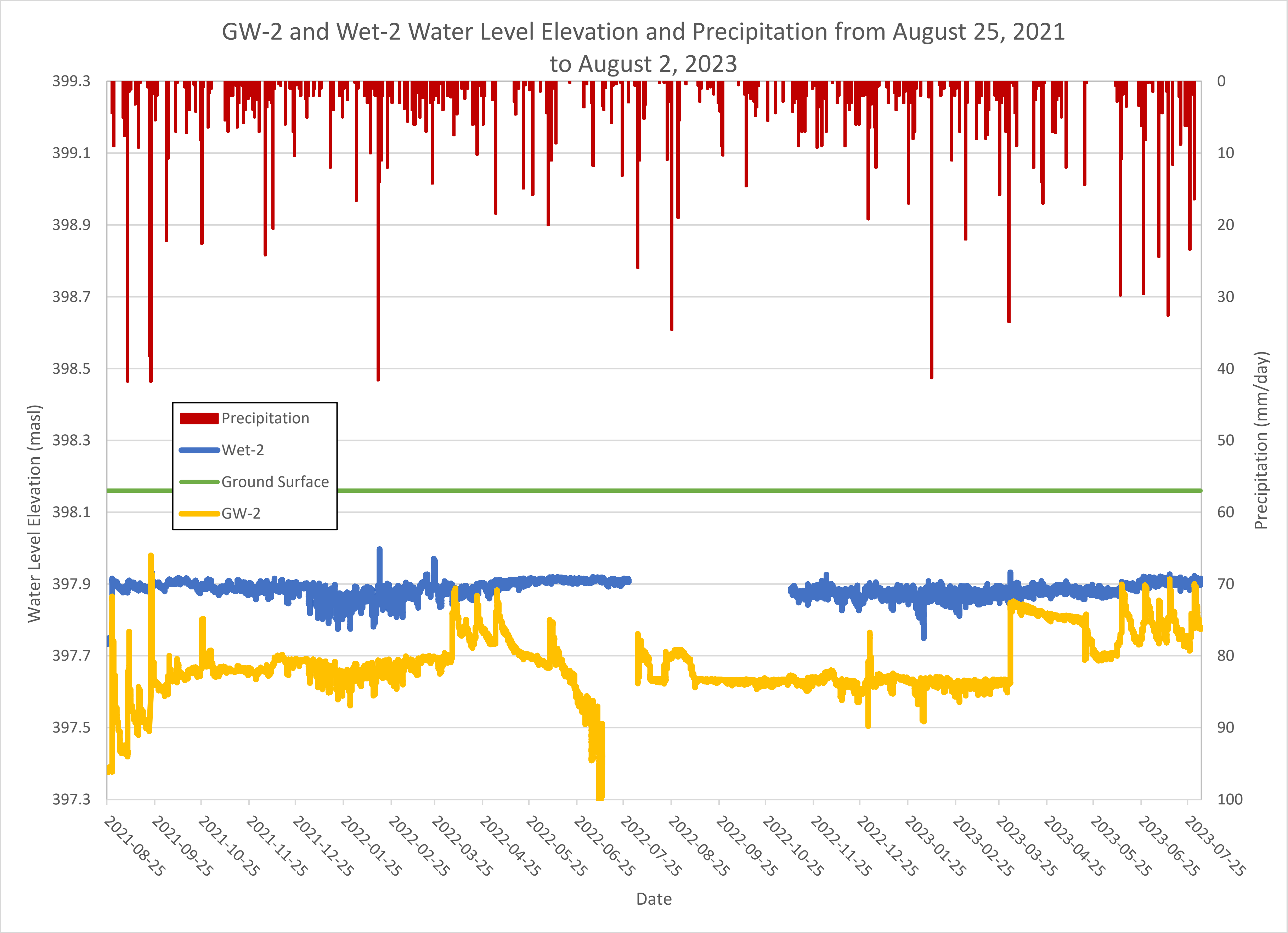
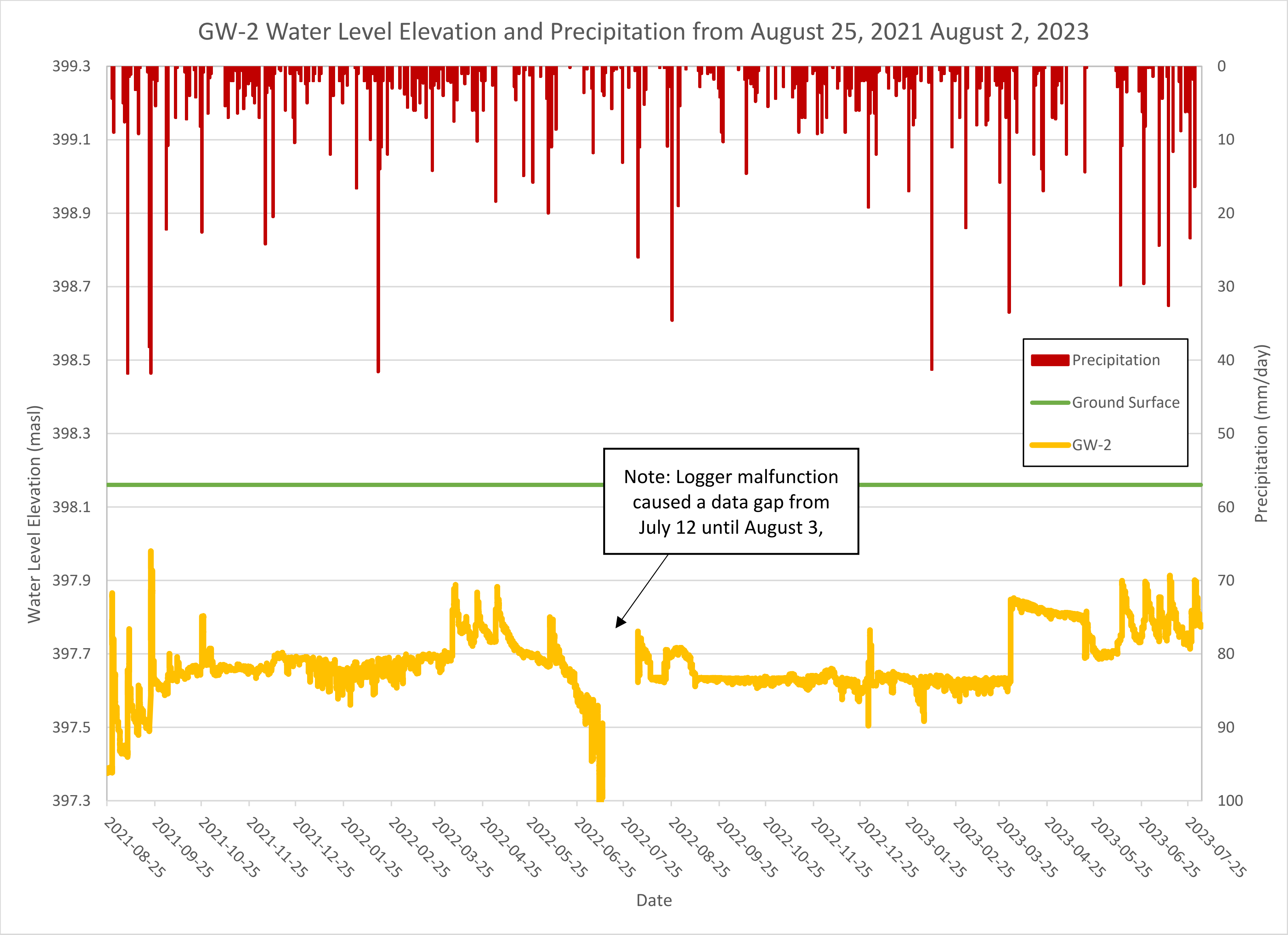
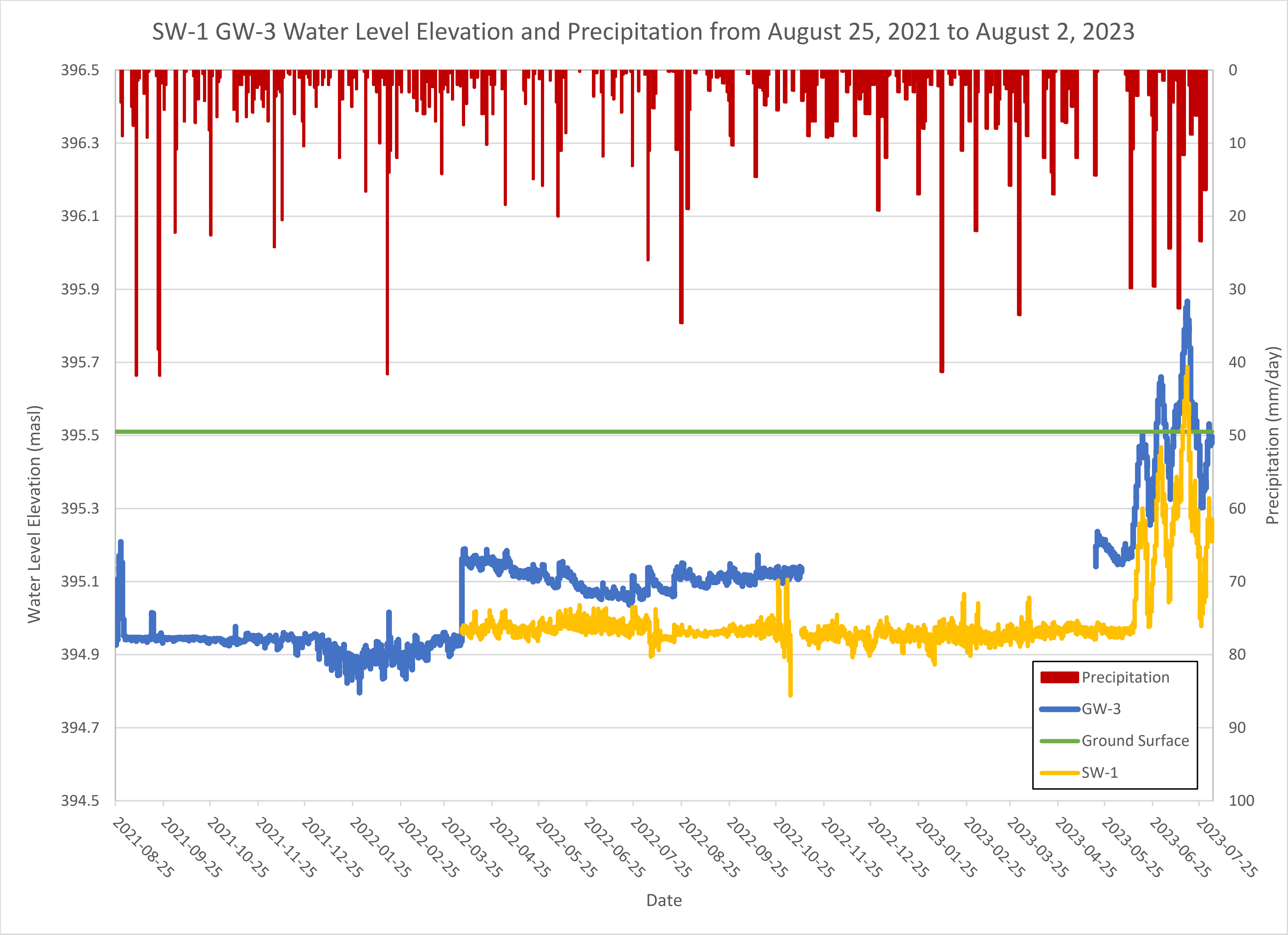
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date

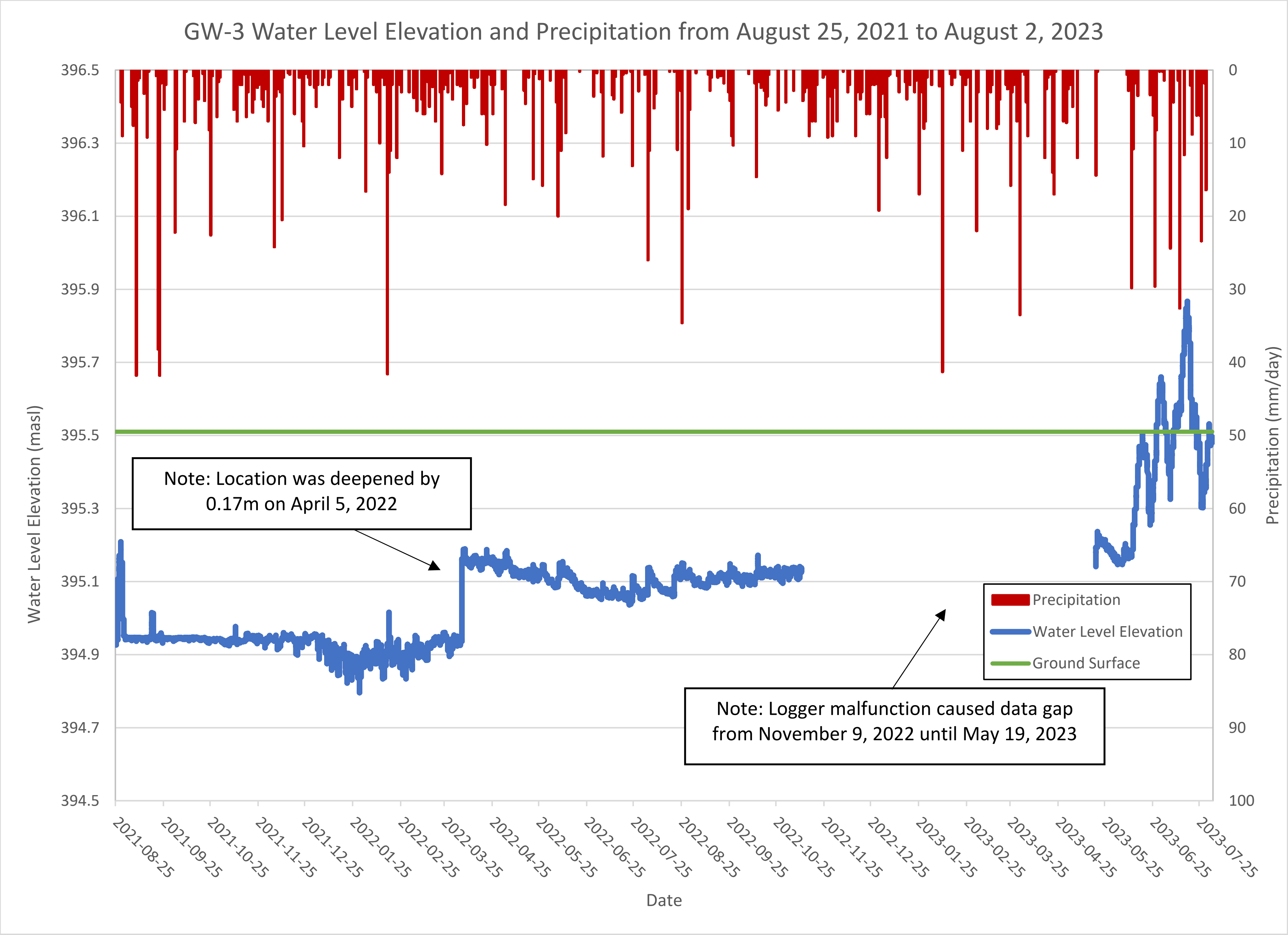

GW-2 and Wet-2 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
399.3
399.1
398.9
398.7
398.5
398.3
398.1
397.9
397.7
397.5
397.3
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Wet-2
Ground Surface
GW-2
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date

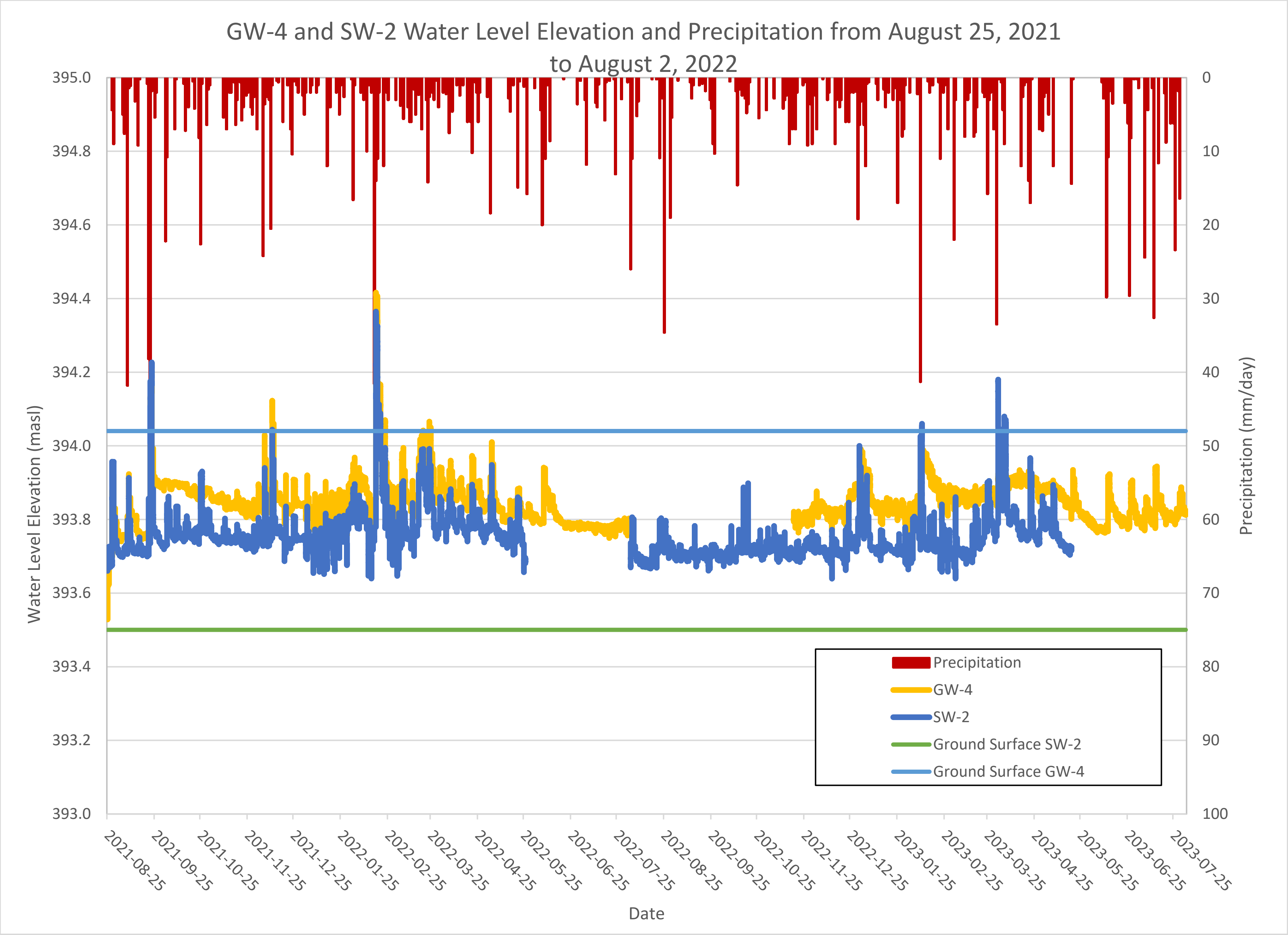


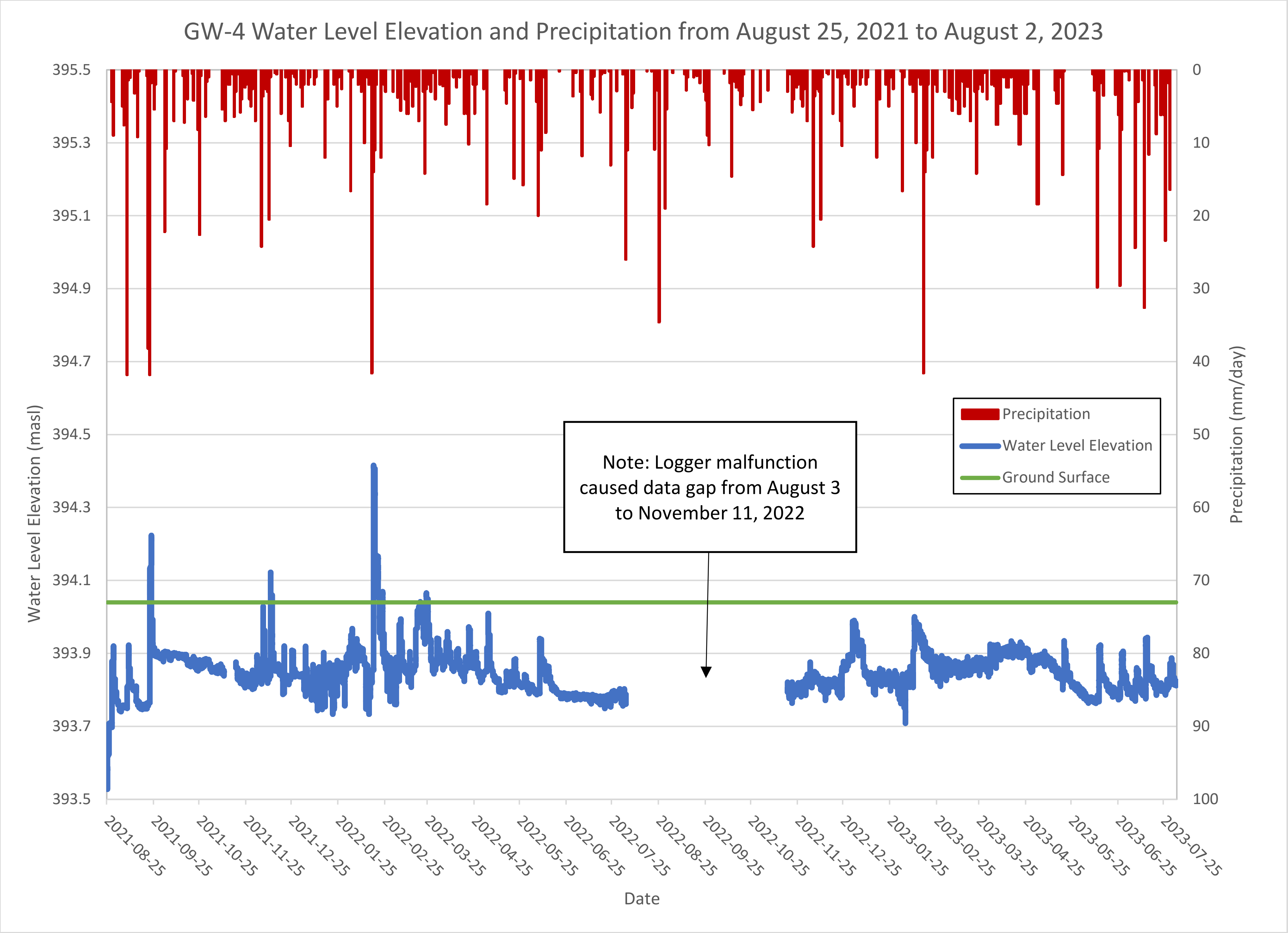
GW-2 Water Level Elevation and Precipitation from August 25, 2021 August 2, 2023

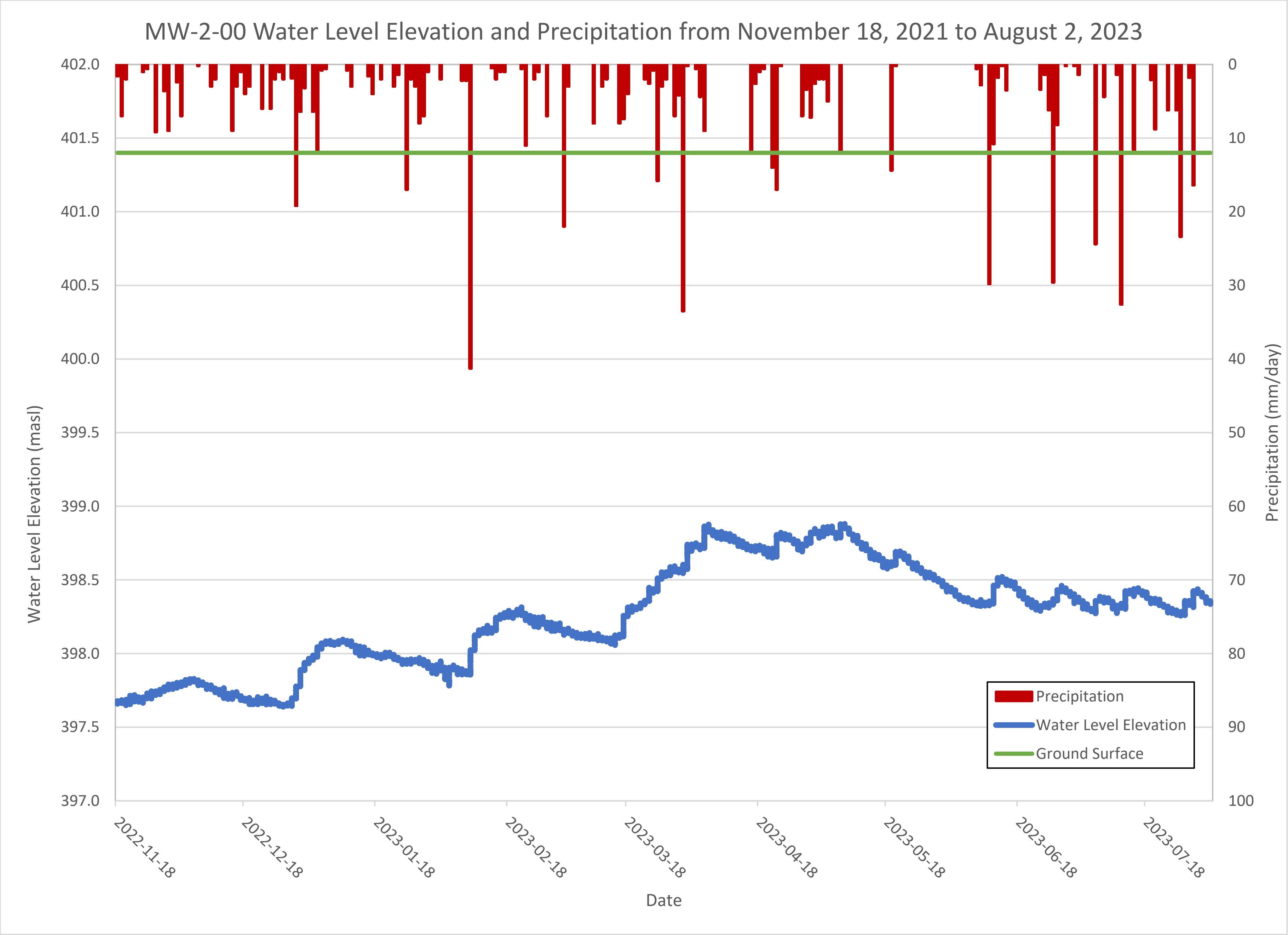
Note: Logger malfunction caused a data gap from July 12 until August 3,

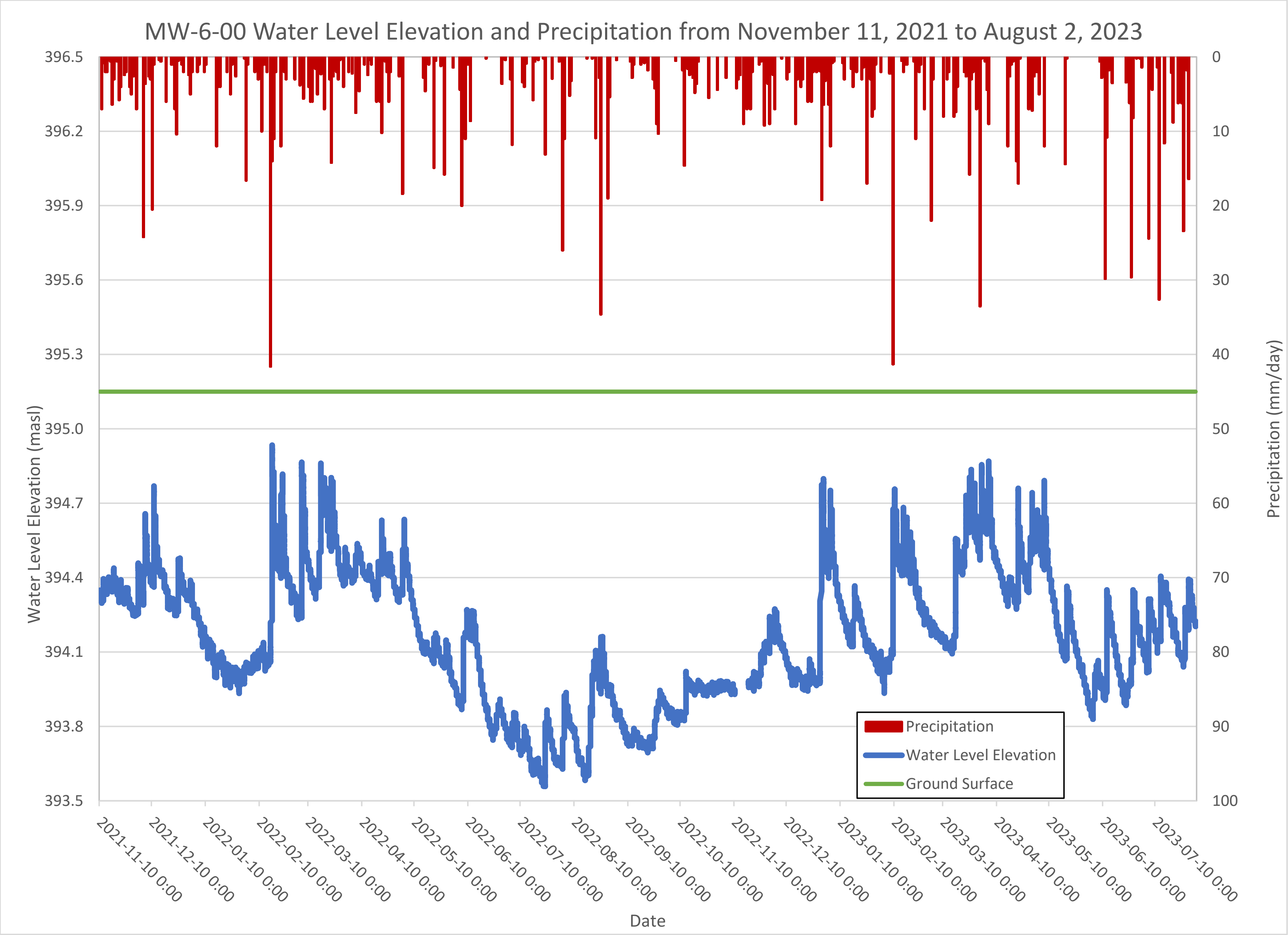

SW-1 GW-3 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
396.5
396.3
396.1
395.9
395.7
395.5
395.3
395.1
394.9
394.7
394.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date
Precipitation
GW-3
Ground Surface
SW-1

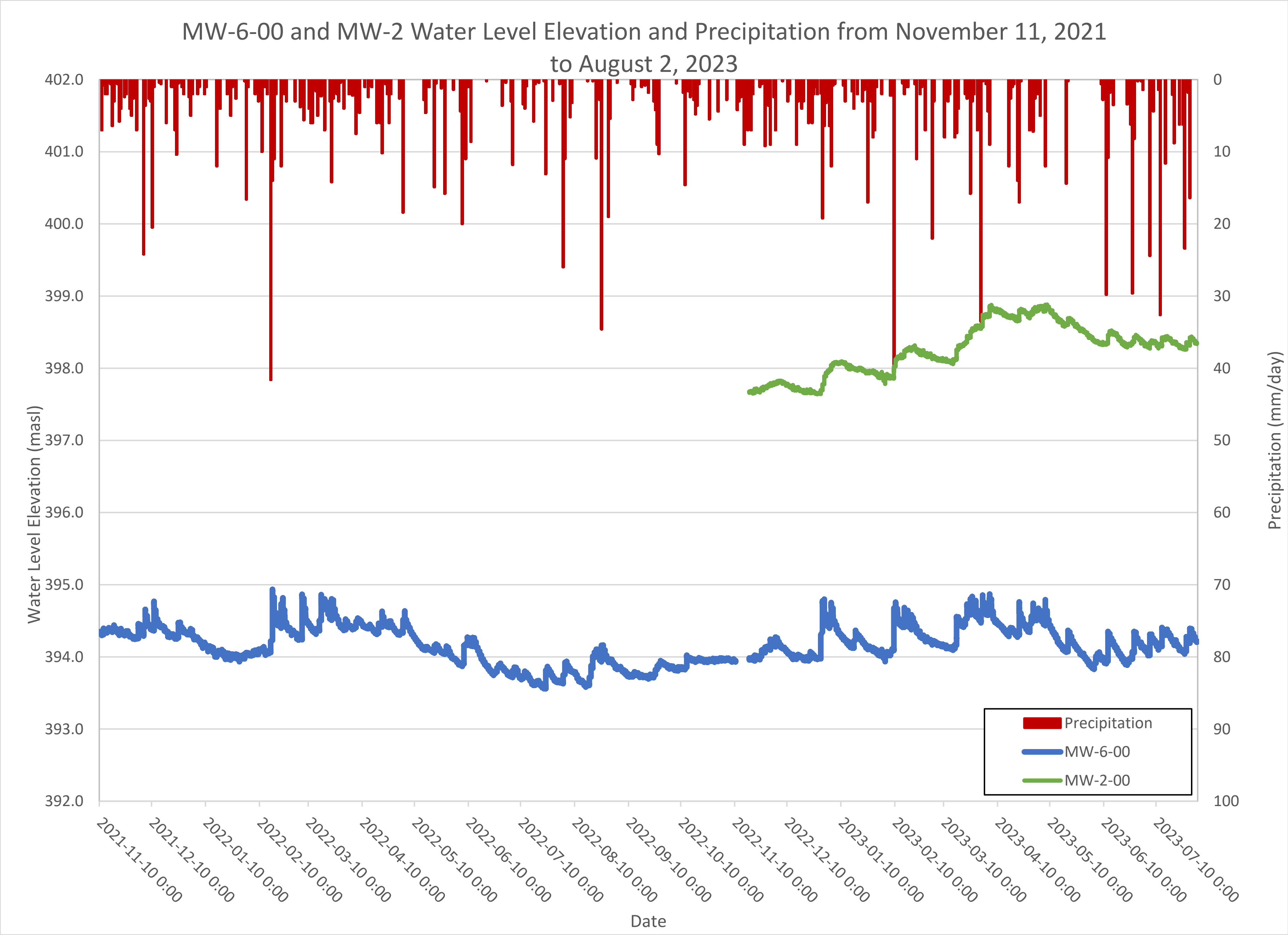

GW-3 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
396.5
396.3
396.1
395.9
395.7
395.5
395.3
395.1
394.9
394.7
394.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Note: Location was deepened by 0.17m on April 5, 2022
Note: Logger malfunction caused data gap from November 9, 2022 until May 19, 2023
Precipitation
Water Level Elevation
Ground Surface
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date


GW-4 and SW-2 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2022
Water Level Elevation (masl)
395.0
394.8
394.6
394.4
394.2
394.0
393.8
393.6
393.4
393.2
393.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Date
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Precipitation
GW-4
SW-2
Ground Surface SW-2
Ground Surface GW-4

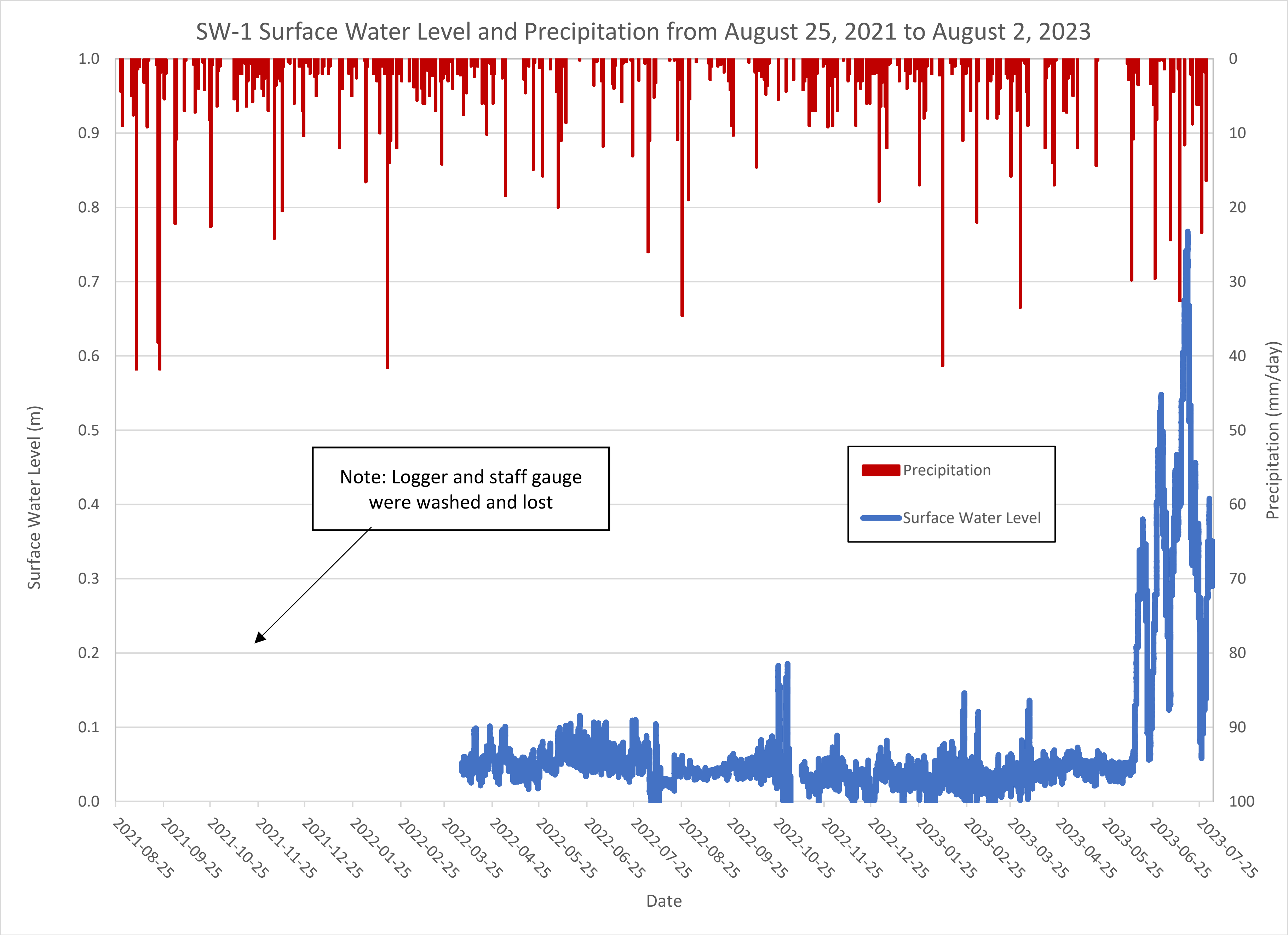

GW-4 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
395.5
395.3
395.1
394.9
394.7
394.5
394.3
394.1
393.9
393.7
393.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Water Level Elevation
Ground Surface
Note: Logger malfunction caused data gap from August 3 to November 11, 2022
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date

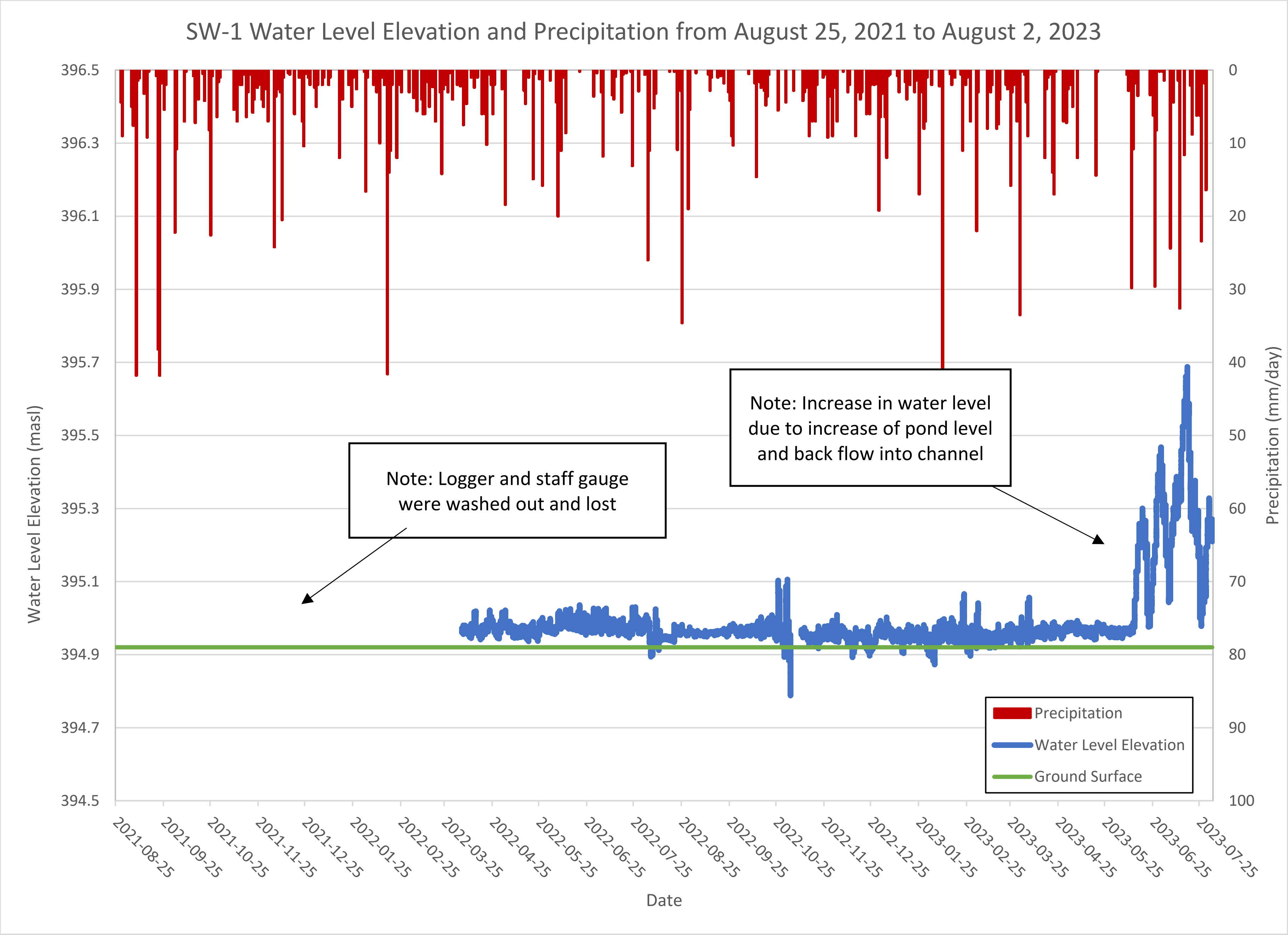

MW-2-00 Water Level Elevation and Precipitation from November 18, 2021 to August 2, 2023
Water Level Elevation (masl)
402.0
401.5
401.0
400.5
400.0
399.5
399.0
398.5
398.0
397.5
397.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
2022-11-18
2022-12-18
2023-01-18
2023-02-18
2023-03-18
2023-04-18
2023-05-18
2023-06-18
2023-07-18
Date
Precipitation
Water Level Elevation
Ground Surface

MW-6-00 Water Level Elevation and Precipitation from November 11, 2021 to August 2, 2023
Water Level Elevation (masl)
396.5
396.2
395.9
395.6
395.3
395.0
394.7
394.4
394.1
393.8
393.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Date
2021-11-10 0:00
2021-12-10 0:00
2022-01-10 0:00
2022-02-10 0:00
2022-03-10 0:00
2022-04-10 0:00
2022-05-10 0:00
2022-06-10 0:00
2022-07-10 0:00
2022-08-10 0:00
2022-09-10 0:00
2022-10-10 0:00
2022-11-10 0:00
2022-12-10 0:00
2023-01-10 0:00
2023-02-10 0:00
2023-03-10 0:00
2023-04-10 0:00
2023-05-10 0:00
2023-06-10 0:00
2023-07-10 0:00
Precipitation
Water Level Elevation
Ground Surface



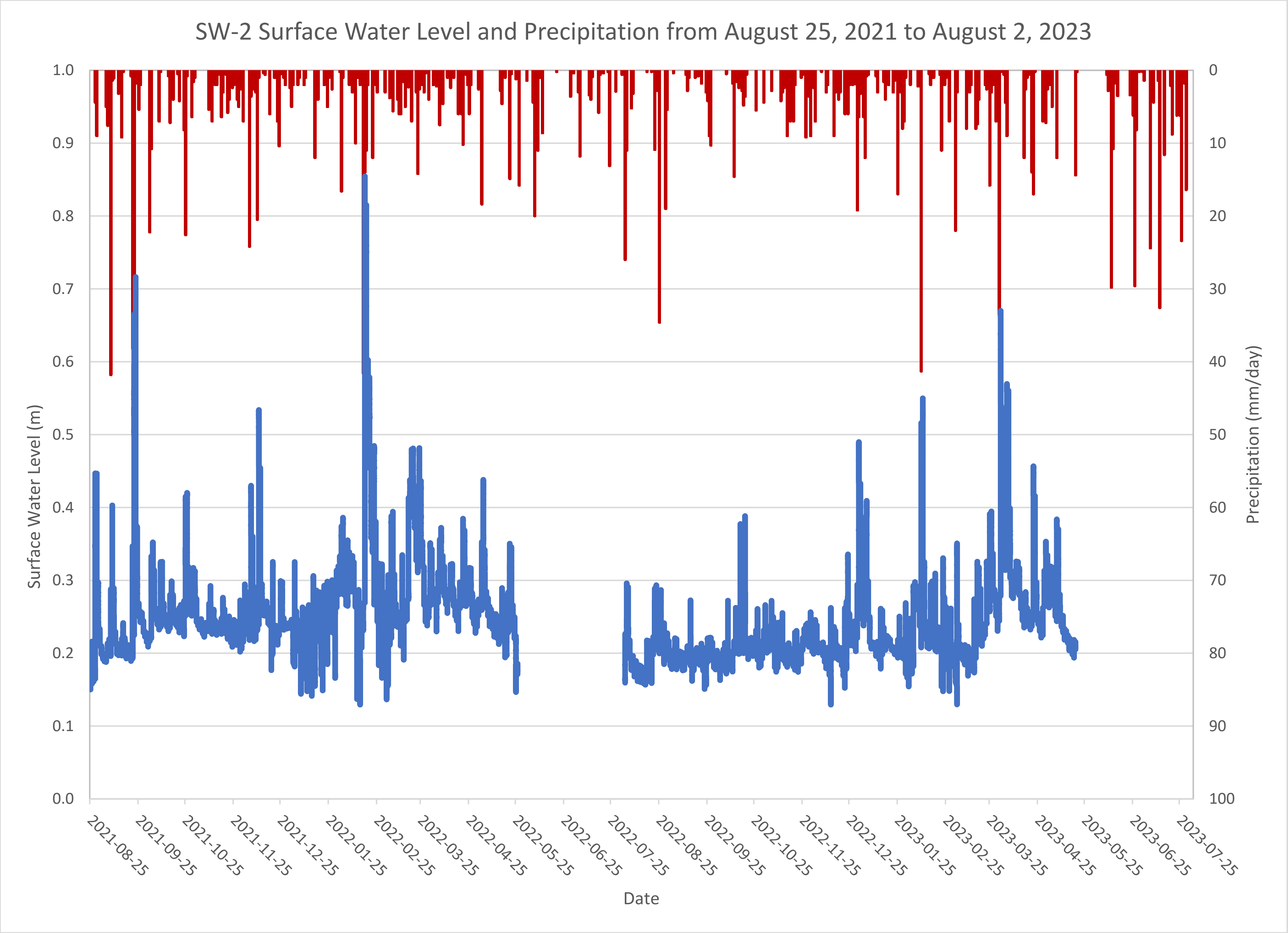
MW-6-00 and MW-2 Water Level Elevation and Precipitation from November 11, 2021 to August 2, 2023

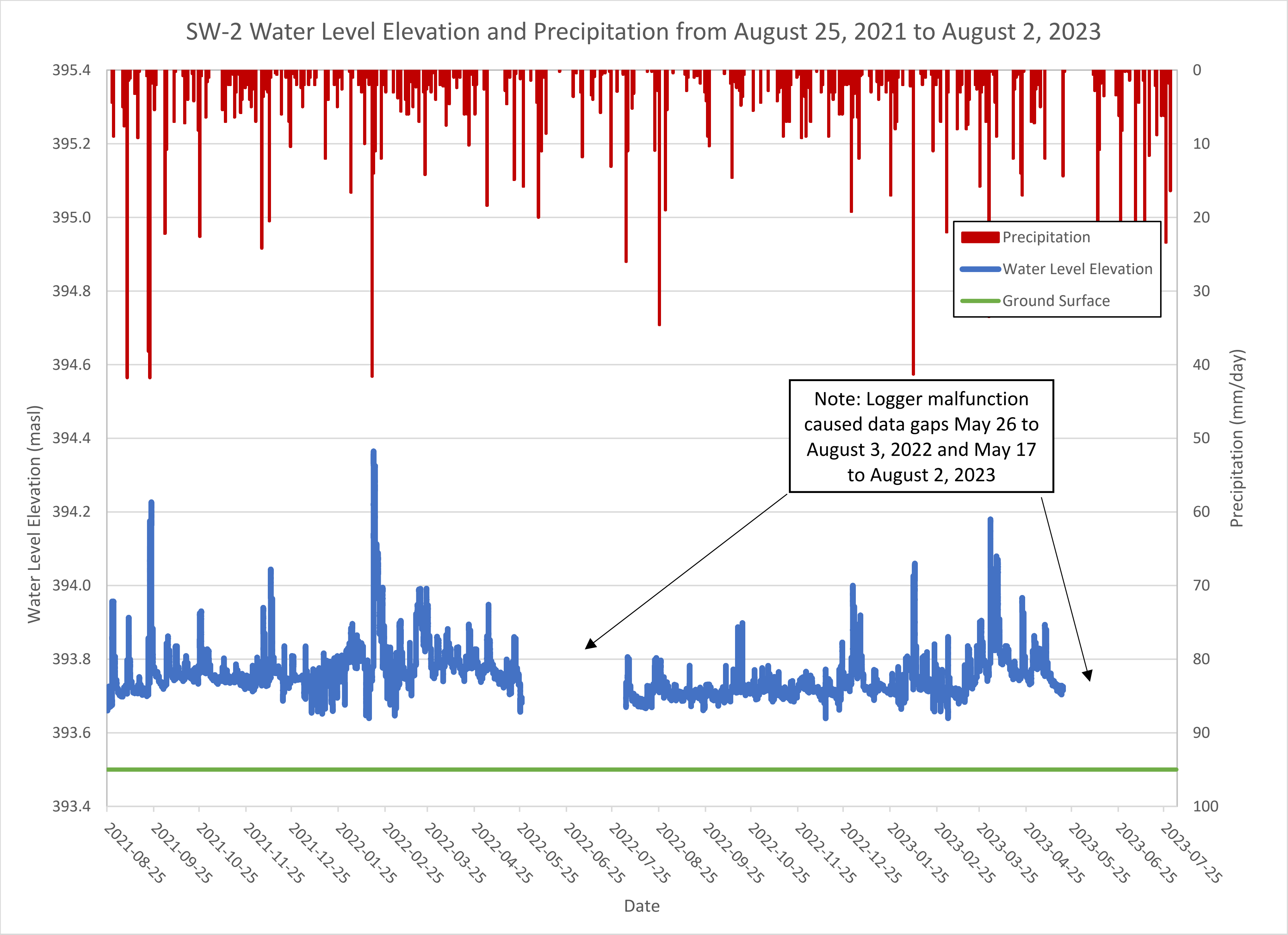

SW-1 Surface Water Level and Precipitation from August 25, 2021 to August 2, 2023
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Note: Logger and staff gauge were washed and lost
Precipitation
Surface Water Level
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date



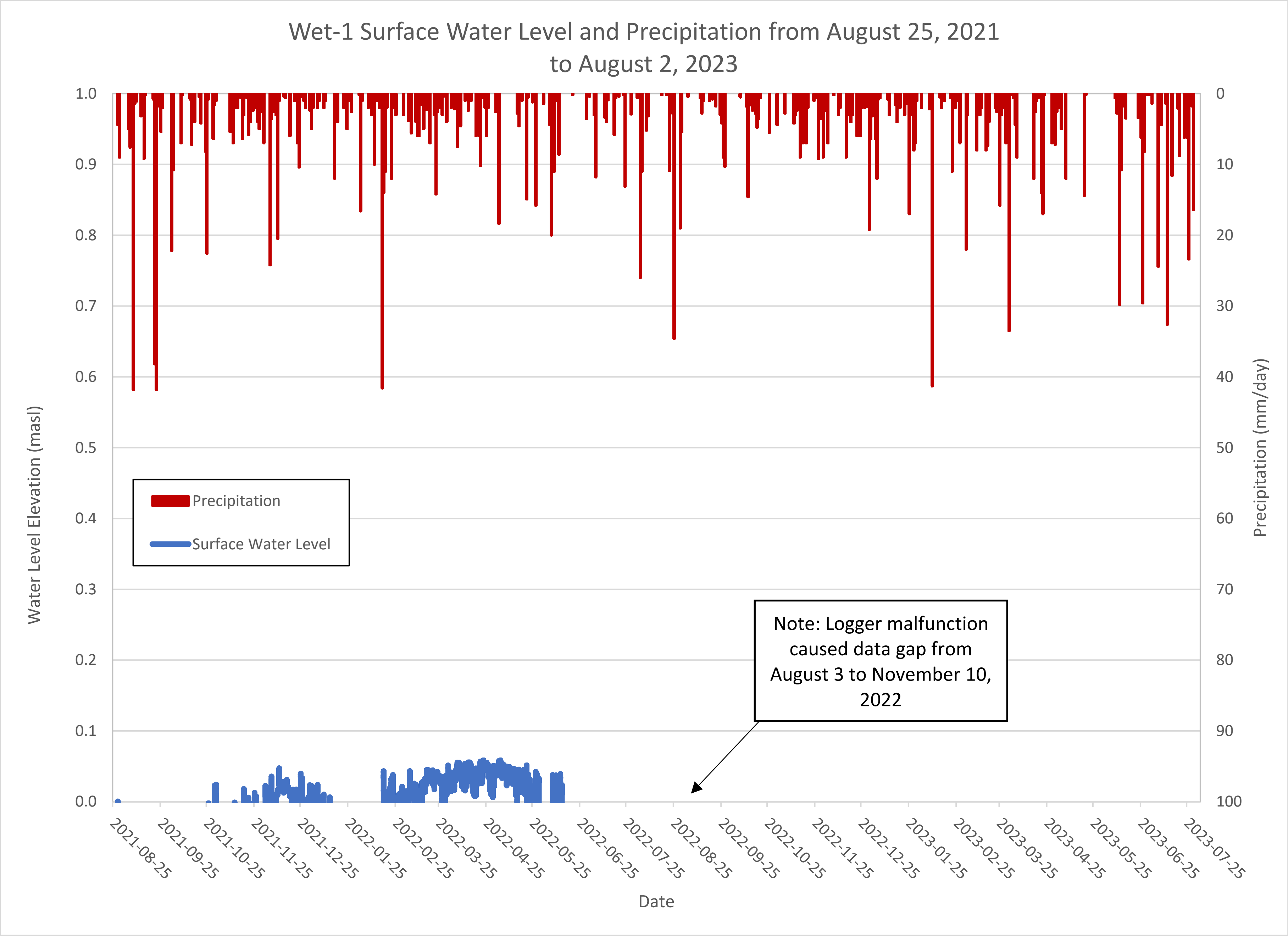
Note: Logger and staff gauge were washed out and lost

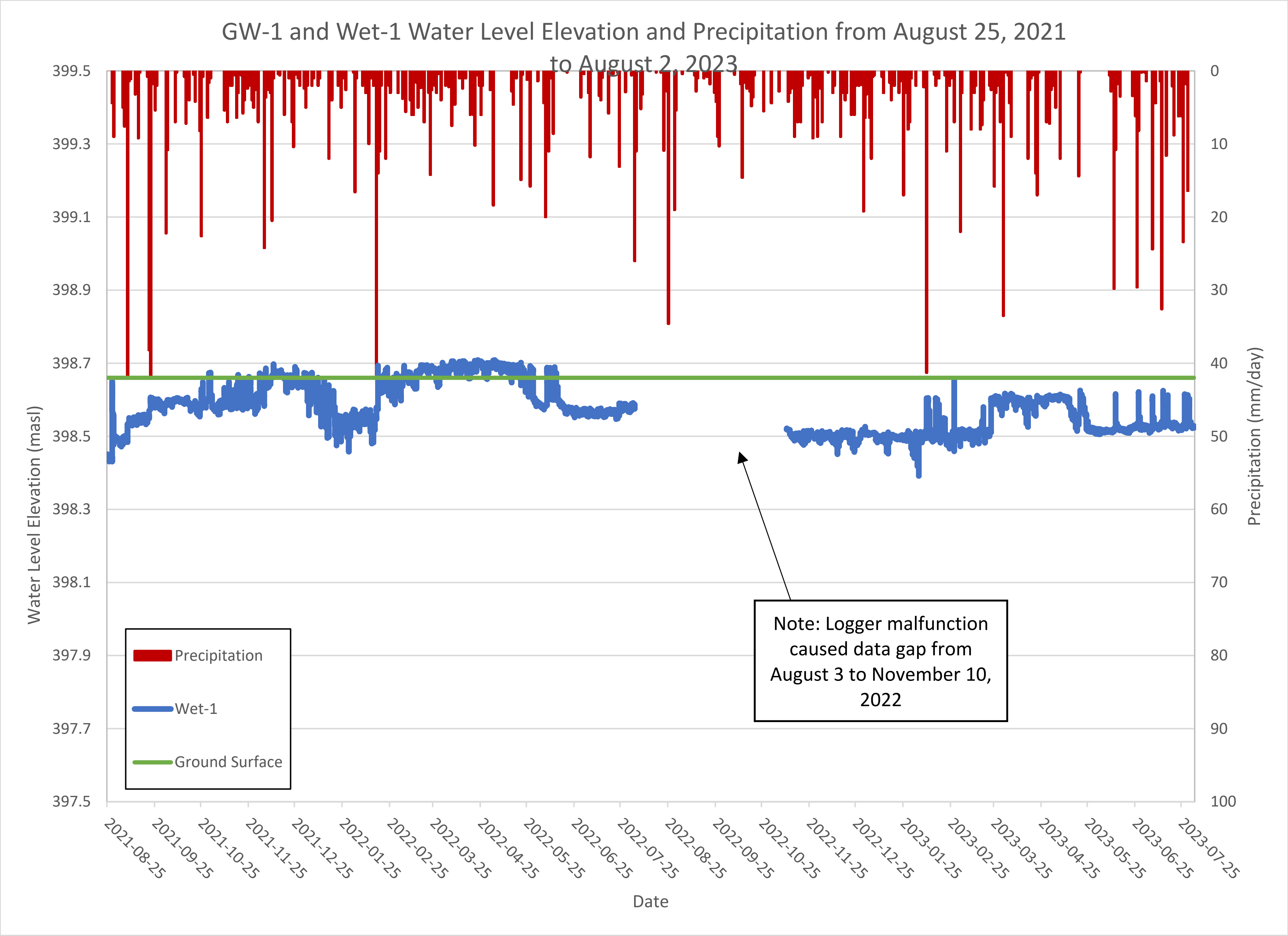
Note: Increase in water level due to increase of pond level and back flow into channel

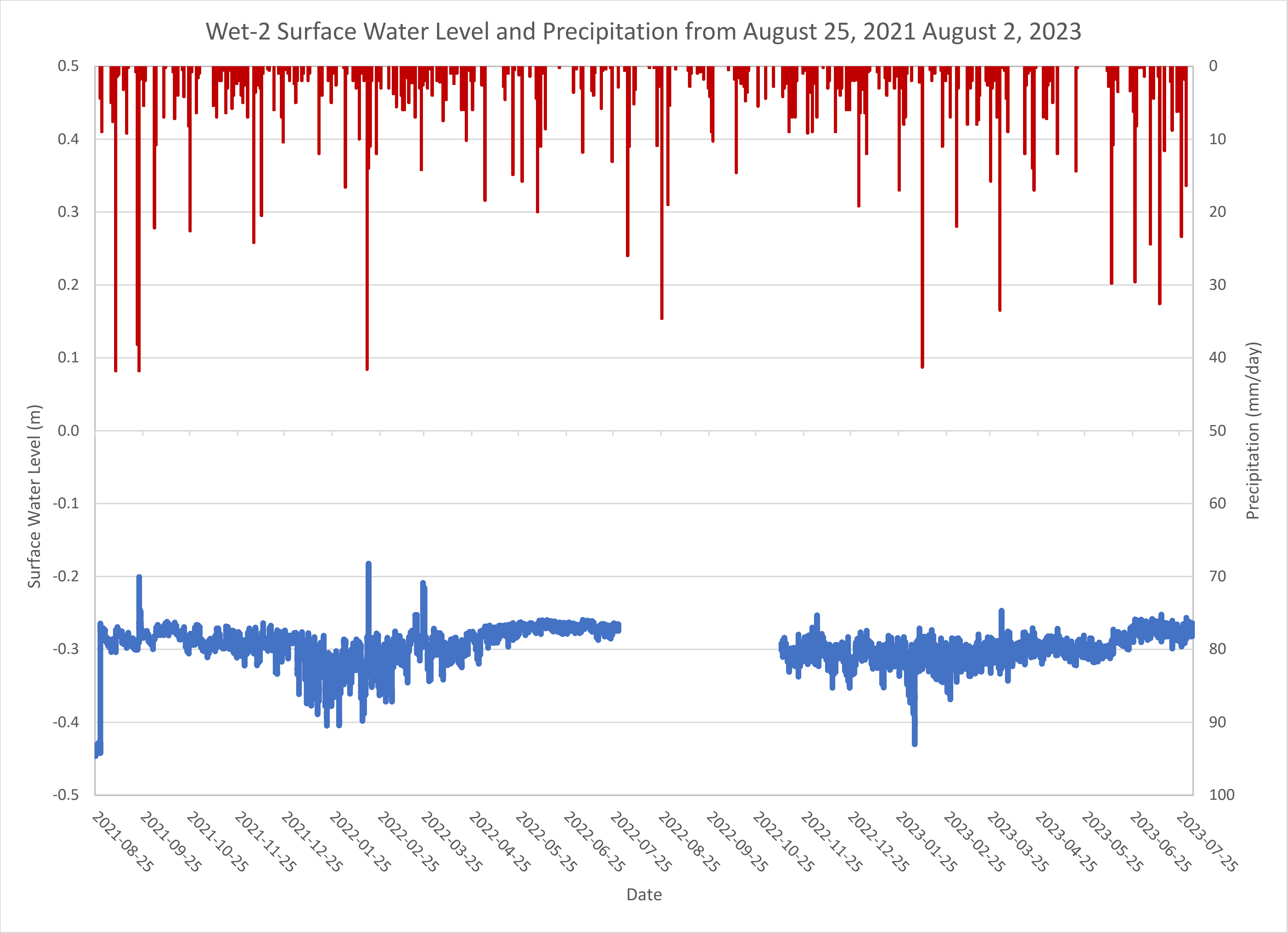

SW-2 Surface Water Level and Precipitation from August 25, 2021 to August 2, 2023
Surface Water Level (m)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Date
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25

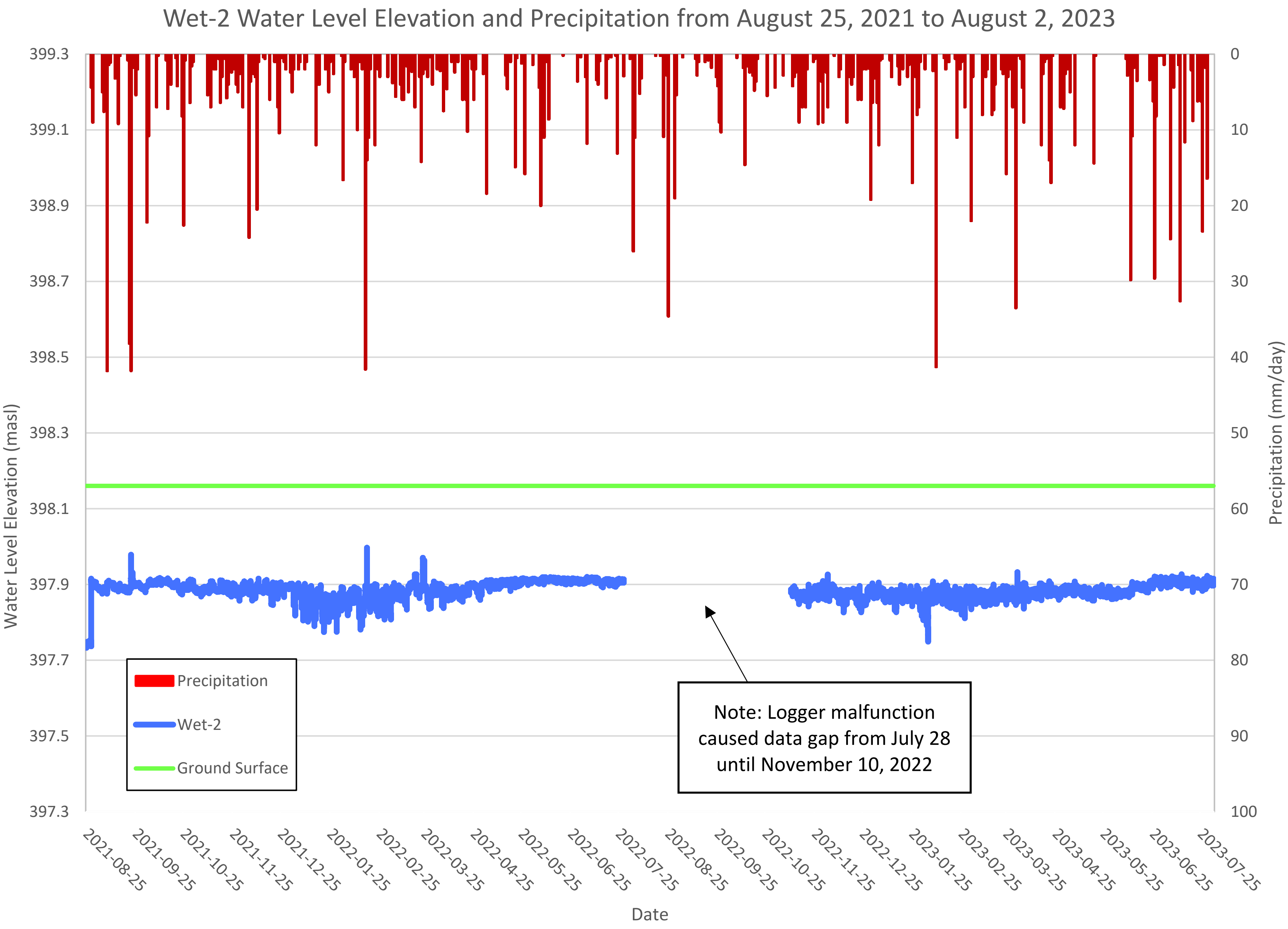


SW-2 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
395.4
395.2
395.0
394.8
394.6
394.4
394.2
394.0
393.8
393.6
393.4
Water Level Elevation (masl)
0
10
20
30
40
50
60
70
80
90
100
Precipitation (mm/day)
Precipitation
Water Level Elevation
Ground Surface
Note: Logger malfunction caused data gaps May 26 to August 3, 2022 and May 17 to August 2, 2023
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date


Wet-1 Surface Water Level and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Precipitation
Surface Water Level
Note: Logger malfunction caused data gap from August 3 to November 10, 2022
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Date


GW-1 and Wet-1 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
399.5
399.3
399.1
398.9
398.7
398.5
398.3
398.1
397.9
397.7
397.5
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Date
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Precipitation
Wet-1
Ground Surface
Note: Logger malfunction caused data gap from August 3 to November 10, 2022


Wet-2 Surface Water Level and Precipitation from August 25, 2021 August 2, 2023
Surface Water Level (m)
Precipitation (mm/day)
Date
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
0
10
20
30
40
50
60
70
80
90
100
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25

Wet-2 Water Level Elevation and Precipitation from August 25, 2021 to August 2, 2023
Water Level Elevation (masl)
399.3
399.1
398.9
398.7
398.5
398.3
398.1
397.9
397.7
397.5
397.3
Precipitation (mm/day)
0
10
20
30
40
50
60
70
80
90
100
Date
2021-08-25
2021-09-25
2021-10-25
2021-11-25
2021-12-25
2022-01-25
2022-02-25
2022-03-25
2022-04-25
2022-05-25
2022-06-25
2022-07-25
2022-08-25
2022-09-25
2022-10-25
2022-11-25
2022-12-25
2023-01-25
2023-02-25
2023-03-25
2023-04-25
2023-05-25
2023-06-25
2023-07-25
Precipitation
Wet-2
Ground Surface
Note: Logger malfunction caused data gap from July 28 until November 10, 2022

Appendix B

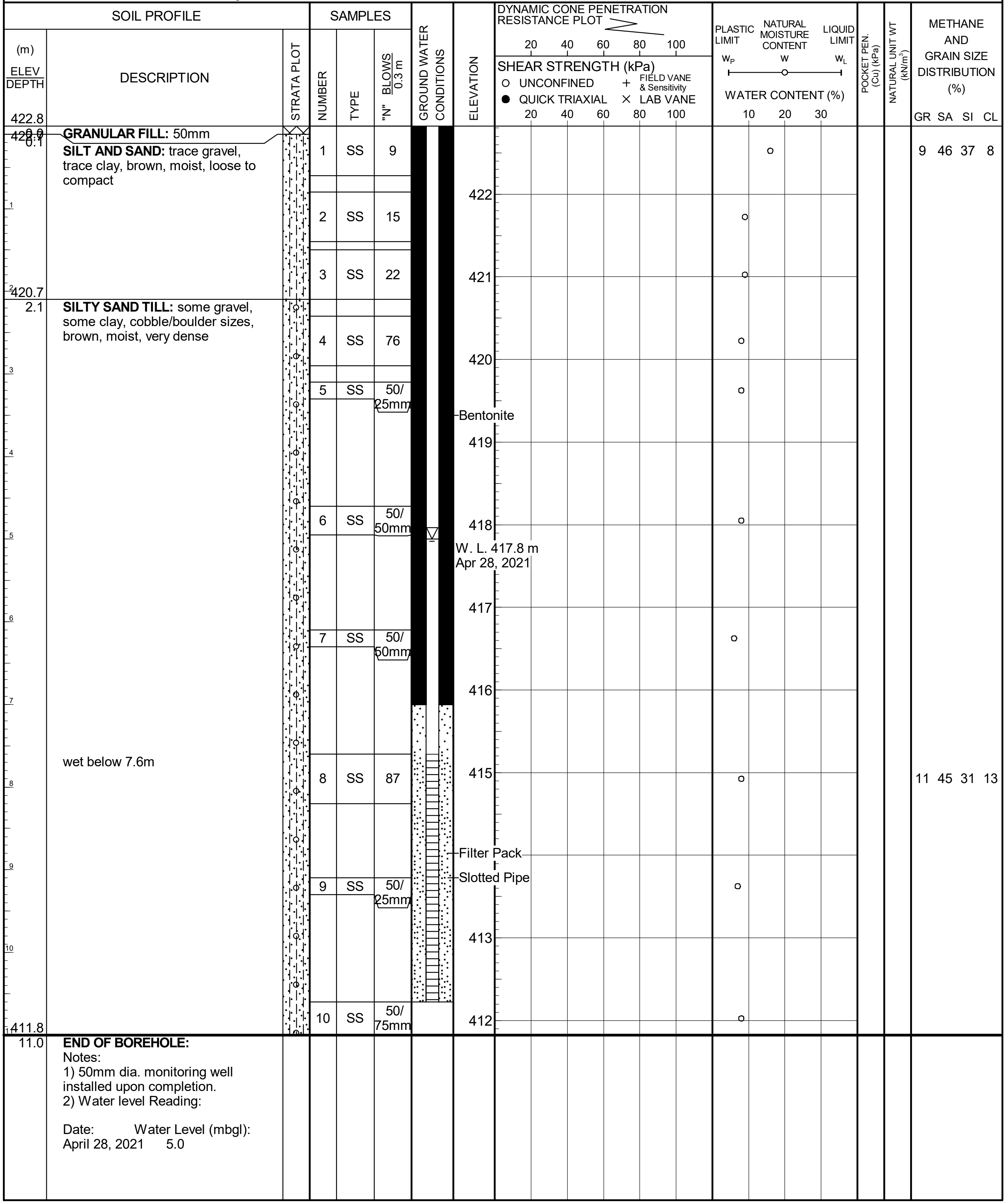
Borehole Logs

LOG OF BOREHOLE MW21-1

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846537.081 E 573786.33

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-15-2021

REF. NO.: 21-129-300
ENCL NO.: 2



(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
422.8					
422.7 0.1	**GRANULAR FILL:** 50mm				
	SILT AND SAND: trace gravel, trace clay, brown, moist, loose to compact	1	SS	9	9 46 37 8
		2	SS	15	
		3	SS	22	
420.7 2.1	**SILTY SAND TILL:** some gravel, some clay, cobble/boulder sizes, brown, moist, very dense	4	SS	76	
		5	SS	50/ 25mm	
		6	SS	50/ 50mm	
		7	SS	50/ 50mm	
	wet below 7.6m	8	SS	87	11 45 31 13
		9	SS	50/ 25mm	
		10	SS	50/ 75mm	
411.8 11.0	**END OF BOREHOLE:** Notes: 1) 50mm dia. monitoring well installed upon completion. 2) Water level Reading: Date: Water Level (mbgl): April 28, 2021 5.0				

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

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LOG OF BOREHOLE MW21-2

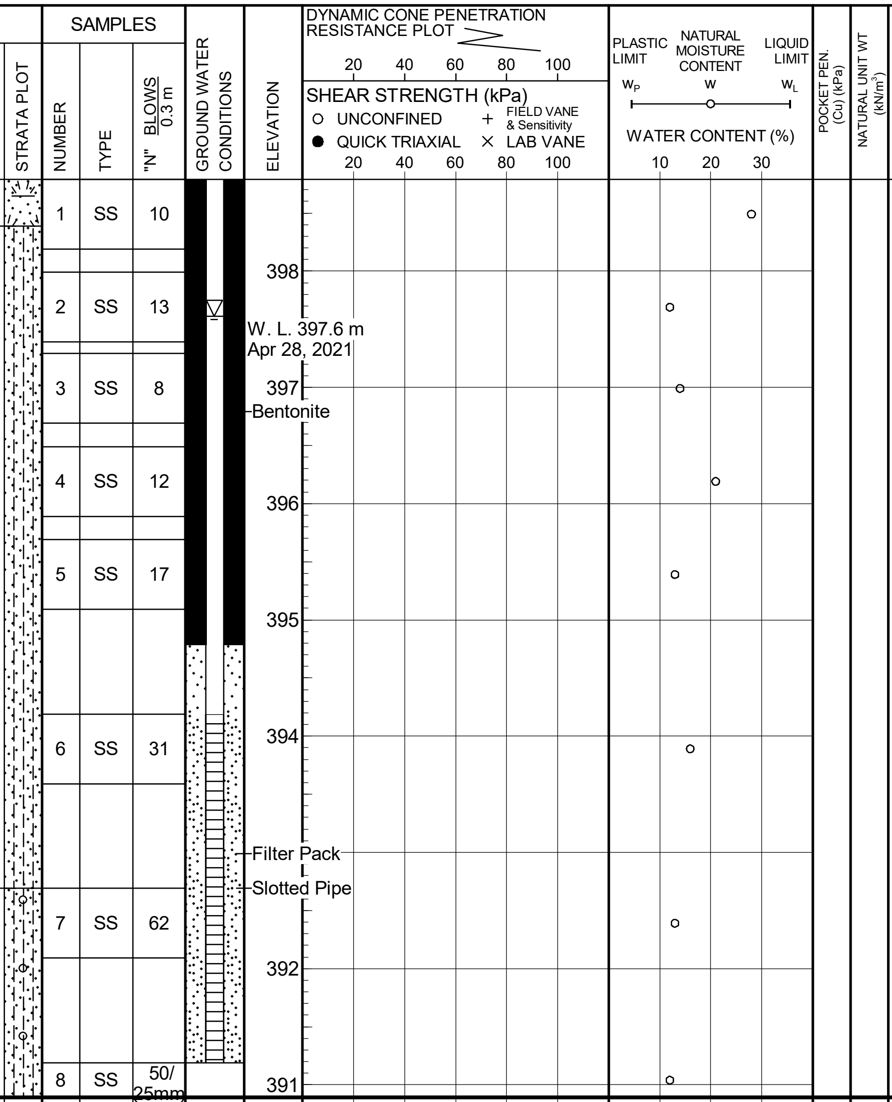
1 OF 1

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846813.344 E 573411.482

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-19-2021

REF. NO.: 21-129-300
ENCL NO.: 3

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
398.8					
0.0	**TOPSOIL:** 350mm	1	SS	10	1 58 35 6
398.4 0.4	**SILTY SAND:** trace to some gravel, trace clay, brown, moist, loose to compact	2	SS	13	
	wet below 1.5m	3	SS	8	
		4	SS	12	
		5	SS	17	
		6	SS	31	10 69 (22)
392.7 6.1	**SILTY SAND TILL:** some clay, cobble/boulder sizes, brown, moist, very dense	7	SS	62	
		8	SS	50/ 25mm	
390.9 7.9	**END OF BOREHOLE:** Notes: 1) 50mm dia. monitoring well installed upon completion. 2) Water level Reading: Date: Water Level (mbgl): April 28, 2021 1.18				



GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

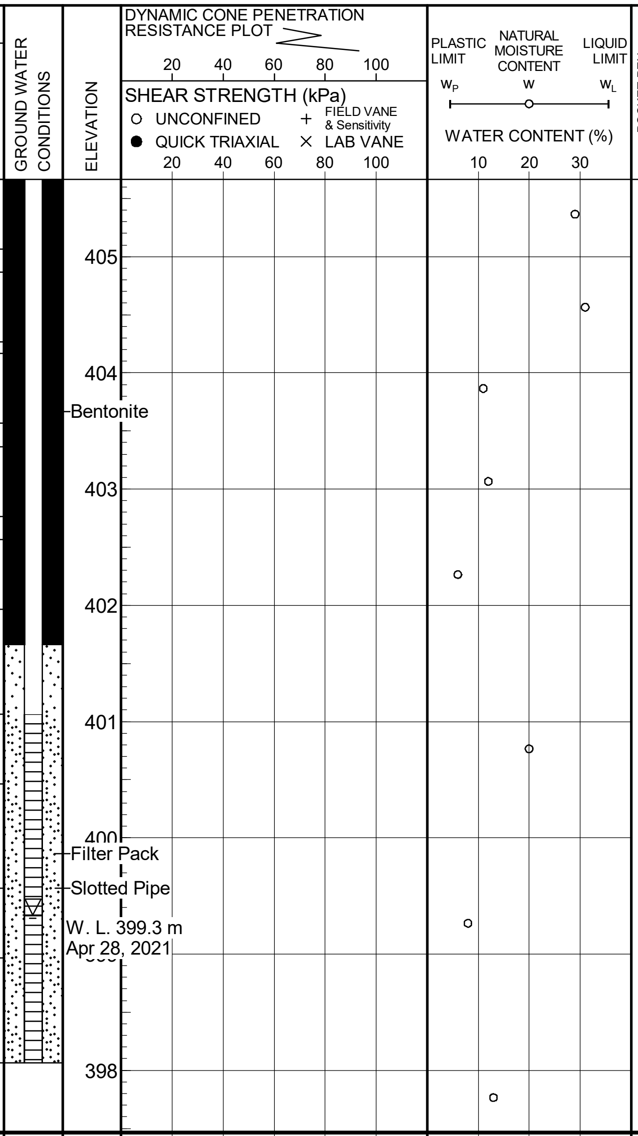
LOG OF BOREHOLE MW21-3

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846862.76 E 573771.456

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-16-2021

REF. NO.: 21-129-300
ENCL NO.: 4

SOIL PROFILE (m) ELEV DEPTH	DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS/0.3 m	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
405.7					
0.0	**TOPSOIL:** 250mm				
405.4 0.3	**FILL**: sand, some silt to silty, some gravel, trace clay, trace organics, brown, moist, loose to compact	1	SS	4	
		2	SS	6	14 67 15 4
		3	SS	8	
		4	SS	22	
402.7 3.0	**SILTY SAND:** trace gravel, trace clay, brown, moist to wet, compact to dense	5	SS	15	
	wet below 4.6m	6	SS	31	4 59 32 5
399.6 6.1	**SILTY SAND TILL:** gravelly, brown, wet, compact	7	SS	12	
	layer of sand, medium to coarse	8	SS	12	
397.5 8.2	**END OF BOREHOLE:** Notes: 1) 50mm dia. monitoring well installed upon completion. 2) Water level Reading: Date: Water Level (mbgl): April 28, 2021 6.33				



POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

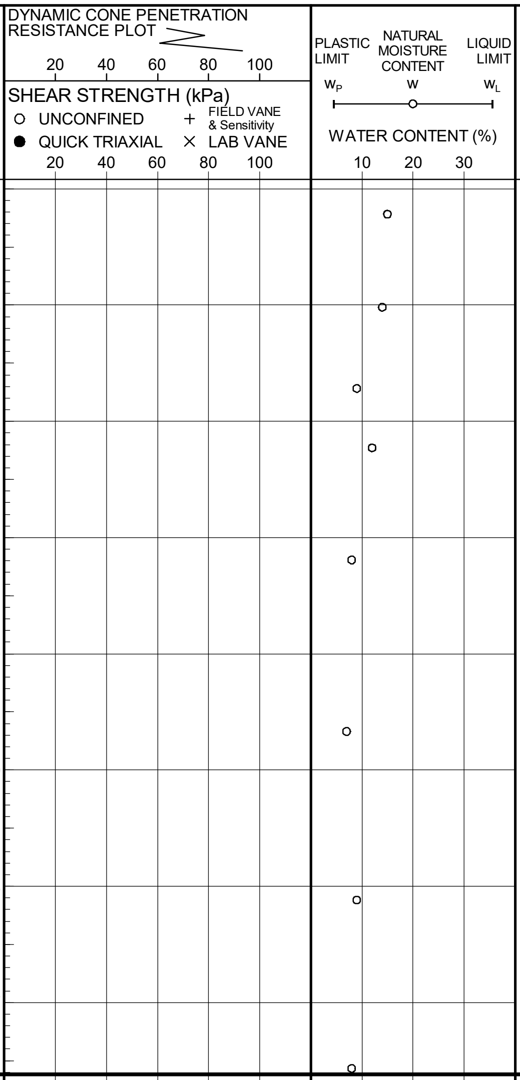
LOG OF BOREHOLE BH21-4

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846678.156 E 573864.767

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-15-2021

REF. NO.: 21-129-300
ENCL NO.: 5

SOIL PROFILE		SAMPLES			METHANE AND GRAIN SIZE DISTRIBUTION (%)
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GR SA SI CL
414.1					
0.0	**TOPSOIL:** 250mm				
413.8 0.3	**FILL**: silty sand, some gravel, trace clay, brown, moist, loose	1	SS	2	
		2	SS	6	16 44 32 8
		3	SS	9	
411.8 2.3	**SILTY SAND TILL:** cobble/boulder sizes, brown, moist to wet, very dense	4	SS	50/25mm	
		5	SS	50/50mm	
	wet below 4.6m	6	SS	50	
		7	SS	50/75mm	
406.4		8	SS	50/50mm	
7.7	**END OF BOREHOLE:**				



Notes:

1) Water level in open borehole:

Date: Water Level (mbgl):
on completion 4.6

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

LOG OF BOREHOLE BH21-5

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846760.737 E 573587.463

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-16-2021

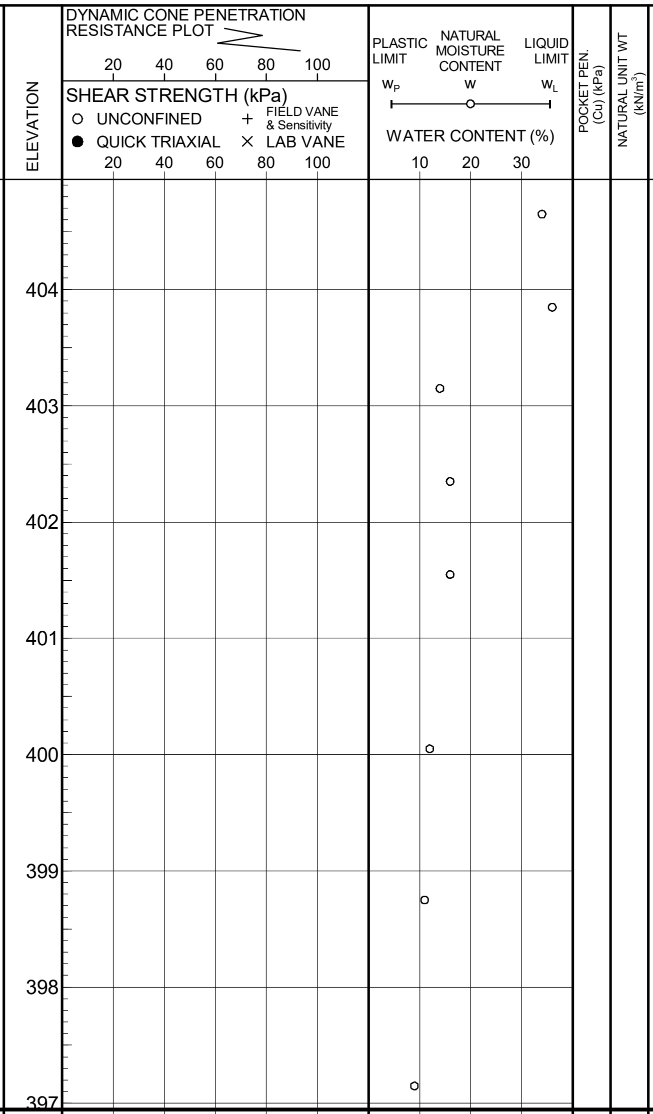
REF. NO.: 21-129-300
ENCL NO.: 6

SOIL PROFILE

(m) ELEV DEPTH	DESCRIPTION
404.9	
404.7 0.0	**TOPSOIL:** 200mm
0.2	**FILL**: silty sand, gravelly, trace clay, brown, wet, loose
403.4 1.5	**SILTY SAND**: trace gravel, brown, moist to wet, compact wet below 2.3m
400.3 4.6	**SILTY SAND TILL:** cobble/boulder sizes, brown to grey, moist, very dense
396.9 8.0	**END OF BOREHOLE:**

SAMPLES

NUMBER	TYPE	"N" BLOWS/0.3 m	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	4	
2	SS	4	24 41 29 6
3	SS	11	
4	SS	15	
5	SS	25	
6	SS	50	
7	SS	50/ 50mm	
8	SS	50/ 100mm	



Notes:

1) Water level in open borehole:

Date: Water Level (mbgl):
on completion 2.3

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

LOG OF BOREHOLE BH21-6

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846610.242 E 573617.42

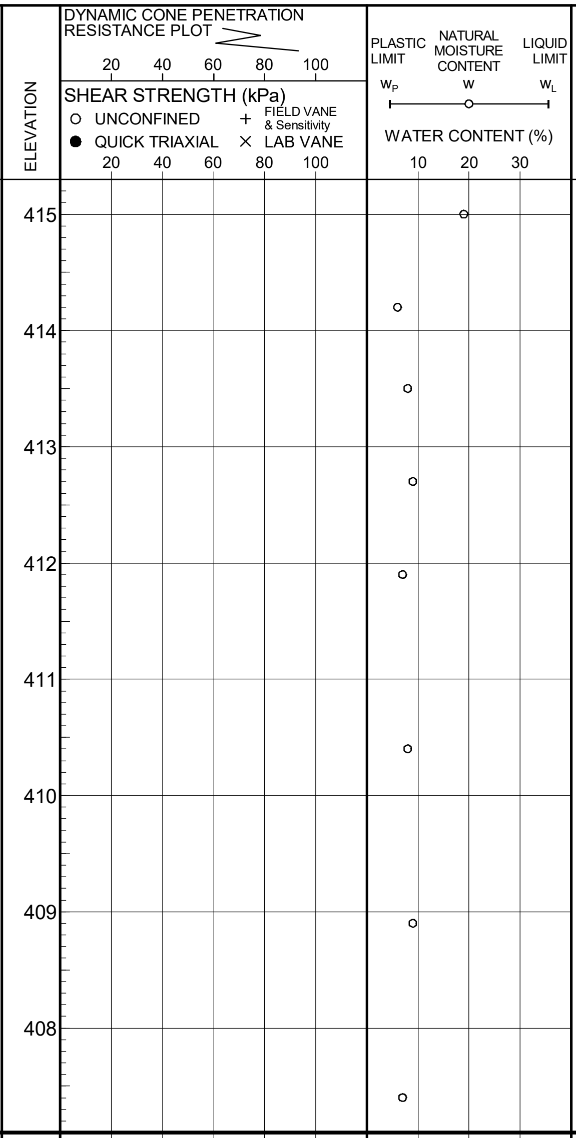
DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-16-2021

REF. NO.: 21-129-300
ENCL NO.: 7

(m) ELEV DEPTH	DESCRIPTION
415.3	
415.1 0.0	**TOPSOIL:** 200mm
0.2	**SANDY GRAVEL**: some silt, brown, moist, compact to dense
413.8 1.5	**SILTY SAND TILL:** cobble/boulder sizes, brown to grey, moist, compact to very dense
407.1 8.2	**END OF BOREHOLE:** Notes: 1) Borehole open and dry upon completion.

SAMPLES NUMBER	TYPE	"N" BLOWS/0.3 m	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	17	
2	SS	48	54 32 (14)
3	SS	19	
4	SS	27	
5	SS	44	
6	SS	29	
7	SS	71	
8	SS	81	

STRATA PLOT | GROUND WATER CONDITIONS | ELEVATION | POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (kN/m³)



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

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

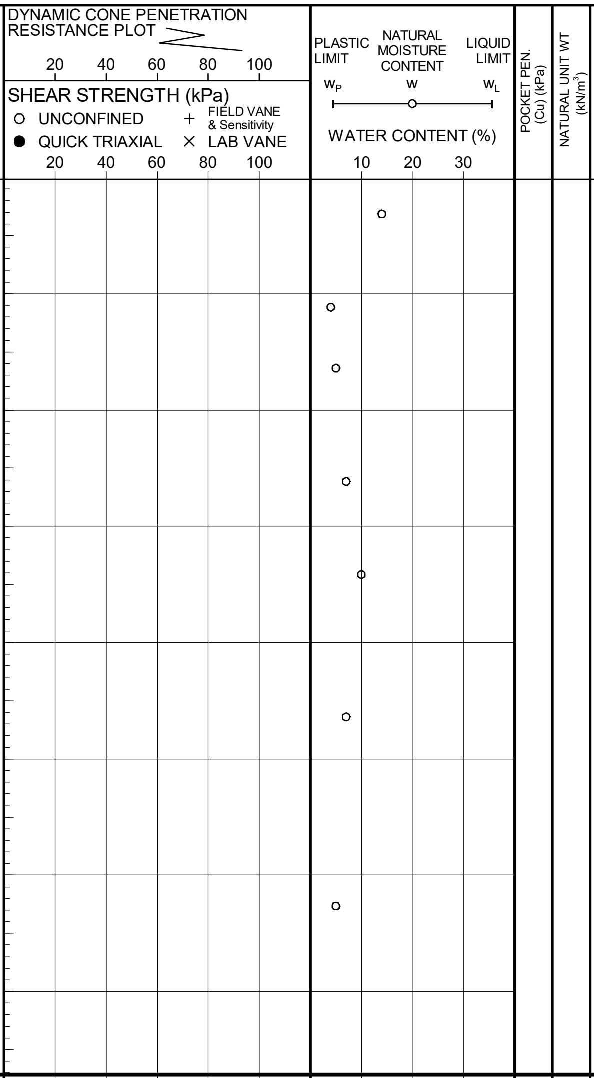
LOG OF BOREHOLE BH21-7

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846717.062 E 573766.909

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-15-2021

REF. NO.: 21-129-300
ENCL NO.: 8

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
412.0							
411.9 0.1	**TOPSOIL:** 100mm **SAND AND GRAVEL**: some silt, brown, moist, loose to very dense	1	SS	4			
		2	SS	65		411	36 47 (17)
		3	SS	50/ 100mm		410	
409.7 2.3	**SILTY SAND TILL:** cobble/boulder sizes, brown to grey, moist to wet, compact to very dense wet below 3m depth	4	SS	28		409	
		5	SS	18		408	
		6	SS	50/ 25mm		407	
		7	SS	50/ 25mm		406 405	
404.3 7.7	**END OF BOREHOLE:** Notes: 1) Water level in open borehole: Date: Water Level (mbgl): on completion 3.0	8	SS	50/ 25mm			



GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

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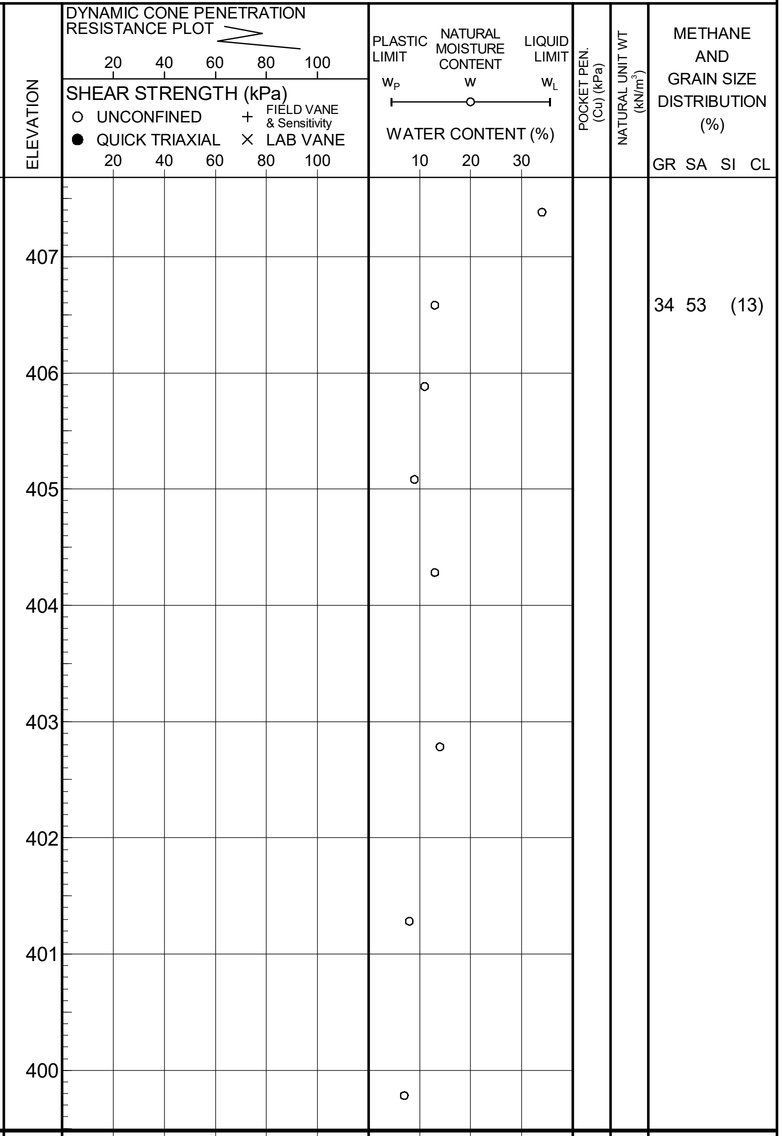
LOG OF BOREHOLE BH21-8

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846819.483 E 573729.609

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-16-2021

REF. NO.: 21-129-300
ENCL NO.: 9

(m) ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	METHANE AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
407.7						
0.0	**TOPSOIL:** 150mm					
407.5 0.2	**GRAVELLY SAND**: some silt, brown, moist, loose to compact	1	SS	3		
		2	SS	19		34 53 (13)
		3	SS	30		
		4	SS	24		
		5	SS	23		
403.1 4.6	**SILTY SAND**: some gravel, brown, moist to wet, dense to loose	6	SS	35		
	wet at 6.1m depth disturbed at 6.1m	7	DIST	(disturbed)		
400.1 7.6	**SILTY SAND TILL:** brown, moist, dense	8	SS	39		
399.5 8.2	**END OF BOREHOLE:** Notes: 1) Water level in open borehole: Date: Water Level (mbgl): on completion 6.1					



GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ 8=3% Strain at Failure

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LOG OF BOREHOLE BH21-9

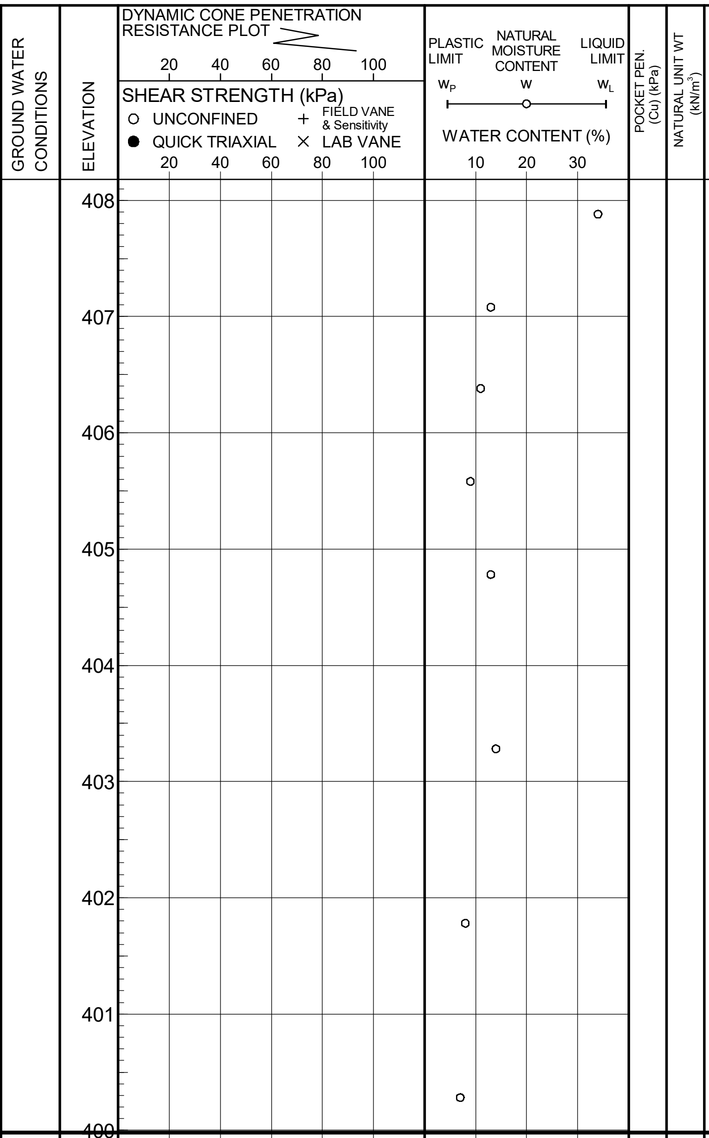
1 OF 1

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846702.204 E 573529.376

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-19-2021

REF. NO.: 21-129-300
ENCL NO.: 10

SOIL PROFILE		SAMPLES			METHANE AND GRAIN SIZE DISTRIBUTION (%)			
(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS/0.3 m	GR	SA	SI	CL
408.2								
408.1 0.1	**TOPSOIL:** 100mm							
	FILL: sand and silt, trace clay, mixed with organics/topsoil, very loose to compact	1	SS	3		41	51	8
		2	SS	2				
		3	SS	10				
405.9 2.3	**SILTY SAND TILL:** brown, moist to wet, compact to very dense	4	SS	31				
	wet at 3m depth							
		5	SS	13				
	layer of medium to coarse sand	6	SS	33				
		7	SS	54				
		8	SS	47				
400.0 8.2	**END OF BOREHOLE:** Notes: 1) Water level in open borehole: Date: Water Level (mbgl): on completion 3.0							



GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ 8=3% Strain at Failure

DS SOIL LOG 21-129-300 ERIN HEIGHTS BOREHOLE LOGS.GPJ DS.GDT 21-5-5

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LOG OF BOREHOLE MW21-10

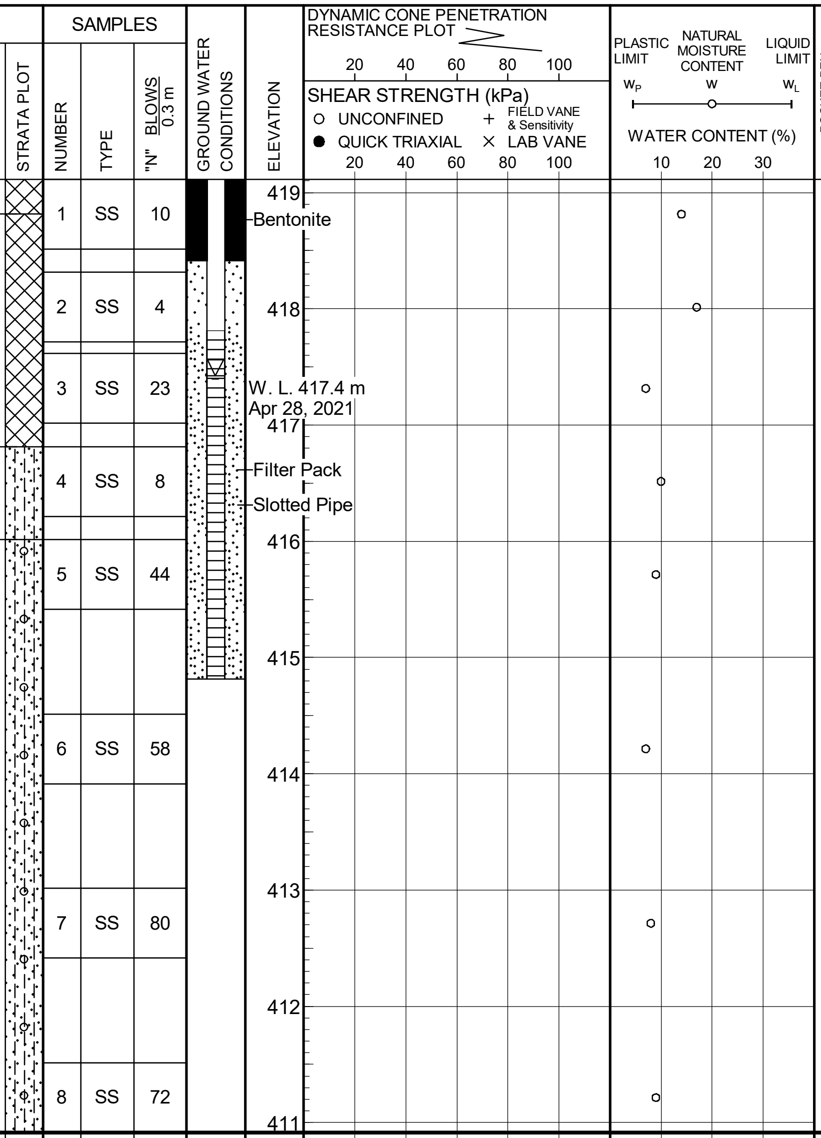
1 OF 1

PROJECT: Preliminary Geotechnical Investigation - Erin Heights Golf Course
CLIENT: Empire Communities
PROJECT LOCATION: 5525 8 Line, Erin, ON
DATUM: Geodetic
BOREHOLE LOCATION: See Drawing 1 N 4846573.281 E 573806.122

DRILLING DATA
Method: Hollow Stem Auger
Diameter: 200mm
Date: Apr-19-2021

REF. NO.: 21-129-300
ENCL NO.: 11

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
419.1					
0.0	**GRANULAR FILL:** 250mm	1	SS	10	
418.8 0.3	**FILL**: silty sand, some gravel, trace clay, brown, moist, loose to compact	2	SS	4	11 54 26 9
		3	SS	23	
416.8 2.3	**SILTY SAND:** trace gravel, trace clay, brown, wet, loose	4	SS	8	8 57 26 9
416.0 3.1	**SILTY SAND TILL:** gravelly, brown to grey, moist, dense to very dense	5	SS	44	
		6	SS	58	
		7	SS	80	
		8	SS	72	
410.9 8.2	**END OF BOREHOLE:**				



Notes:
1) 50mm dia. monitoring well installed upon completion.
2) Water level Reading:

Date:	Water Level (mbgl):
April 28, 2021	1.69

GROUNDWATER ELEVATIONS
Measurement 1st ▽ 2nd ▼ 3rd ▼ 4th ▼

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

Appendix C

Hydraulic Conductivity Analyses

K from Grain Size Analysis Report

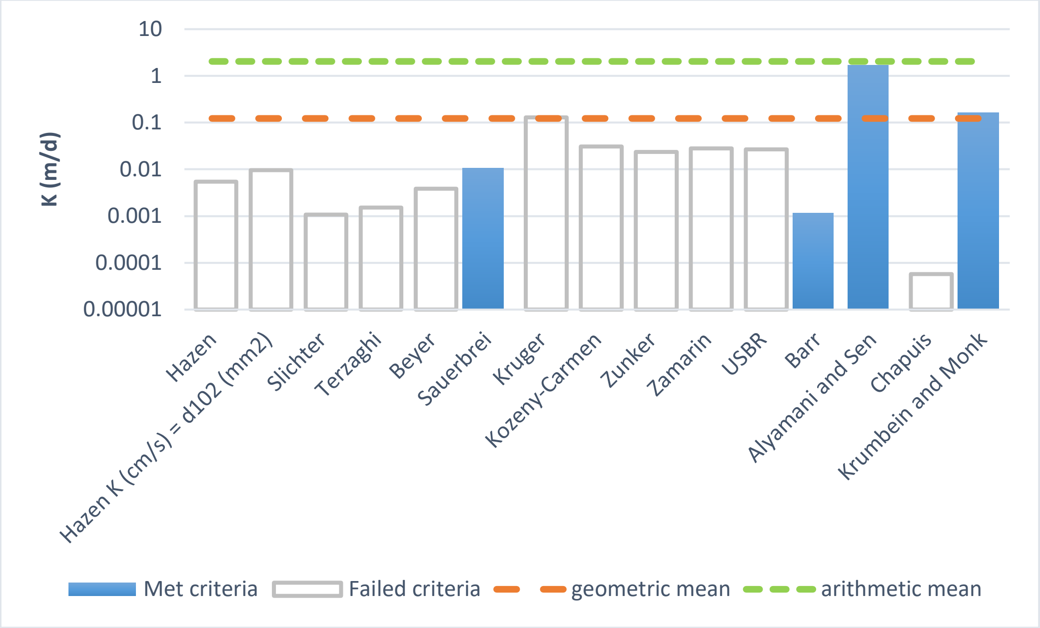
Date: 20-May-21

Sample Name: MW21-1, SS1, 0.3 mBGS, Silt and Sand

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.631E-05	.631E-07	0.01	
Hazen K (cm/s) = d_{10} (mm)	.111E-04	.111E-06	0.01	
Slichter	.124E-05	.124E-07	0.00	
Terzaghi	.177E-05	.177E-07	0.00	
Beyer	.444E-05	.444E-07	0.00	
Sauerbrei	.123E-04	.123E-06	0.01	
Kruger	.150E-03	.150E-05	0.13	
Kozeny-Carmen	.356E-04	.356E-06	0.03	
Zunker	.273E-04	.273E-06	0.02	
Zamarin	.324E-04	.324E-06	0.03	
USBR	.311E-04	.311E-06	0.03	
Barr	.133E-05	.133E-07	0.00	
Alyamani and Sen	.196E-02	.196E-04	1.70	
Chapuis	.661E-07	.661E-09	0.00	
Krumbein and Monk	.187E-03	.187E-05	0.16	
Shepherd	.965E-02	.965E-04	8.33	
geometric mean meeting criteria	5.E-05	5.E-07	4.E-02	
arithmetic mean meeting criteria	5.E-04	5.E-06	5.E-01	

K from Grain Size Analysis Report

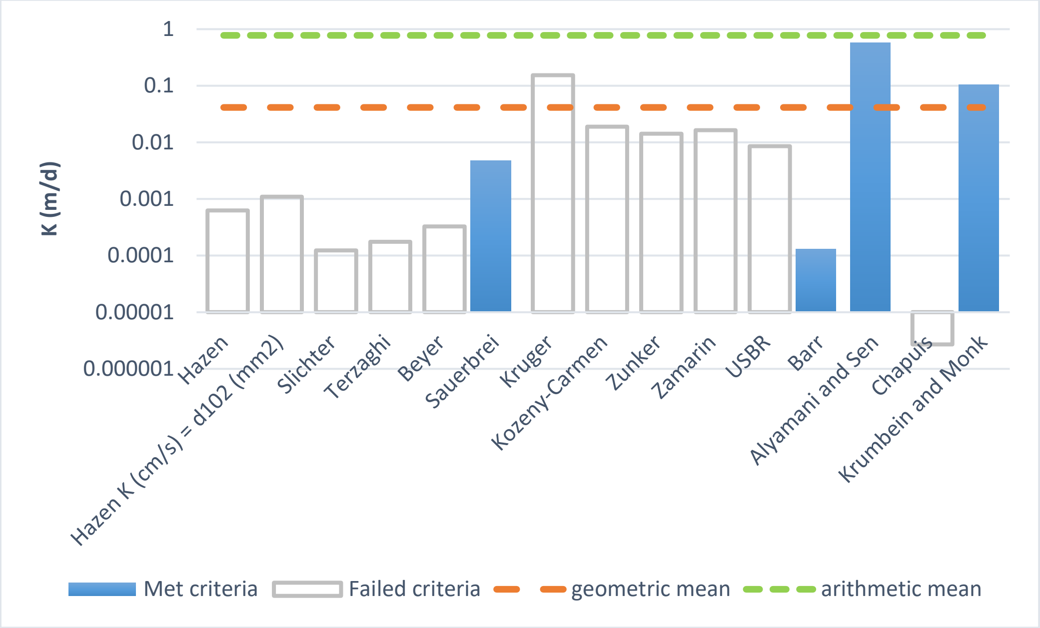
Date: 20-May-21

Sample Name: MW21-1, SS8, 7.9 mBGS, Silty Sand Till

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.723E-06	.723E-08	0.00	
Hazen K (cm/s) = d_{10} (mm)	.128E-05	.128E-07	0.00	
Slichter	.142E-06	.142E-08	0.00	
Terzaghi	.203E-06	.203E-08	0.00	
Beyer	.378E-06	.378E-08	0.00	
Sauerbrei	.551E-05	.551E-07	0.00	
Kruger	.179E-03	.179E-05	0.15	
Kozeny-Carmen	.218E-04	.218E-06	0.02	
Zunker	.164E-04	.164E-06	0.01	
Zamarin	.191E-04	.191E-06	0.02	
USBR	.995E-05	.995E-07	0.01	
Barr	.152E-06	.152E-08	0.00	
Alyamani and Sen	.670E-03	.670E-05	0.58	
Chapuis	.313E-08	.313E-10	0.00	
Krumbein and Monk	.122E-03	.122E-05	0.11	
Shepherd	.370E-02	.370E-04	3.19	
geometric mean meeting criteria	2.E-05	2.E-07	1.E-02	
arithmetic mean meeting criteria	2.E-04	2.E-06	2.E-01	

K from Grain Size Analysis Report

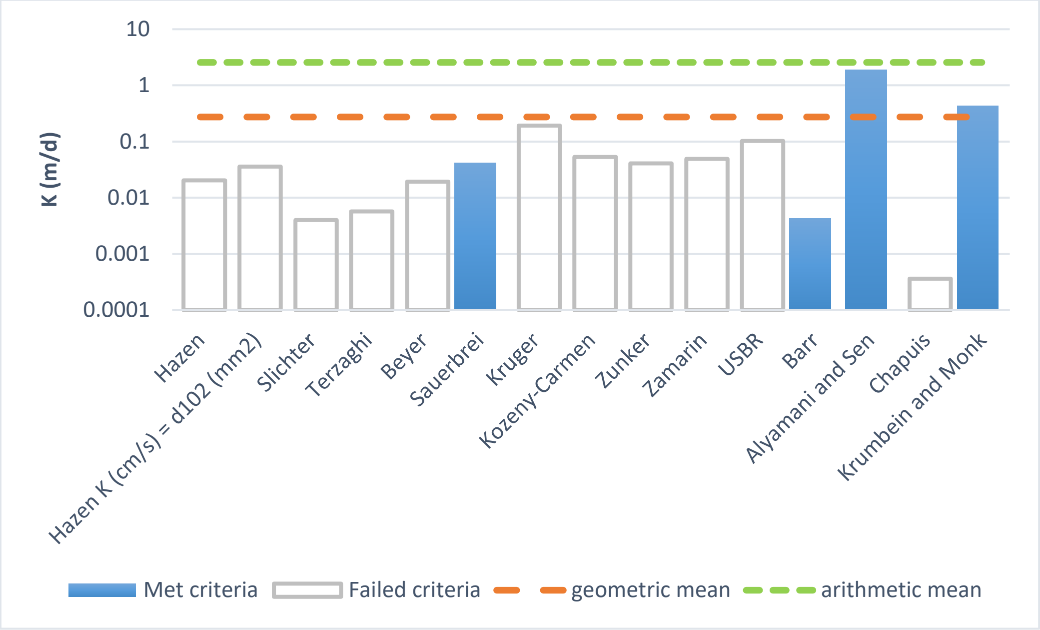
Date: 20-May-21

Sample Name: MW21-2, SS1, 0.4 mBGS, Silty Sand

Mass Sample (g): 100

T (oC) 20

Poorly sorted sand with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.234E-04	.234E-06	0.02	
Hazen K (cm/s) = d_{10} (mm)	.414E-04	.414E-06	0.04	
Slichter	.461E-05	.461E-07	0.00	
Terzaghi	.657E-05	.657E-07	0.01	
Beyer	.225E-04	.225E-06	0.02	
Sauerbrei	.484E-04	.484E-06	0.04	
Kruger	.221E-03	.221E-05	0.19	
Kozeny-Carmen	.616E-04	.616E-06	0.05	
Zunker	.474E-04	.474E-06	0.04	
Zamarin	.566E-04	.566E-06	0.05	
USBR	.118E-03	.118E-05	0.10	
Barr	.494E-05	.494E-07	0.00	
Alyamani and Sen	.220E-02	.220E-04	1.90	
Chapuis	.420E-06	.420E-08	0.00	
Krumbein and Monk	.505E-03	.505E-05	0.44	
Shepherd	.121E-01	.121E-03	10.43	
geometric mean meeting criteria	1.E-04	1.E-06	1.E-01	
arithmetic mean meeting criteria	7.E-04	7.E-06	6.E-01	

K from Grain Size Analysis Report

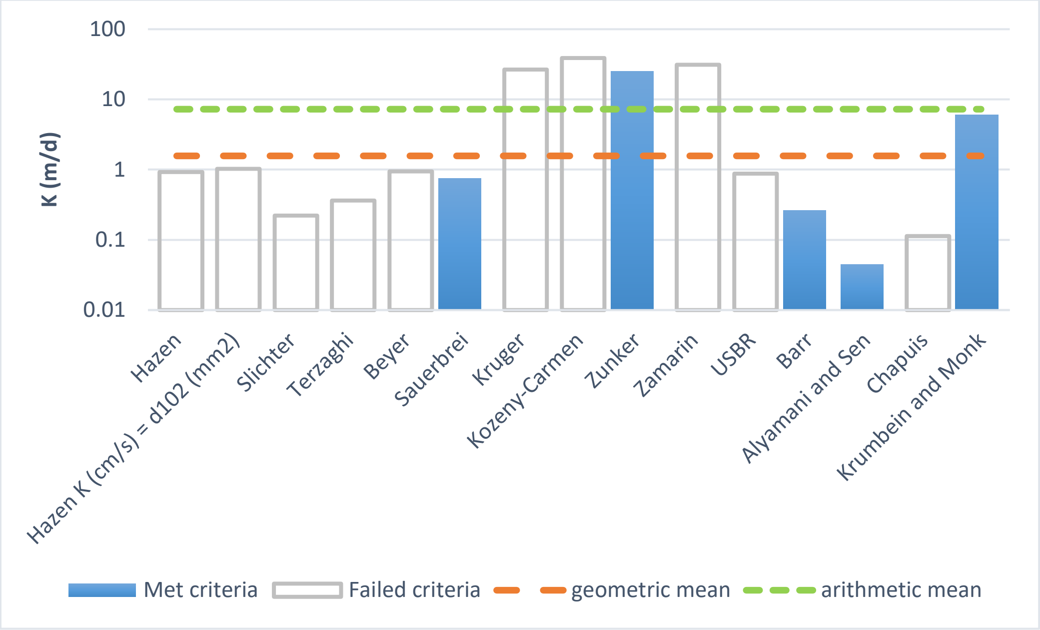
Date: 20-May-21

Sample Name: MW21-2, SS6, 4.9 mBGS, Silty Sand

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.107E-02	.107E-04	0.93	
Hazen K (cm/s) = d_{10} (mm)	.118E-02	.118E-04	1.02	
Slichter	.256E-03	.256E-05	0.22	
Terzaghi	.420E-03	.420E-05	0.36	
Beyer	.110E-02	.110E-04	0.95	
Sauerbrei	.862E-03	.862E-05	0.75	
Kruger	.308E-01	.308E-03	26.58	
Kozeny-Carmen	.452E-01	.452E-03	39.06	
Zunker	.292E-01	.292E-03	25.26	
Zamarin	.359E-01	.359E-03	31.01	
USBR	.101E-02	.101E-04	0.87	
Barr	.304E-03	.304E-05	0.26	
Alyamani and Sen	.518E-04	.518E-06	0.04	
Chapuis	.131E-03	.131E-05	0.11	
Krumbein and Monk	.701E-02	.701E-04	6.06	
Shepherd	.129E-01	.129E-03	11.17	
geometric mean meeting criteria	1.E-03	1.E-05	1.E+00	
arithmetic mean meeting criteria	7.E-03	7.E-05	6.E+00	

K from Grain Size Analysis Report

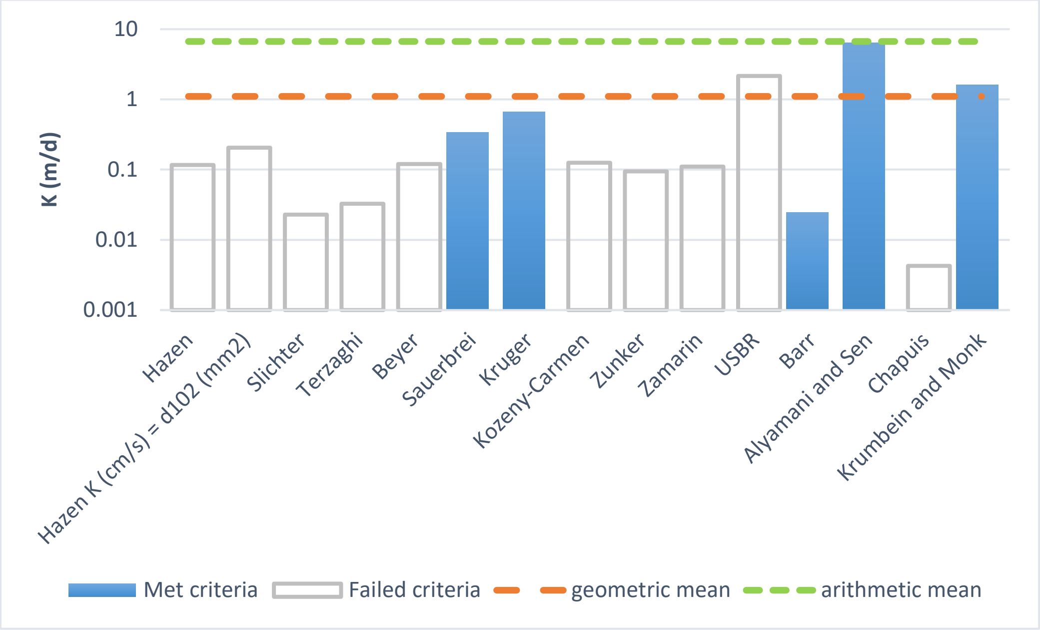
Date: 19-May-21

Sample Name: MW21-3, SS2, 1.1 mBGS, Fill

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand low in fines



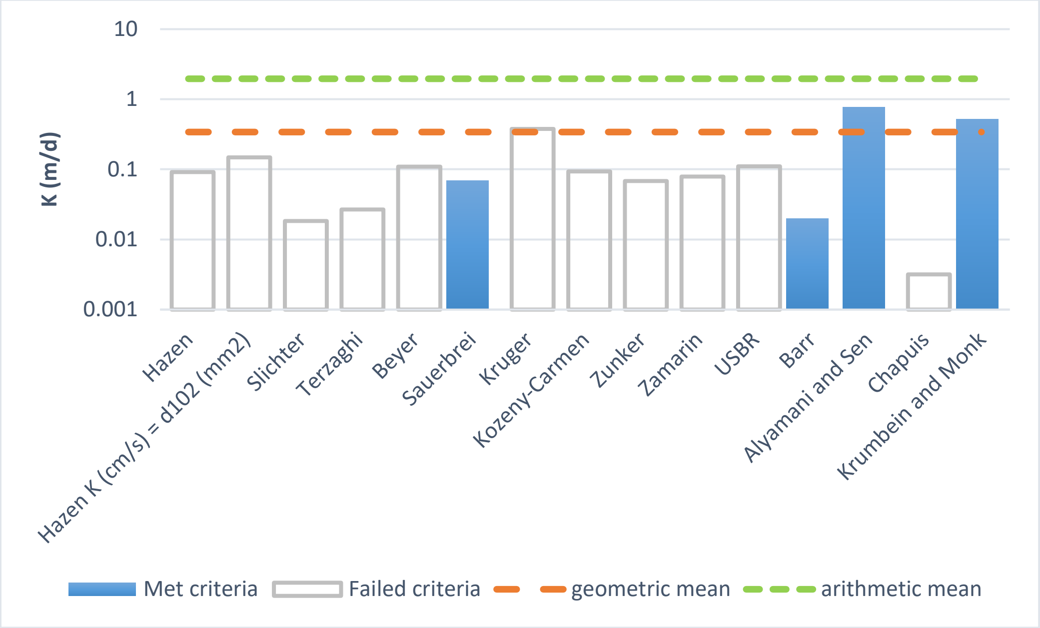
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.135E-03	.135E-05	0.12	
Hazen K (cm/s) = d_{10} (mm)	.237E-03	.237E-05	0.20	
Slichter	.265E-04	.265E-06	0.02	
Terzaghi	.378E-04	.378E-06	0.03	
Beyer	.139E-03	.139E-05	0.12	
Sauerbrei	.394E-03	.394E-05	0.34	
Kruger	.775E-03	.775E-05	0.67	
Kozeny-Carmen	.145E-03	.145E-05	0.13	
Zunker	.109E-03	.109E-05	0.09	
Zamarin	.128E-03	.128E-05	0.11	
USBR	.251E-02	.251E-04	2.17	
Barr	.284E-04	.284E-06	0.02	
Alyamani and Sen	.745E-02	.745E-04	6.43	
Chapuis	.494E-05	.494E-07	0.00	
Krumbein and Monk	.187E-02	.187E-04	1.62	
Shepherd	.359E-01	.359E-03	31.03	
geometric mean meeting criteria	7.E-04	7.E-06	6.E-01	
arithmetic mean meeting criteria	2.E-03	2.E-05	2.E+00	

K from Grain Size Analysis Report   Date: 20-May-21

Sample Name: MW21-3, SS6, 4.9 mBGS, Silty Sand Till

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

Poorly sorted sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.105E-03	.105E-05	0.09	
Hazen K (cm/s) = d_{10} (mm)	.171E-03	.171E-05	0.15	
Slichter	.212E-04	.212E-06	0.02	
Terzaghi	.311E-04	.311E-06	0.03	
Beyer	.127E-03	.127E-05	0.11	
Sauerbrei	.795E-04	.795E-06	0.07	
Kruger	.439E-03	.439E-05	0.38	
Kozeny-Carmen	.108E-03	.108E-05	0.09	
Zunker	.786E-04	.786E-06	0.07	
Zamarin	.915E-04	.915E-06	0.08	
USBR	.128E-03	.128E-05	0.11	
Barr	.230E-04	.230E-06	0.02	
Alyamani and Sen	.897E-03	.897E-05	0.78	
Chapuis	.368E-05	.368E-07	0.00	
Krumbein and Monk	.599E-03	.599E-05	0.52	
Shepherd	.974E-02	.974E-04	8.42	
geometric mean meeting criteria	2.E-04	2.E-06	2.E-01	
arithmetic mean meeting criteria	4.E-04	4.E-06	3.E-01	

K from Grain Size Analysis Report

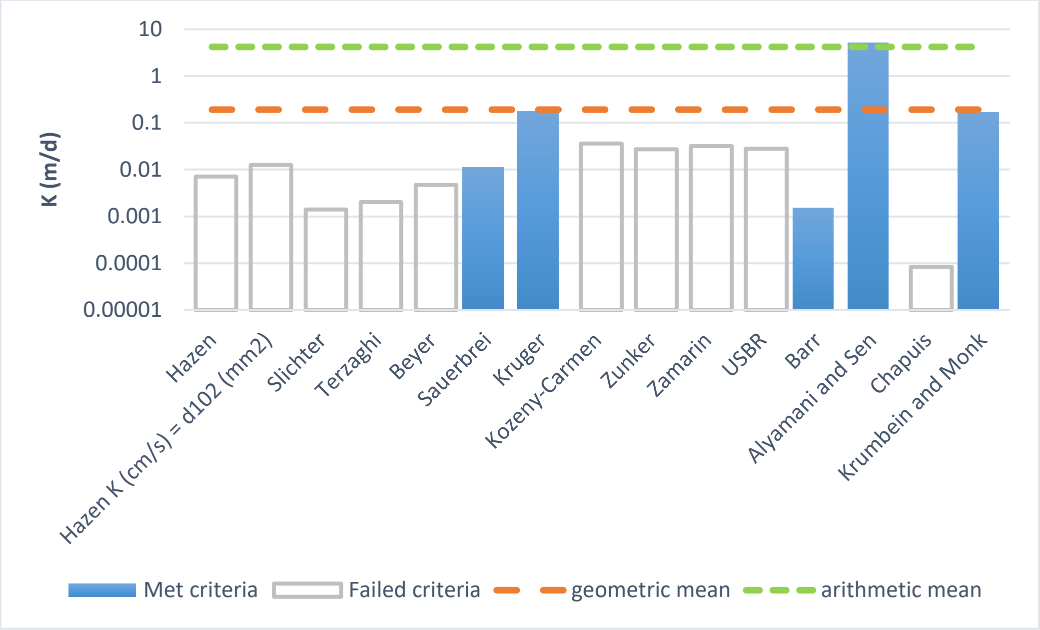
Date: 19-May-21

Sample Name: MW21-4, SS2, 1.1 mBGS, Fill

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand with fines



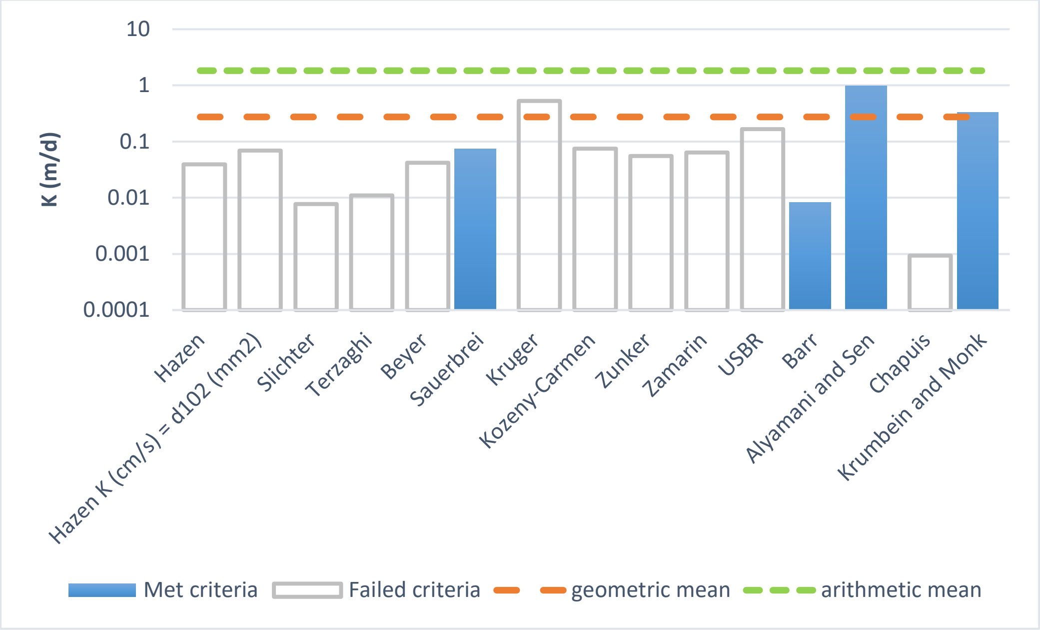
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.829E-05	.829E-07	0.01	
Hazen K (cm/s) = d_{10} (mm)	.146E-04	.146E-06	0.01	
Slichter	.163E-05	.163E-07	0.00	
Terzaghi	.232E-05	.232E-07	0.00	
Beyer	.543E-05	.543E-07	0.00	
Sauerbrei	.128E-04	.128E-06	0.01	
Kruger	.203E-03	.203E-05	0.18	
Kozeny-Carmen	.415E-04	.415E-06	0.04	
Zunker	.315E-04	.315E-06	0.03	
Zamarin	.369E-04	.369E-06	0.03	
USBR	.325E-04	.325E-06	0.03	
Barr	.175E-05	.175E-07	0.00	
Alyamani and Sen	.595E-02	.595E-04	5.14	
Chapuis	.972E-07	.972E-09	0.00	
Krumbein and Monk	.192E-03	.192E-05	0.17	
Shepherd	.227E-01	.227E-03	19.62	
geometric mean meeting criteria	9.E-05	9.E-07	8.E-02	
arithmetic mean meeting criteria	1.E-03	1.E-05	1.E+00	

K from Grain Size Analysis Report   Date: 19-May-21

Sample Name: MW21-5, AS2, 1.1 mBGS, Fill

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

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.454E-04	.454E-06	0.04	
Hazen K (cm/s) = d_{10} (mm)	.798E-04	.798E-06	0.07	
Slichter	.894E-05	.894E-07	0.01	
Terzaghi	.128E-04	.128E-06	0.01	
Beyer	.483E-04	.483E-06	0.04	
Sauerbrei	.855E-04	.855E-06	0.07	
Kruger	.614E-03	.614E-05	0.53	
Kozeny-Carmen	.865E-04	.865E-06	0.07	
Zunker	.643E-04	.643E-06	0.06	
Zamarin	.742E-04	.742E-06	0.06	
USBR	.193E-03	.193E-05	0.17	
Barr	.959E-05	.959E-07	0.01	
Alyamani and Sen	.114E-02	.114E-04	0.98	
Chapuis	.107E-05	.107E-07	0.00	
Krumbein and Monk	.386E-03	.386E-05	0.33	
Shepherd	.895E-02	.895E-04	7.73	
geometric mean meeting criteria	1.E-04	1.E-06	1.E-01	
arithmetic mean meeting criteria	4.E-04	4.E-06	3.E-01	

K from Grain Size Analysis Report

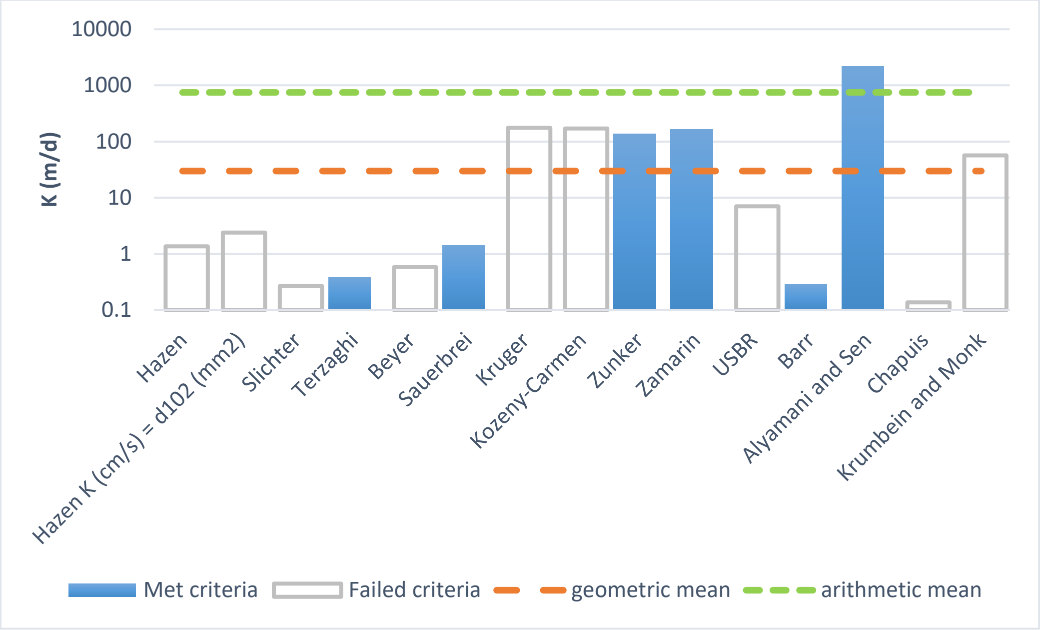
Date: 20-May-21

Sample Name: BH21-6, SS2, 1.1 mBGS, Sandy Gravel

Mass Sample (g): 100

T (oC) 20

Poorly sorted sandy gravel low in fines



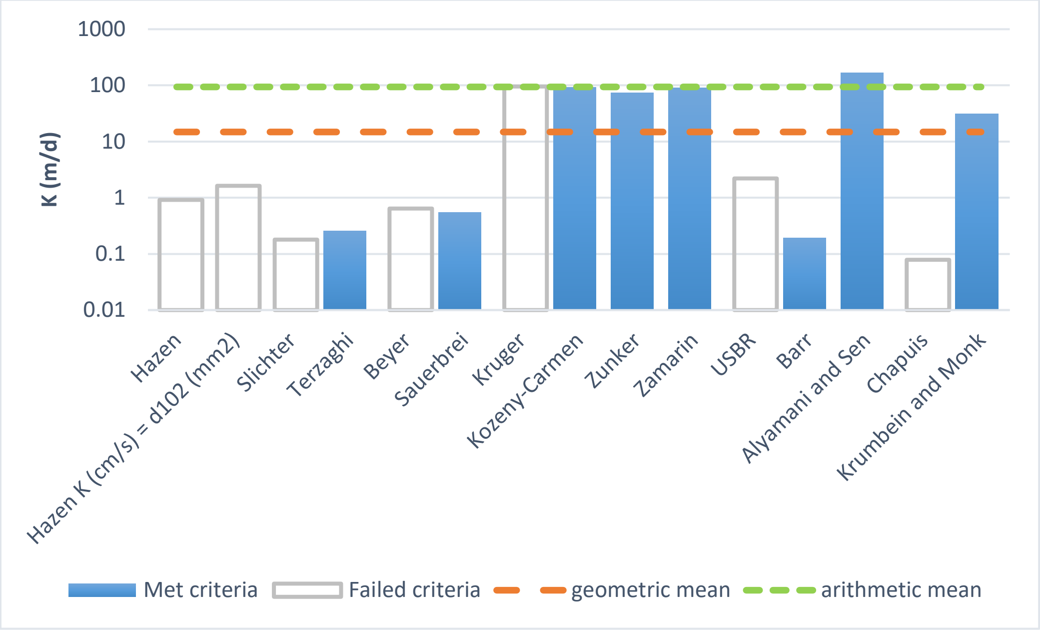
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.158E-02	.158E-04	1.36	
Hazen K (cm/s) = d_{10} (mm)	.279E-02	.279E-04	2.41	
Slichter	.310E-03	.310E-05	0.27	
Terzaghi	.443E-03	.443E-05	0.38	
Beyer	.668E-03	.668E-05	0.58	
Sauerbrei	.165E-02	.165E-04	1.43	
Kruger	.202E+00	.202E-02	174.39	
Kozeny-Carmen	.199E+00	.199E-02	171.65	
Zunker	.157E+00	.157E-02	135.72	
Zamarin	.193E+00	.193E-02	166.38	
USBR	.819E-02	.819E-04	7.08	
Barr	.333E-03	.333E-05	0.29	
Alyamani and Sen	.251E+01	.251E-01	2169.34	
Chapuis	.158E-03	.158E-05	0.14	
Krumbein and Monk	.652E-01	.652E-03	56.36	
Shepherd	.320E+01	.320E-01	2767.67	
geometric mean meeting criteria	2.E-02	2.E-04	1.E+01	
arithmetic mean meeting criteria	5.E-01	5.E-03	4.E+02	

K from Grain Size Analysis Report	Date: 20-May-21

Sample Name: BH21-7, SS2, 1.1 mBGS, Sand and Gravel

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

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.106E-02	.106E-04	0.92	
Hazen K (cm/s) = d_{10} (mm)	.188E-02	.188E-04	1.62	
Slichter	.209E-03	.209E-05	0.18	
Terzaghi	.298E-03	.298E-05	0.26	
Beyer	.741E-03	.741E-05	0.64	
Sauerbrei	.636E-03	.636E-05	0.55	
Kruger	.110E+00	.110E-02	94.88	
Kozeny-Carmen	.108E+00	.108E-02	93.23	
Zunker	.854E-01	.854E-03	73.75	
Zamarin	.105E+00	.105E-02	90.47	
USBR	.254E-02	.254E-04	2.20	
Barr	.224E-03	.224E-05	0.19	
Alyamani and Sen	.194E+00	.194E-02	167.43	
Chapuis	.908E-04	.908E-06	0.08	
Krumbein and Monk	.357E-01	.357E-03	30.82	
Shepherd	.448E+00	.448E-02	387.42	
geometric mean meeting criteria	1.E-02	1.E-04	1.E+01	
arithmetic mean meeting criteria	7.E-02	7.E-04	6.E+01	

K from Grain Size Analysis Report

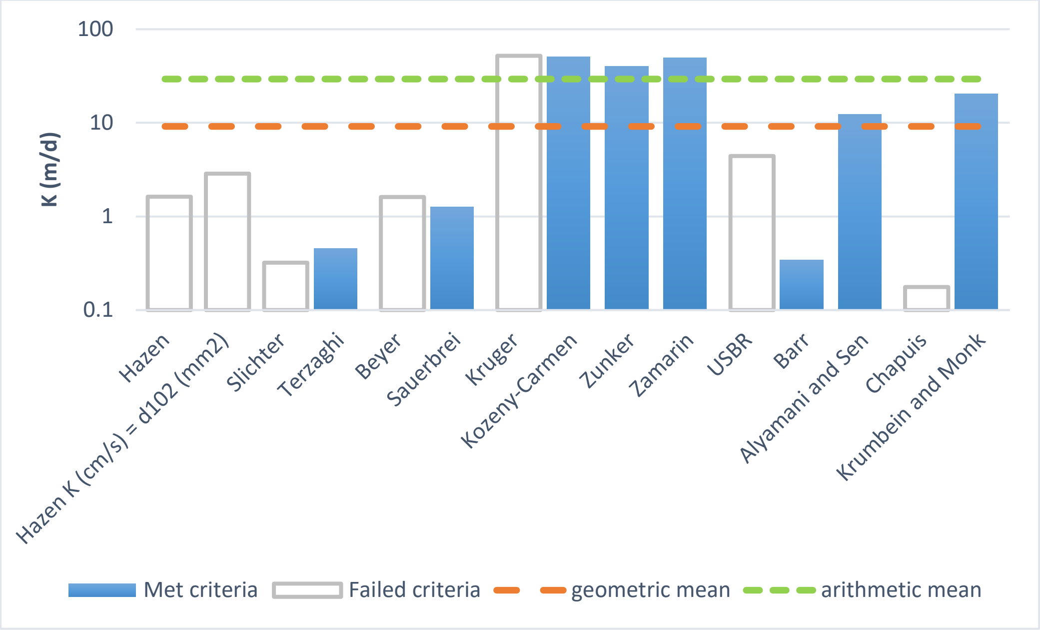
Date: 20-May-21

Sample Name: BH21-8, SS2, 1.1 mBGS, Gravelly Sand

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.189E-02	.189E-04	1.63	
Hazen K (cm/s) = d_{10} (mm)	.333E-02	.333E-04	2.88	
Slichter	.371E-03	.371E-05	0.32	
Terzaghi	.529E-03	.529E-05	0.46	
Beyer	.187E-02	.187E-04	1.61	
Sauerbrei	.146E-02	.146E-04	1.26	
Kruger	.601E-01	.601E-03	51.90	
Kozeny-Carmen	.590E-01	.590E-03	51.01	
Zunker	.467E-01	.467E-03	40.34	
Zamarin	.573E-01	.573E-03	49.50	
USBR	.510E-02	.510E-04	4.40	
Barr	.398E-03	.398E-05	0.34	
Alyamani and Sen	.143E-01	.143E-03	12.35	
Chapuis	.204E-03	.204E-05	0.18	
Krumbein and Monk	.237E-01	.237E-03	20.44	
Shepherd	.102E+00	.102E-02	88.31	
geometric mean meeting criteria	8.E-03	8.E-05	7.E+00	
arithmetic mean meeting criteria	3.E-02	3.E-04	2.E+01	

K from Grain Size Analysis Report

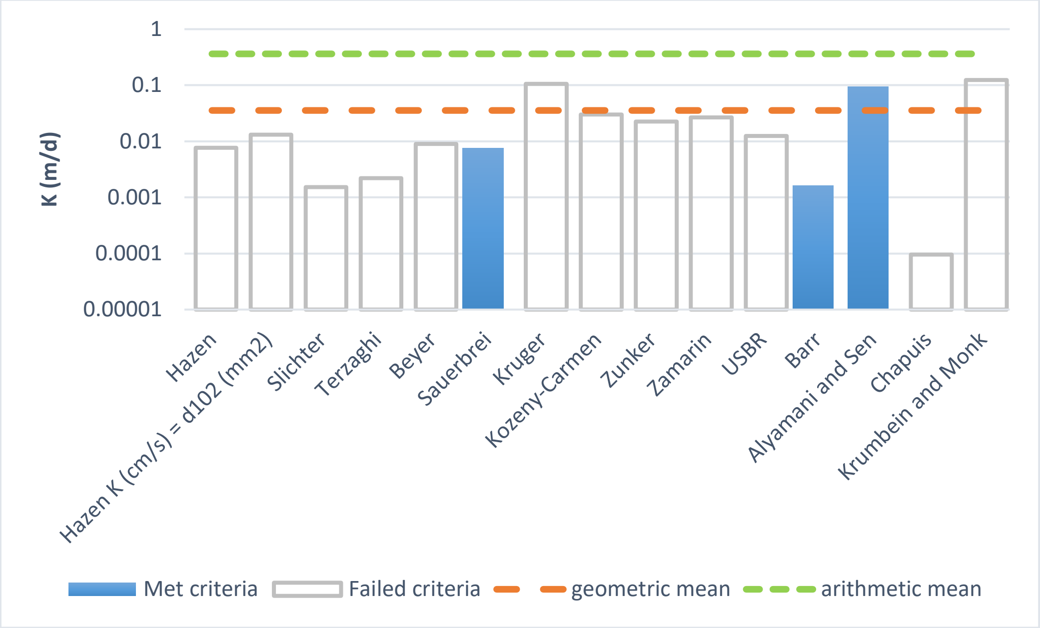
Date: 19-May-21

Sample Name: MW21-9, SS1, 0.3 mBGS, Fill

Mass Sample (g): 100

T (oC) 20

Poorly sorted sandy silt with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.889E-05	.889E-07	0.01	
Hazen K (cm/s) = d_{10} (mm)	.152E-04	.152E-06	0.01	
Slichter	.176E-05	.176E-07	0.00	
Terzaghi	.254E-05	.254E-07	0.00	
Beyer	.104E-04	.104E-06	0.01	
Sauerbrei	.880E-05	.880E-07	0.01	
Kruger	.122E-03	.122E-05	0.11	
Kozeny-Carmen	.348E-04	.348E-06	0.03	
Zunker	.261E-04	.261E-06	0.02	
Zamarin	.308E-04	.308E-06	0.03	
USBR	.145E-04	.145E-06	0.01	
Barr	.190E-05	.190E-07	0.00	
Alyamani and Sen	.110E-03	.110E-05	0.09	
Chapuis	.111E-06	.111E-08	0.00	
Krumbein and Monk	.143E-03	.143E-05	0.12	
Shepherd	.156E-02	.156E-04	1.35	
geometric mean meeting criteria	1.E-05	1.E-07	1.E-02	
arithmetic mean meeting criteria	4.E-05	4.E-07	3.E-02	

K from Grain Size Analysis Report

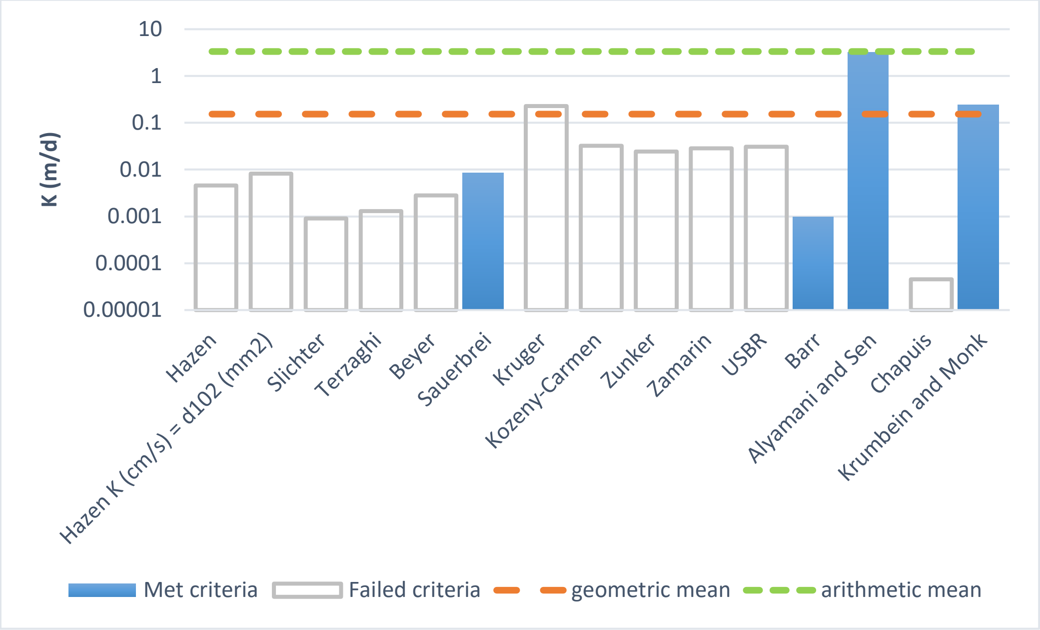
Date: 19-May-21

Sample Name: MW21-10, SS2, 1.1 mBGS, Fill

Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand with fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.534E-05	.534E-07	0.00	
Hazen K (cm/s) = d_{10} (mm)	.944E-05	.944E-07	0.01	
Slichter	.105E-05	.105E-07	0.00	
Terzaghi	.150E-05	.150E-07	0.00	
Beyer	.327E-05	.327E-07	0.00	
Sauerbrei	.996E-05	.996E-07	0.01	
Kruger	.266E-03	.266E-05	0.23	
Kozeny-Carmen	.376E-04	.376E-06	0.03	
Zunker	.283E-04	.283E-06	0.02	
Zamarin	.330E-04	.330E-06	0.03	
USBR	.355E-04	.355E-06	0.03	
Barr	.113E-05	.113E-07	0.00	
Alyamani and Sen	.368E-02	.368E-04	3.18	
Chapuis	.524E-07	.524E-09	0.00	
Krumbein and Monk	.278E-03	.278E-05	0.24	
Shepherd	.153E-01	.153E-03	13.25	
geometric mean meeting criteria	6.E-05	6.E-07	5.E-02	
arithmetic mean meeting criteria	1.E-03	1.E-05	9.E-01	

K from Grain Size Analysis Report

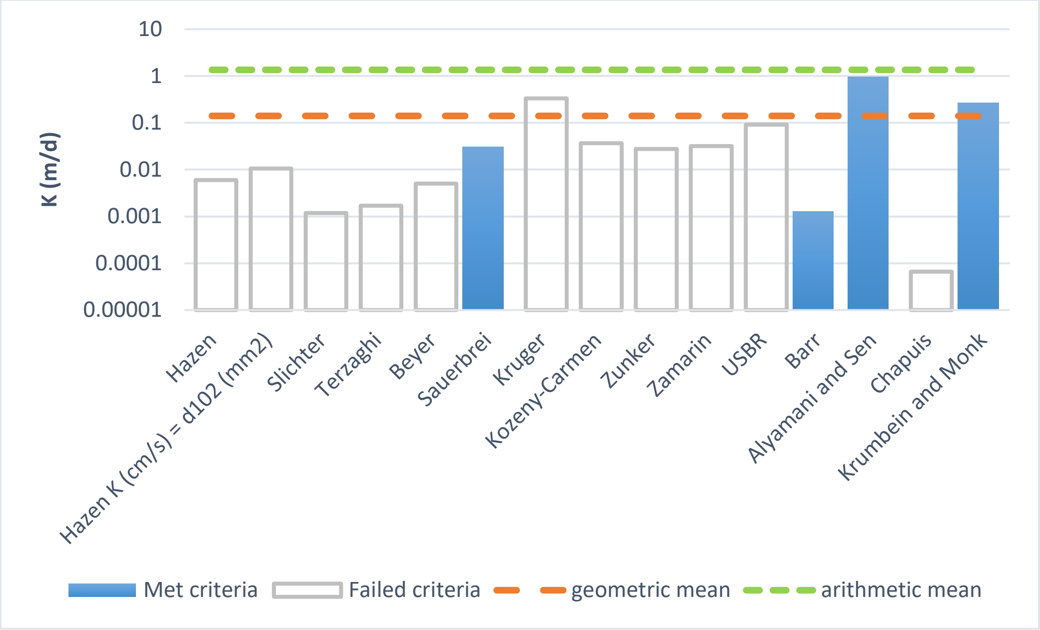
Date: 20-May-21

Sample Name: MW21-10, SS4, 2.6 mBGS, Silty Sand (above the till)

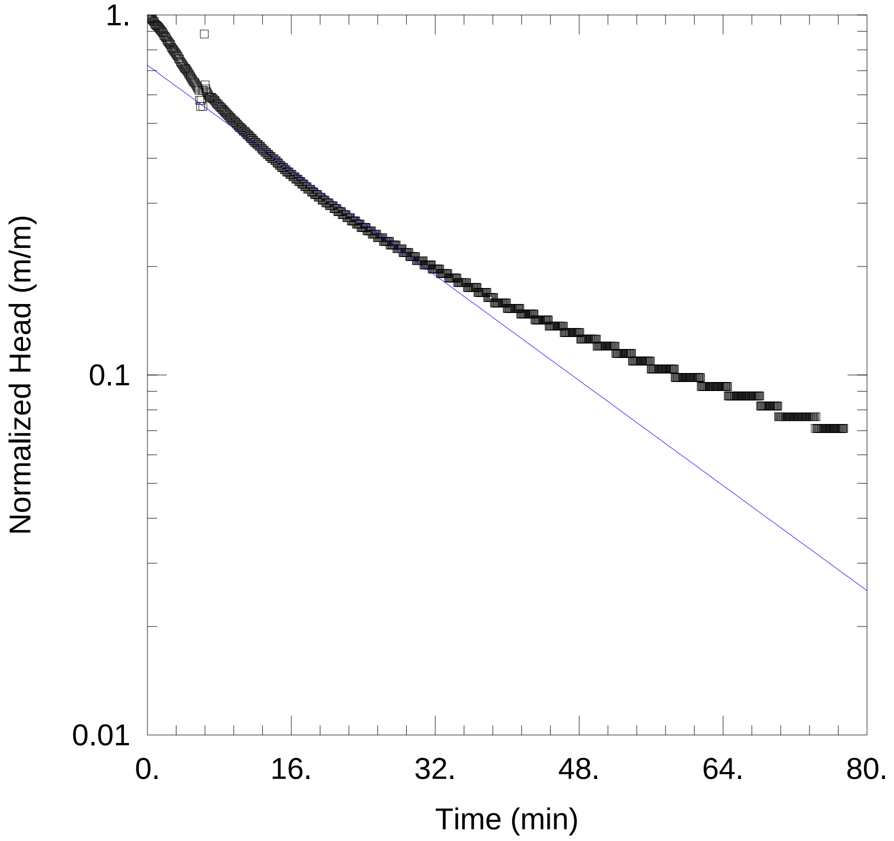
Mass Sample (g): 100

T (oC) 20

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.697E-05	.697E-07	0.01	
Hazen K (cm/s) = d_{10} (mm)	.123E-04	.123E-06	0.01	
Slichter	.137E-05	.137E-07	0.00	
Terzaghi	.195E-05	.195E-07	0.00	
Beyer	.579E-05	.579E-07	0.00	
Sauerbrei	.359E-04	.359E-06	0.03	
Kruger	.385E-03	.385E-05	0.33	
Kozeny-Carmen	.423E-04	.423E-06	0.04	
Zunker	.317E-04	.317E-06	0.03	
Zamarin	.368E-04	.368E-06	0.03	
USBR	.106E-03	.106E-05	0.09	
Barr	.147E-05	.147E-07	0.00	
Alyamani and Sen	.110E-02	.110E-04	0.95	
Chapuis	.762E-07	.762E-09	0.00	
Krumbein and Monk	.306E-03	.306E-05	0.26	
Shepherd	.640E-02	.640E-04	5.53	
geometric mean meeting criteria	6.E-05	6.E-07	6.E-02	
arithmetic mean meeting criteria	4.E-04	4.E-06	3.E-01	



WELL TEST ANALYSIS

Data Set: C:\...\MW21-1.aqt
Date: 08/10/23 Time: 09:31:52

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.
Client: EC (Erin) GP Inc.
Location: 5525 Eighth Line, Erin
Test Well: MW21-1
Test Date: August 2, 2023

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

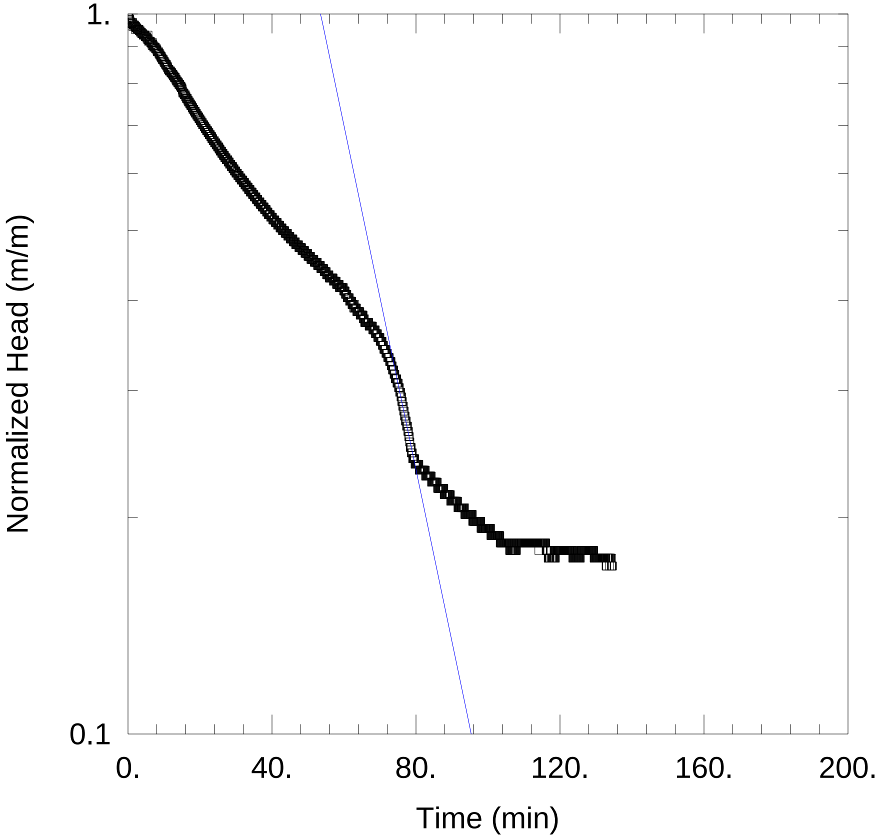
K = 2.22E-7 m/sec
y0 = 1.326 m

AQUIFER DATA

Saturated Thickness: 3.05 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW21-1)

Initial Displacement: 1.83 m
Total Well Penetration Depth: 6.03 m
Casing Radius: 0.0254 m
Static Water Column Height: 5.98 m
Screen Length: 3.05 m
Well Radius: 0.1 m



WELL TEST ANALYSIS

Data Set: C:\...\MW21-2.aqt
Date: 08/10/23 Time: 09:49:54

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.
Client: EC (Erin) GP Inc.
Location: 5525 Eighth Line, Erin
Test Well: MW21-2
Test Date: August 2, 2023

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

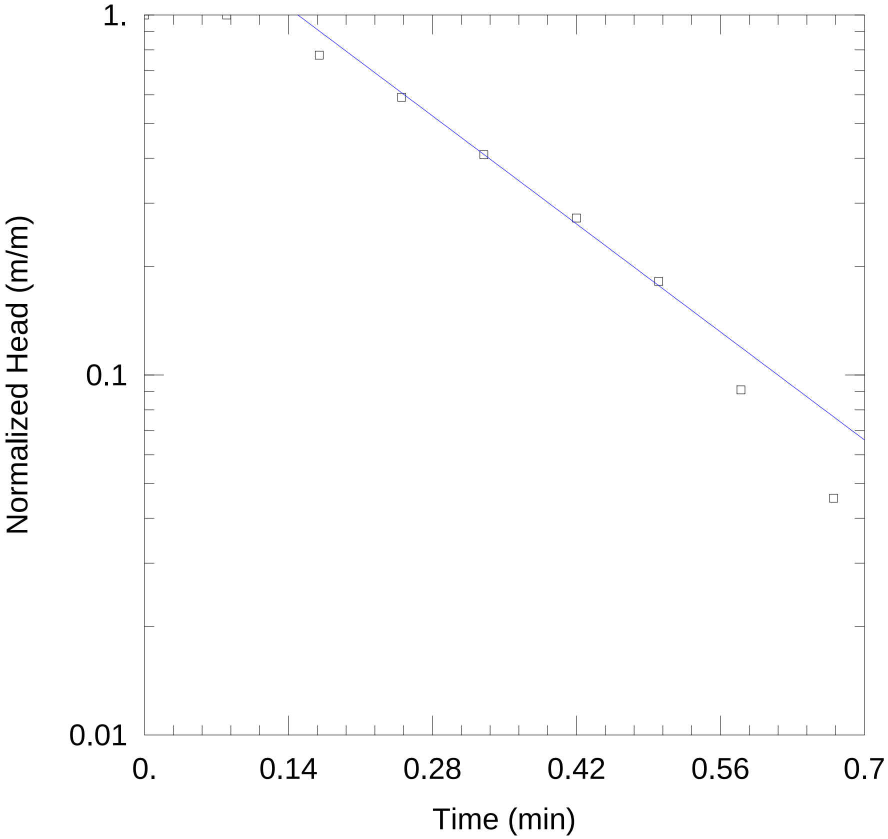
K = 2.881E-7 m/sec
y0 = 43.29 m

AQUIFER DATA

Saturated Thickness: 5.7 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW21-2)

Initial Displacement: 2.28 m
Total Well Penetration Depth: 5.75 m
Casing Radius: 0.0254 m
Static Water Column Height: 5.7 m
Screen Length: 3.05 m
Well Radius: 0.1 m



WELL TEST ANALYSIS

Data Set: C:\...\MW21-3.aqt
Date: 08/10/23 Time: 10:03:01

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.
Client: EC (Erin) GP Inc.
Location: 5525 Eighth Line, Erin
Test Well: MW21-3
Test Date: August 2, 2023

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

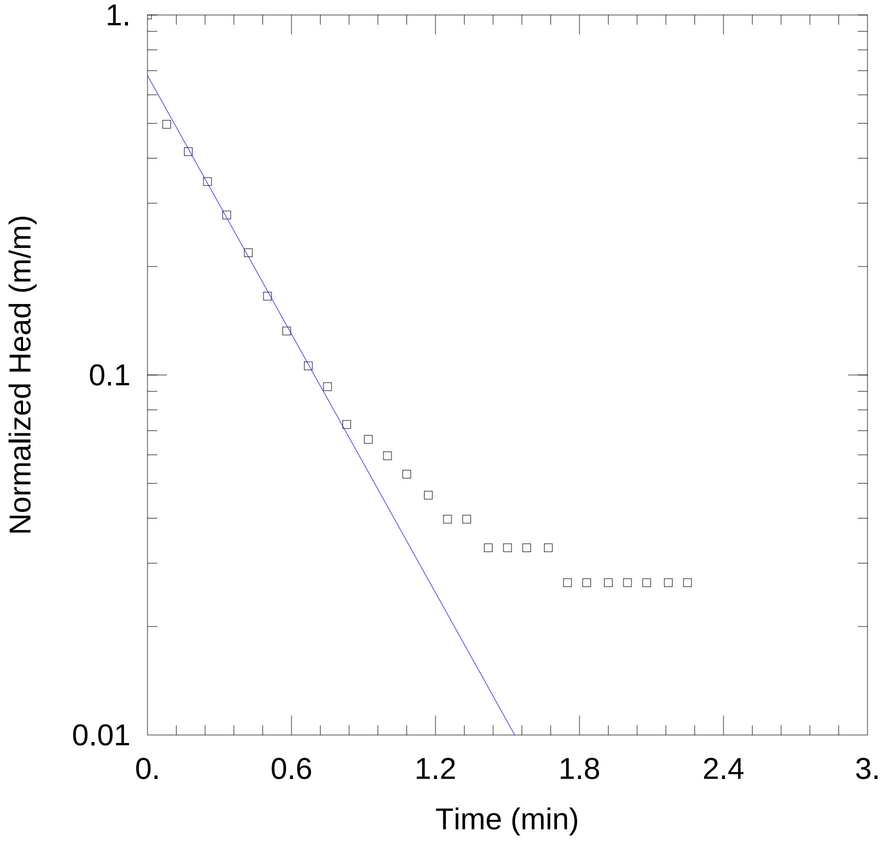
K = 4.613E-5 m/sec
y0 = 0.4591 m

AQUIFER DATA

Saturated Thickness: 1.34 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW21-3)

Initial Displacement: 0.22 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 1.34 m
Screen Length: 3.05 m
Well Radius: 0.1 m



WELL TEST ANALYSIS

Data Set: C:\...\MW21-10.aqt
Date: 08/10/23 Time: 08:36:59

PROJECT INFORMATION

Company: Terra-Dynamics Consulting Inc.
Client: EC (Erin) GP Inc.
Location: 5525 Eighth Line, Erin
Test Well: MW21-10
Test Date: August 2, 2023

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.531E-5 m/sec
y0 = 1.025 m

AQUIFER DATA

Saturated Thickness: 2.45 m
Anisotropy Ratio (Kz/Kr): 1.

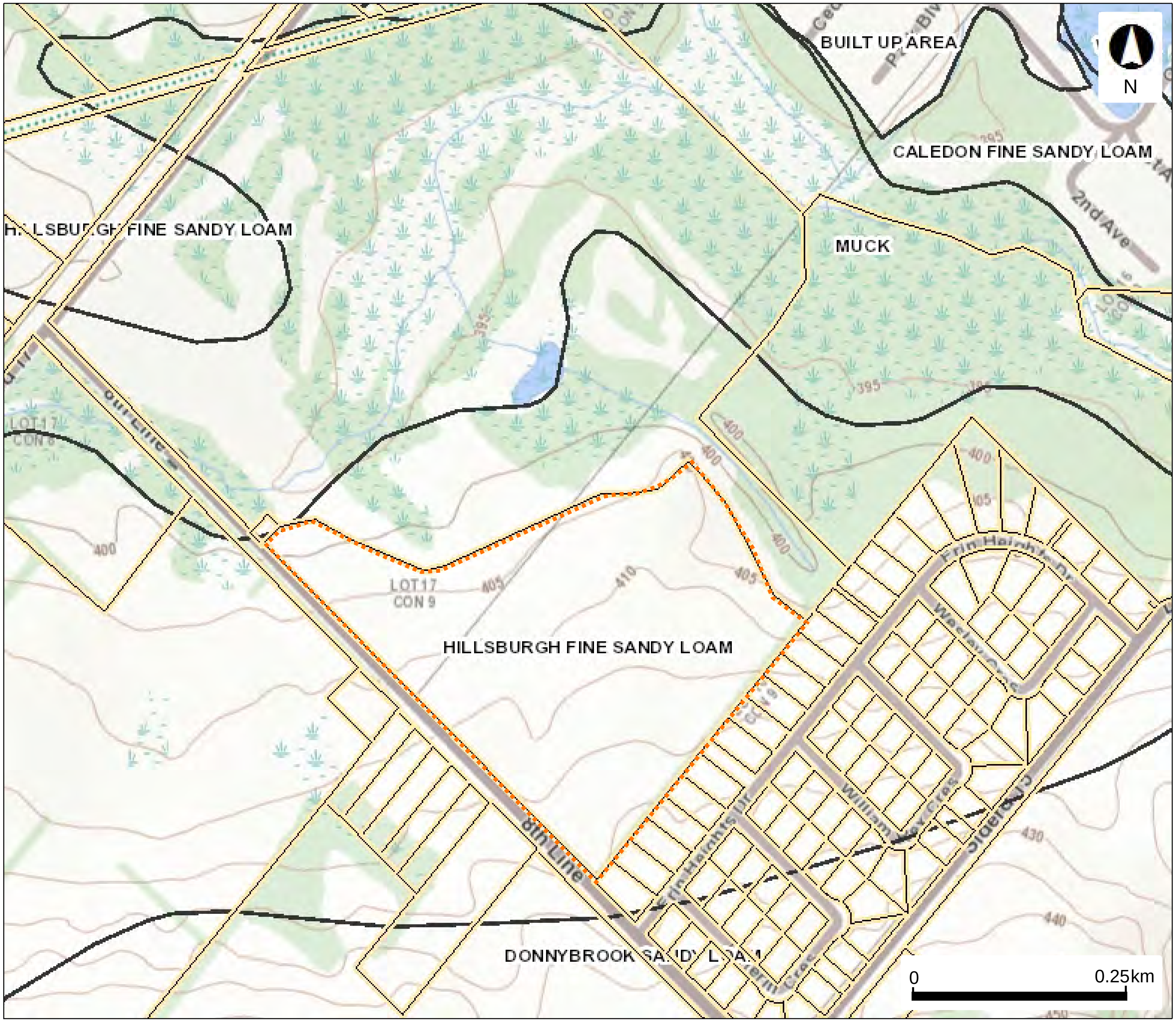
WELL DATA (MW21-10)

Initial Displacement: 1.51 m
Total Well Penetration Depth: 3.05 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.45 m
Screen Length: 3.05 m
Well Radius: 0.1 m

Appendix D

Provincial Maps

OMAFRA Soil Type

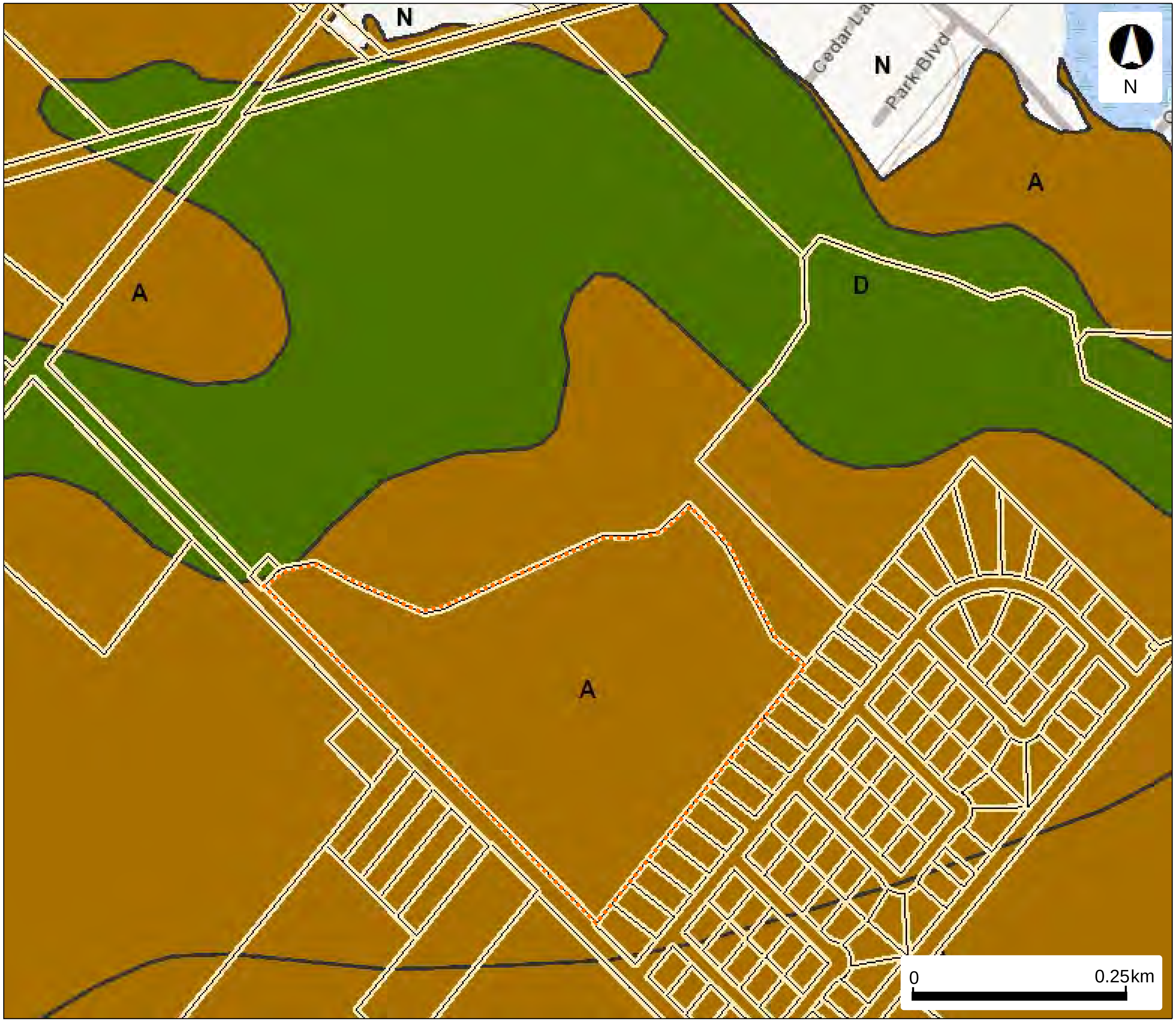


Legend

- 🟨 Assessment Parcel
- ☐ Soil Name Label

Map Created: 1/24/2022
Map Center: 43.77106 N, -80.08421 W

OMAFRA Hydrologic Soil Group



Legend

☐ Assessment Parcel

Hydrologic Soil Group

- 🟫 A - High
- 🟨 B - Moderate
- 🟦 C - Slow
- 🟩 D - Very Slow

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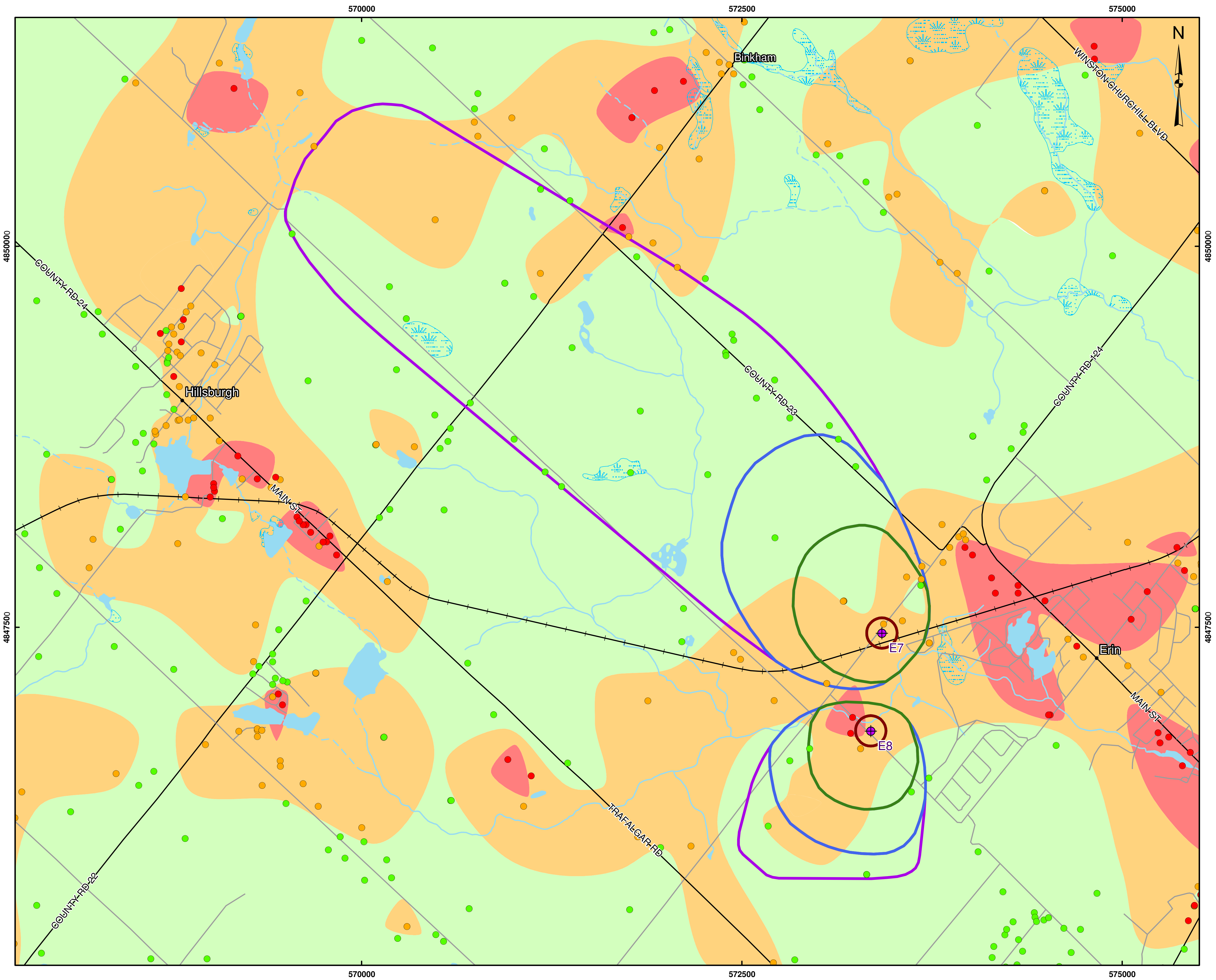
Ontario

Map Created: 1/24/2022
Map Center: 43.77151 N, -80.08421 W



LEGEND

⊕ Production Well

Wells Used in ISI Analysis

- ● Low Vulnerability
- ● Medium Vulnerability
- ● High Vulnerability

— Highway

— Major Road

— Local Road

┼ Railways

— Watercourse, Permanent

-- Watercourse, Intermittent

▨ Waterbody

▨ Wetland

Wellhead Protection Area

- ☐ WHPA A (100 m)
- ☐ WHPA B (2 year)
- ☐ WHPA C (5 year)
- ☐ WHPA D (25 year)

ISI Vulnerability

- 🟩 Low (>80)
- 🟧 Medium (30 - 80)
- 🟥 High (<30)

REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v2006.4
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 17N

0.5 0.25 0 0.5 1 1.5

SCALE 1:25,000 KILOMETERS

PROJECT

SOURCE WATER PROTECTION - TOWN OF ERIN

TITLE

ISI VULNERABILITY MAPPING - BEDROCK, ERIN MUNICIPAL WELLS

Golder Associates
Mississauga, Ontario

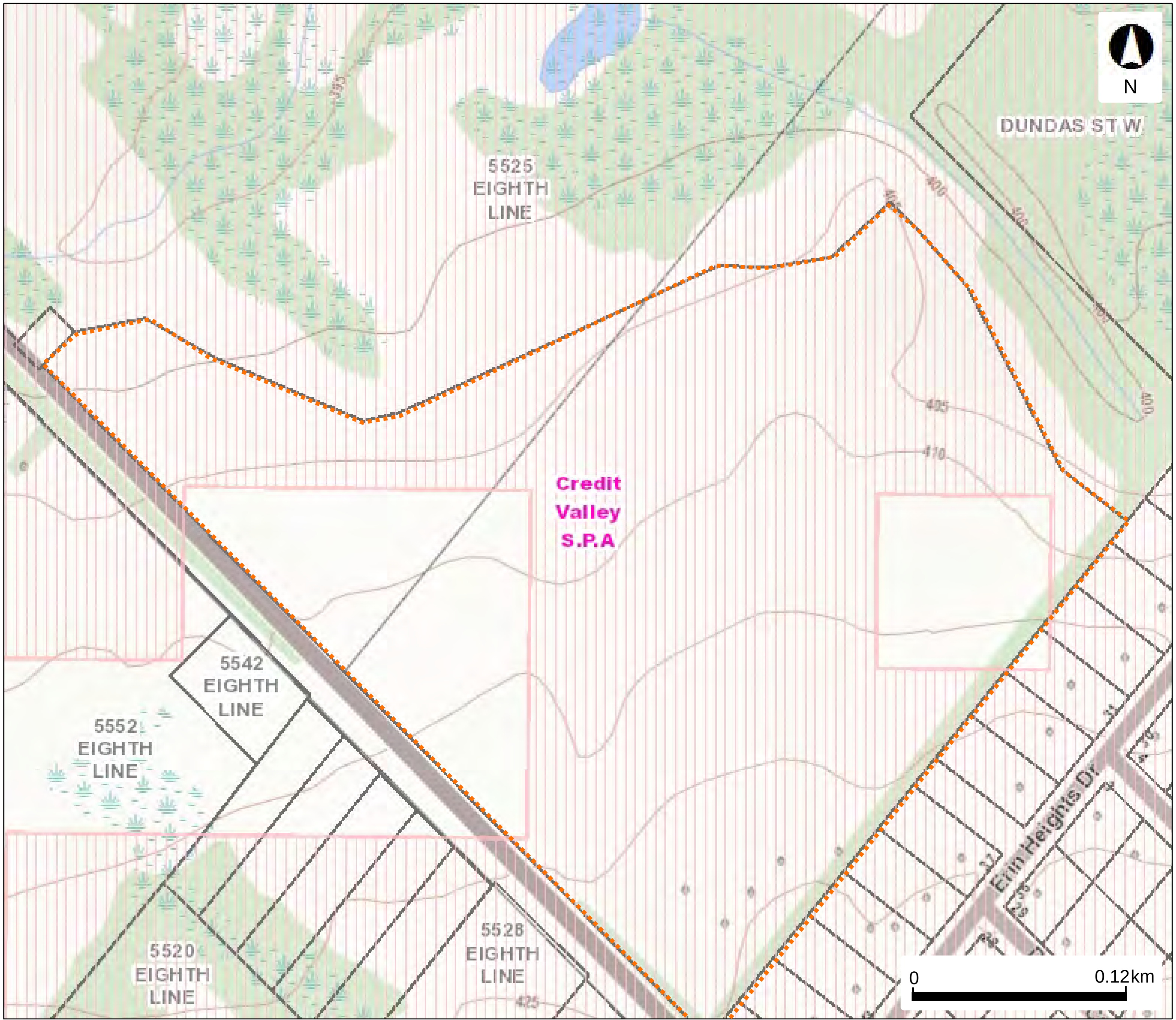
PROJECT NO. 09-1112-6139		
DESIGN	PRM	1 Apr. 2010
GIS	PRM	1 Apr. 2010
CHECK	GP	1 Apr. 2010
REVIEW	JP	1 Apr. 2010

SCALE AS SHOWN REV. 0.0

FIGURE: 5

G:\Projects\2009\09-1112-6139_Bel_Erin\GIS\MXDs\Draft\Blackport_Hydrogeology\ISI_Vulnerability_Erin_Bedrock.mxd

Highly Vulnerable Aquifer



Legend

- ☐ Source Protection Areas
- ▥ Highly Vulnerable Aquifers
- ☐ Assessment Parcel with Addre

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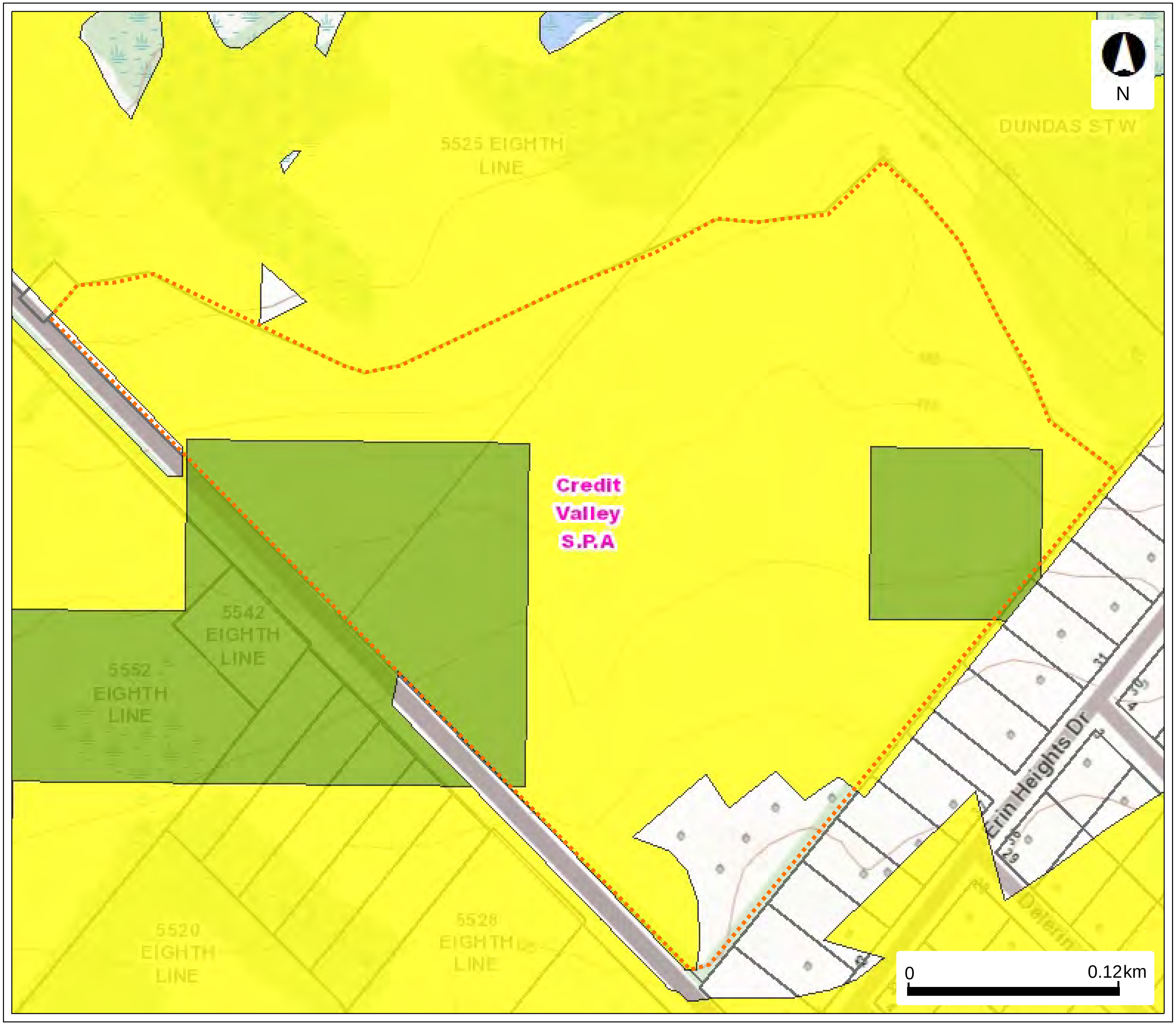
Ontario

Map Created: 1/18/2022
Map Center: 43.76998 N, -80.08494 W

Significant Groundwater Recharge Areas



Legend

☐ Source Protection Areas

Significant Groundwater Recharge Area

🟩 0

🟩 2

🟩 4

🟨 6

☐ Assessment Parcel with Addre

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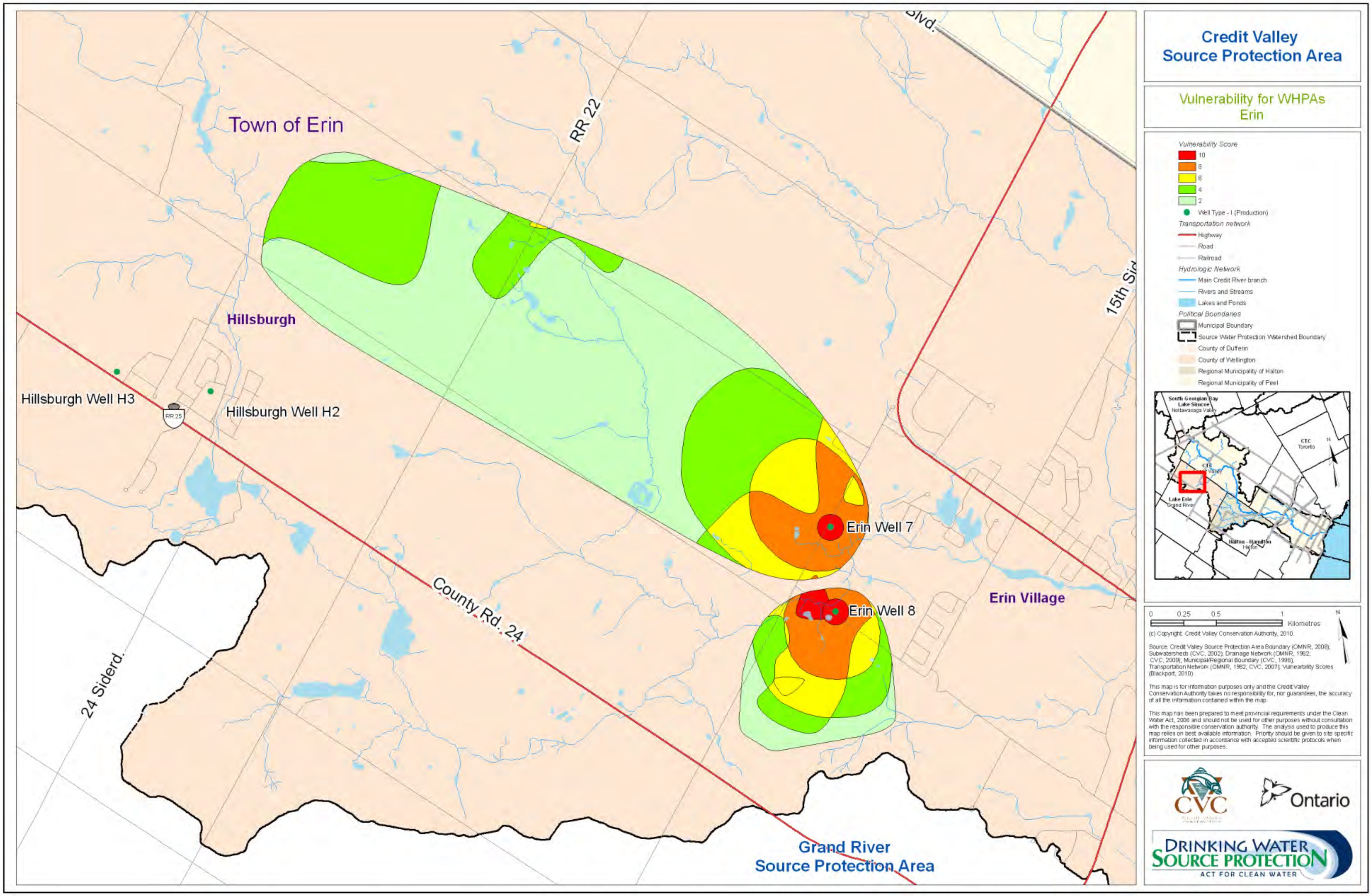
Ontario

Map Created: 1/18/2022
Map Center: 43.76972 N, -80.08491 W



(c) Copyright. Credit Valley Conservation Authority, 2010.

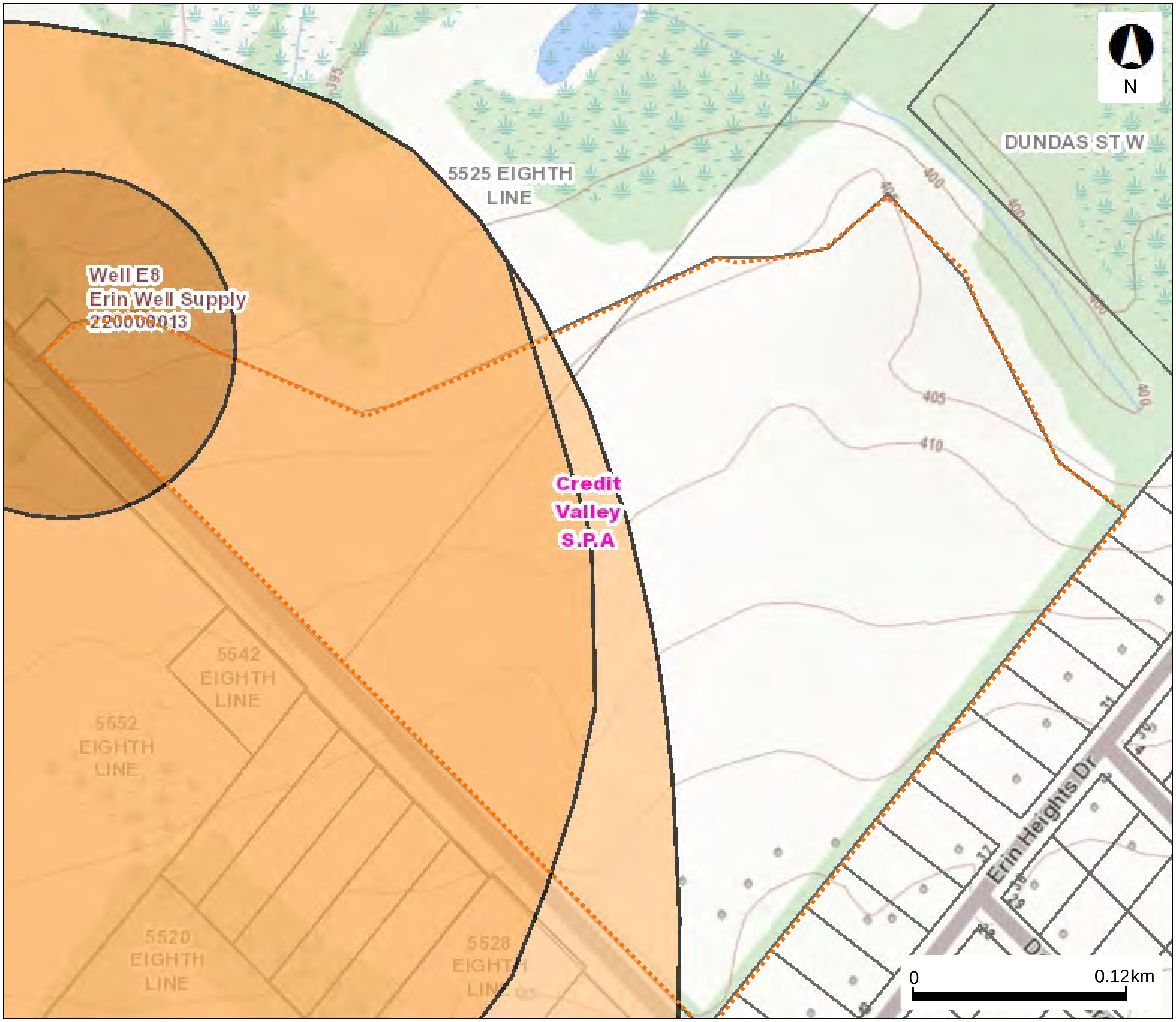
Source: Credit Valley Source Protection Area Boundary (OMNR, 2008); Subwatersheds (CVC, 2002); Drainage Network (OMNR, 1982; CVC, 2009); Municipal/Regional Boundary (CVC, 1998); Transportation Network (OMNR, 1982; CVC, 2007); Vulnearbility Scores (Blackport, 2010)

This map is for information purposes only and the Credit Valley Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within the map.

This map has been prepared to meet provincial requirements under the Clean Water Act, 2006 and should not be used for other purposes without consultation with the responsible conservation authority. The analysis used to produce this map relies on best available information. Priority should be given to site specific information collected in accordance with accepted scientific protocols when being used for other purposes.

Figure 4.21: Vulnerability Scores for WHPAs – Erin

Wellhead Protection Areas



Legend

☐ Source Protection Areas

Wellhead Protection Area

■	A
■	B
■	C
■	C1
■	D
■	F

☐ Assessment Parcel with Addre

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Ontario

Map Created: 1/18/2022
Map Center: 43.76994 N, -80.08491 W

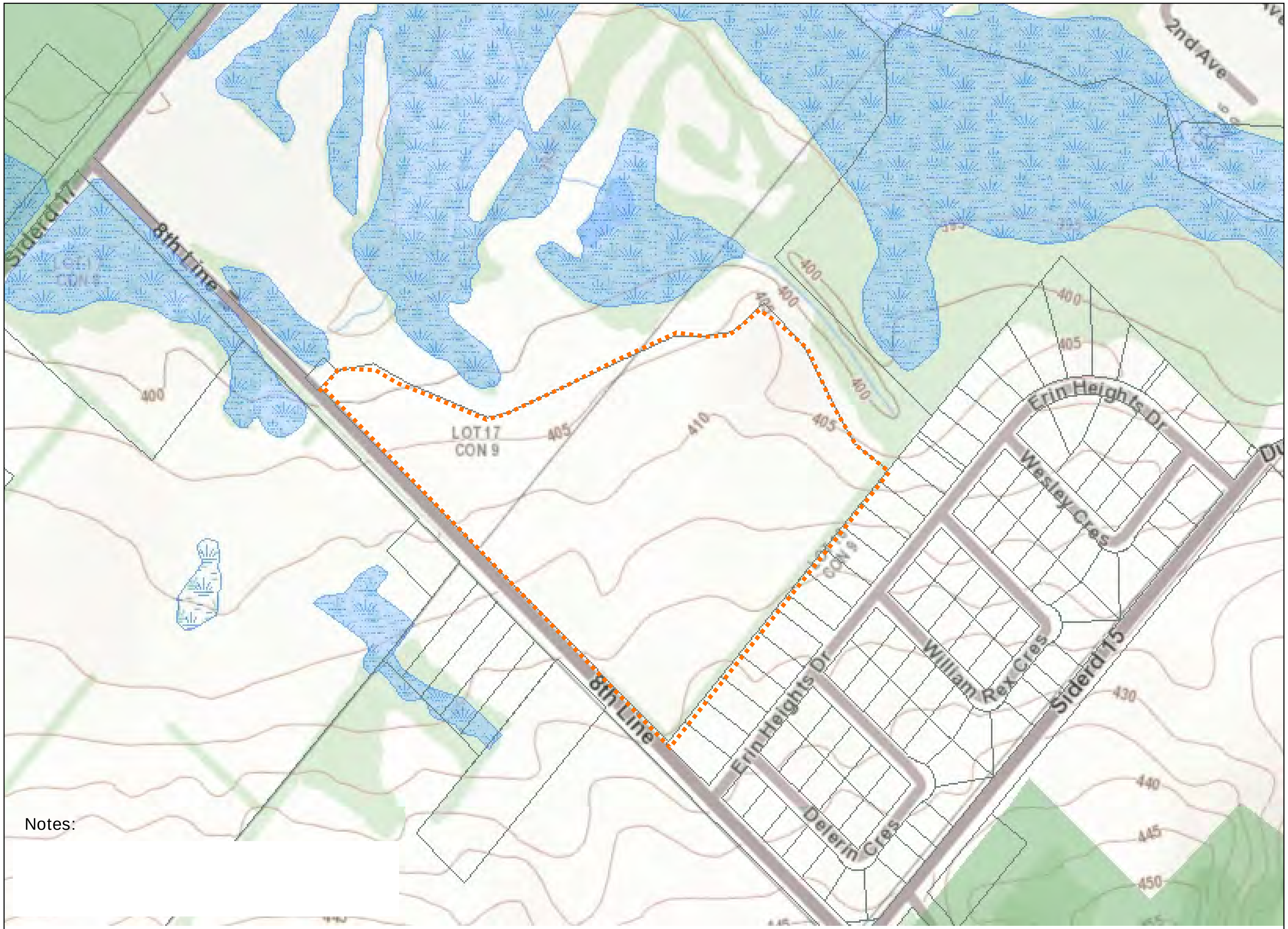
Ontario

Ministry of Natural Resources and Forestry

Make-a-Map: Natural Heritage Areas

West Credit River Wetland Complex

Map created:1/18/2022



Legend

☐ Assessment Parcel

ANSI

▨ Earth Science Provincially Significant/sciences de la terre d'importance provinciale

▨ Earth Science Regionally Significant/sciences de la terre d'importance régionale

▨ Life Science Provincially Significant/sciences de la vie d'importance provinciale

▨ Life Science Regionally Significant/sciences de la vie d'importance régionale

Evaluated Wetland

🟦 Provincially Significant/considérée d'importance provinciale

🟦 Non-Provincially Significant/non considérée d'importance provinciale

☐ Unevaluated Wetland

🟩 Conservation Reserve

⬜ Provincial Park

🟩 Natural Heritage System

0.3 0 0.17 0.3 Kilometres

Absence of a feature in the map does not mean they do not exist in this area.

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