



July 26, 2023

Project No. 23599569

Jane Wilson, M.Sc., P.Eng.

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N1H 7Y6

HYDROGEOLOGICAL BASELINE ASSESSMENT MARKDALE TREATMENT AND DISPOSAL FACILITY

Dear Ms. Wilson,

WSP Canada Inc. (WSP) was retained by J.L. Richards & Associates Limited (JLR) to provide hydrogeological consulting services in support of the proposed expansion of the Markdale Wastewater Treatment Plant (WWTP), referred to herein as the 'Site'. It is understood that JLR is conducting a Schedule B Municipal Class Environmental Assessment (MCEA) for the Markdale WWTP.

Scope of Work

The scope of work for the current investigation consisted of:

- Reviewing historical Site data, including groundwater level measurements, borehole and well completion logs, groundwater quality data, facility design plans, and publicly available geological and stratigraphic information;
- Developing a conceptual hydrostratigraphic model of the Site, including characterization of the seasonal groundwater fluctuations;
- Identification of data gaps (if any) which may affect the future planning and design activities; and
- Preparation of a report documenting the results of the assessment, and providing recommendations with regard to the hydrogeological conditions, and their bearing on the construction plans.

Site Background

The Markdale WWTP is owned and operated by the Municipality of Grey Highlands (the 'Municipality'). In 2018, amended Environmental Compliance Approval (ECA) 9653-B5GLKM was issued to increase the Wastewater Treatment Plant's rated capacity from 1,122 m³/d to 1,722 m³/d.

Significant features of the Markdale WWTP are two aerated lagoons (Cells 1 and 2), Parshall flume for flow monitoring and an alum dosing system for phosphorous removal. The treated effluent from the lagoons is discharged to eight Rapid Infiltration Basins (RIBs) which gradually release the treated effluent into the subsurface. Figure 1 illustrates the layout of the RIBs and monitoring wells related to monitoring the RIB that are on-Site. The Cells, flume and dosing system are located more than 100 m east of the RIB system and are not shown on Figure 1.

Cell 1 was constructed to act as a primary treatment cell, whereas Cell 2 can provide winter storage if needed. Discharge to the RIBs occurs during favourable seasonal conditions (between March 1st and November 30th, as permitted) and winterized basins are used after November 30th. The treated sewage effluent enters the RIB, infiltrates into the underlying granular material, and enters the groundwater system. The treated effluent travels via advective groundwater flow away from the RIB in a radial pattern to the northwest, west, and southwest, and emerges as groundwater discharge at or slightly above the Rocky Saugeen River. The objective of the system is to have zero “direct discharge” to the Rocky Saugeen River in order to protect the high quality and fish and aquatic life habitat associated with the river (WSP, 2022). It is understood that as part of the on-going development plan the Municipality exploring the potential for increasing the overall discharge rate to the RIB system, by between 25% to 100%.

Rapid Infiltration Basins

The rapid infiltration basins (RIB) system is currently governed under Certificate of Approval (CofA) Number 0899-5BYJHZ (October 2018). The system is permitted to operate annually between March 1 and November 30, with a design flow of 1,722 m³/day (WSP, 2022). The RIB system was previously governed by CofA No. 0899-5BYJHZ, dated November 2002, which permitted discharge at a rate of 1,122 m³/day. The rapid infiltration system consists of eight basins, each approximately 56 metres long by 6 metres wide, and 0.6 metres deep (Figure 1). The RIB system is underlain by native deposits of silty sand and gravel material. A mounding assessment was completed in 1981 (Morrison, 1981) which was used to determine the configuration and size of the basins.

Amended Environmental Approval Certificate (ECA) Number 9378-9M2RLX, issued in August 2014, permitted the modification of two basins to enable year-round system operation. Existing Basins 6 and 7 were modified for winter operation in the summer of 2015. They are comprised of a clear stone bed on top of the existing sand bed, a 300 mm diameter distribution pipe, clear stone and sand backfill, filter cloth and are covered with topsoil (200 mm deep) and seed. The system is designed to feed at a rate of 50% greater than the design flow rate (2,871 m³/day) during the gravity mode of operation (when contents of Cell 2 is high enough to feed by gravity to the RIB) and at the design rate only 1,914 m³/day (if only one pump runs) when the effluent pump is required to lift the Cell 2 effluent into the RIB side of Structure No. 6 during the pumping mode of operation.

The RIB system is operated as follows:

- During the normal RIB operating season (March 1 to November 30) RIB 1 to 5, and 8 are utilized. Two out of the six RIB are fed simultaneously per week, with the remaining four basins resting. Over the subsequent weeks flow is alternated between basins to allow the previously active basins to rest / drain. The schedule for Basin use is:
 - Week 1: Basins 2 and 3 are operational
 - Week 2: Basins 5 and 8 are operational
 - Week 3: Basins 1 and 4 are operational
- Basins 6 and 7 are utilized when freezing conditions are occurring.

The rate of discharge from the individual RIB gradually decline over time. When flow rate has declined by 30% to 40% of the peak flow, renovation to the bottom sand is required by rototilling (i.e., ‘raking’) to break up any biological growth (i.e., matting) which may have formed on the bottom sands leading to restricted discharge. After the weekly drying period, the basins are rototilled to near full capacity. If more severe plugging is experienced in the sand to operational manual recommends that a 50 mm layer of sand be skimmed off and replaced with new filter sand of the gradation shown in the specifications.

As part of on-going management of the system, groundwater level measurements are collected from monitoring wells in the vicinity of the RIB on a monthly basis which allows for assessment of the rise in groundwater level (i.e., mounding) when the basins are discharging. The operational manual (WSP, 2022) stipulates that the highest groundwater level under each basin should not be close than 0.6 m of the invert of the basins. Groundwater quality sampling is also conducted as part of the on-going monitoring program.

In 1981 (Henderson Paddon, 1981) an area was identified between Cell 1 and the railway which was considered to have potential suitable physical conditions for use as a backup location in the event an increase in the treated discharge volumes required additional basins to be installed. The choice of backup location was based on the results of a test pitting, drilling, and piezometer installation, which identified a crescent shaped ridge north of the of the “main lagoon” (i.e., Cell 1), which consisted of a stoney sand deposit. Several natural “dry” kettles were noted in the area, which was considered indicative of “good permeability” and the depth to groundwater was estimated to be 4 to 5 m below grade (Henderson Paddon, 1981).

Topography and Drainage

The Site is located within the Saugeen Conservation Watershed. The topography at the Site is characterized by relatively high elevation ground in the area of the Cells, treatment area and RIB. The ground surface elevation along the RIB varies between approximately 404 to 405 masl. From the RIB, the ground slopes downward southwest, west, and northwest into the valley coincident with the Rocky Saugeen River (DWS 2022). The Rocky Saugeen River is at an elevation of approximately 400 masl along the western edge of the WWTP property. The ground surface elevations at the monitoring well locations range from about 402.7 to 404.3, based on surveyed monitoring well data (Novakovic, 1992). Figure 2 presents a cross-section of the Site, along the axis of the major groundwater monitoring well transect.

Geology

Regional geological mapping indicates that the quaternary geology in the Markdale area consists of a mix of glaciofluvial ice-contact deposits (gravel and sand, minor till) and eskar, kame, end moraine, ice-marginal delta and subaqueous fan deposits (Quaternary Geology of Ontario, 1991). Within the river valley it is expected that the surficial deposits will consist of organic and modern alluvial deposits associated with the Rocky Saugeen River. The Saugeen Kames are present in the Markdale area, which consist of glaciofluvial ice-contact sand and gravel (Waterloo Hydrogeologic Inc., 2003). Bedrock in the Markdale area, and at the WTP site, is expected to be the Guelph Formation composed of sandstone, shale, dolostone and/or siltstone from the Middle and Lower Silurian period (Bedrock Geology of Ontario, 1991).

Geological conditions at the Site were evaluated based on the results presented in the various historical intrusive investigation reports. Figure 1 indicates the location of historical test pit and borehole locations. The overall geological conditions described in the historical report is generally consistent with local mapping and indicate that the surficial geology in area of the RIB system, and over the Site as a whole, consists of coarse-grained glaciofluvial material. Drilling data (Henderson and Paddon, 1981; Golder Associates, 1984) specifically characterizes the surficial deposits at the RIB as consisting of sand and gravel, with silt, cobbles, and occasional boulders. Deeper drilling in the RIB area notes a sandy silt unit is present underlying the surficial sand and gravel. The sandy silt is in turn underlain by silt till, which is present above the bedrock. The following table summarizes the current understanding of the Site stratigraphy in the area of the RIB system, based on the (relatively limited) borehole data available. Figure 2 provides a section across the Site that illustrates the stratigraphic profile based on the available borehole drilling data. Based on the lithologic descriptions in the historical reports and publicly available mapping, and the (relatively limited) borehole data currently available it appears that the surficial geology over most of the area between the lagoon berm and the Saugeen River consists of coarse-grain sand and gravel deposits.

Table 1: Summary of Stratigraphy – RIB Area

Formation	Elevation ¹ (masl)	Thickness (m)
Sand and Gravel	399.0 to 404.0	3 - 5
Sandy Silt	391.5 to 399.0	7.5
Till	389.8 to 391.5	1.4
Bedrock	<398.8	---

Notes: ¹ elevations based on drilling results from borehole OW26C (Henderson and Paddon, 1981)

Due to the differences in ground surface elevation across the Site it is expected that the thickness and depth of individual units will vary. The depth to bedrock at the Site is expected to be range from approximately 9 mbgs to 14 mbgs.

Hydrogeology

The available historical reports indicate that a total of about 60 boreholes / monitoring wells have been advanced at the Site as part of previous investigations (Figure 1). The existence of the various wells was not confirmed as part of the current investigation. Seven groundwater monitoring wells (OW1-86, OW2-86, OW6-86, OW6A86, OW6B-86, OW13-86 and OW16-79), installed between 1979 and 1986, are currently included in the monthly monitoring program. These seven monitoring locations are reportedly located along the anticipated flow path of the treated effluent from beneath the RIB system toward the river. Seeps have been noted in the past at various locations along the slope between the RIB and the Rocky Saugeen River (Douglas Water Services, 2022). The seeps are at two locations in particular, Sta. TP3-79 and CW2; Figure 1, are incorporated into the routine monitoring program. The seeps are considered to represent locations where the shallow groundwater table intersects the ground surface for at least a portion of the year, leading to local discharge. It is expected that the shallow groundwater flow pattern roughly mimics topography, with lateral groundwater flow away from the topographic high areas toward the low-lying Rocky Saugeen River.

Groundwater Mounding at the Rapid Infiltration Basins

Groundwater levels have been monitored annually at the above noted monitoring wells, and monitoring reports are available for the years from 2014 to 2021. Historical water level readings collected at monitoring wells located around the RIB indicate that the depth to the water table in the RIB area generally varied from about 1.1 m to 3.9 metres (Douglas Water Services (DWS), 2022). The operation and monitoring report for 1992 (Novakovic, 1992) provides figures illustrating the effect of discharge to the RIB system on the groundwater table at the time. The report indicates the maximum rise in the groundwater table was noted around the RIB system on the order of 1.3 m from the surrounding area, with a groundwater elevation of between 401 and 402 masl (compared to a bottom elevation for the RIB system of approximately 403.3 masl).

Figures 3A through 3E (attached) provide the groundwater hydrographs from the various monitoring wells in the on-going monitoring program. The results of the water level monitoring activities since 2014 indicate that the 'average' depth to groundwater in the vicinity of the RIB, as measured at wells OW1-86 and OW2-86 appears to have declined since 2014. These measurements are consistent with the pattern of effluent discharge to the RIB system. The average daily discharge rates in 2014 ranged from approximate 1,000 to 2,000 m³/day (WSP, 2015), which corresponds to some of the highest reported average effluent discharge rates to the RIB system. In 2021 those rates had reportedly decreased to between 600 and 900 m³/day (DWS, 2022). The effect of the relative discharge rate can also be noted in the final months of 2021, when the average daily discharge rate reportedly increased to over 2,000 m³/day (DWS, 2021), and a rise in the groundwater level was

noted at both OW1-86 and OW2-86 at that time. Direct correlation of the height of the water table in the vicinity of the RIB system is complicated by the relative paucity of recent water level measurements collected at wells OW1-86 and OW2-86 however the general pattern indicates that, as would be expected, the water levels at OW1-86 and OW2-86 are strongly influence by the RIB system. The groundwater elevation at these wells ranged from about 400 to 402.3 masl over the period of monitoring, rising within approximately 1 m of the RIB invert during period of highest loading.

The groundwater hydrographs for the remaining wells appear to show a slight decline in average water level between 2014 and 2021, however the pattern is not as marked as OW1-86 and OW2-86, and the range of water level fluctuations are generally consistent over time. The fluctuations in water level at these wells are attributed more to seasonal and year-over-year fluctuations in climatic conditions (e.g., rainfall, temperature). The range in water table fluctuations was generally on the order of one meter over the year, with a general pattern of relatively high groundwater levels in the late winter and spring, and relatively low water levels in the summer and early fall.

Future development plans are considering increased loading rates above the current capacity of 1,722 m³/day, to rates ranging from 25% higher (2,150 m³/day) to 100% (3,450 m³/day). The highest historical loading rates for the RIB system over period of 2014 to the present were approximately 2,000 L/day, which is within approximately 10% of the smallest increased flow rate under consideration. Although a precise correlation cannot be made between the reported effluent disposal rate to the RIB system and the groundwater level using the available data, the general patterns provide an understanding of the discharge rate (or range of rates) that are expected to allow the system to remain within the allowable operational limits.

As a calibration approach to the mounding expectations at the RIB system, mounding calculations completed as part of the pre-construction assessment (Henderson Paddon, 1981) were re-run using the most recent discharge data and groundwater level information. The results of the mounding review were broadly consistent with the pre-construction predictions. Figure 4 provides the results of the groundwater mounding estimates at higher discharge rates. Using the basic mounding calculations, estimates were made of the expected groundwater level based on increased loading rates of 25% (2,150 m³/day), 50% (2,575 m³/day), and 100% (3,450 m³/day) of the currently permitted limit. Figure 4 (attached) illustrates the estimated depth to groundwater below ground surface for the various loading rates. The estimates suggest that at an average loading rate of approximately 2,350 m³/day the groundwater level will rise to within the minimum separation distance of 0.6 m from the base of the RIB bed (i.e., ground surface). These results imply that an increase in the permitted discharge rate of 25% may be manageable with the current bed configuration, but a 50% increase would not be achievable.

It is important to note that the mounding estimates above are based on the data available, which has several limitations. The historical groundwater level monitoring events were relatively infrequent and do not likely capture the true range of groundwater level fluctuations at the RIB. They also do not likely have sufficient resolution to have measured the rise in water levels under conditions of high loading and simultaneous significant precipitation events. In addition, water level measurements were collected in the vicinity of only one bed, with little to no information available regarding the water level fluctuations at the remaining RIB. Given the limitations of the groundwater level data, and the general nature of the mounding estimates, the recommended loading limits should be considered approximate.

Water Quality Monitoring

Groundwater quality samples are collected from all the wells in the routine monitoring program, as well as selected groundwater seep locations and from the Rocky Saugeen River upstream and downstream of the Site. The sampled parameters include total phosphorous, dissolved reactive phosphorous, total kjeldahl nitrogen,

ammonia nitrogen, nitrite, nitrate, chloride, and dissolved organic carbon. The monitoring reports generally limit the discussion of the results and potential for impacts to a comparison of the upstream and downstream parameter concentrations in the Rocky Saugeen River. The annual reports since 2015 have (nearly) consistently indicated no increase in parameter concentrations at the downstream station, or “only a marginal increase”. The reports generally provide no specific comment on the changes in concentration over time at the various monitoring wells or provide further comment on the significance of “marginal” changes in parameter concentrations.

Conclusions and Recommendations

- The groundwater level monitoring data collected since 2014 indicate that the depth to groundwater in the vicinity of the RIB system, particularly at Basin 6, ranged from approximately 400 to 402 masl. The separation between the water table the RIB invert (approximately 403.3 masl) was consistently greater than the minimum depth (0.6 m) stipulated in the RIB operations manual.
- The reported maximum average loading rate since 2014 was approximately 2,000 m³/day, which resulted in groundwater levels rising to within approximately 1 m of the underside of the RIB invert in the vicinity of the active monitoring wells.
- Water level monitoring since 2014 indicates that the groundwater level below the RIB system is directly affected by the rate of loading. The effect of effluent loading on the groundwater level appears to largely dissipate within approximately 50 m of the RIB. These findings are generally consistent with the performance evaluation provided in the 1992 monitoring report.
- Mounding calculations were used to estimate the potential rise in groundwater levels in the event discharge rates are increased to the RIB. It was estimated that the RIB system could accommodate average discharge rates as high as approximately 2,300 m³/day before the groundwater level rises to within the 0.6 m separation limit from the RIB invert. This rate is considered approximate, and the height of groundwater level rise will vary depending on the individual RIB bed, climatic conditions, and time of year.
- Groundwater level measurements are collected on a regular basis at a relatively limited number of wells across the Site, and only two wells in the vicinity of one basin (Basin 6). It would be beneficial to include additional wells (either existing or new wells) in the monthly monitoring program to allow evaluation of the change in water level associated with the other basins.
- Collection of water levels on a monthly basis using an electric water level tape is likely providing only a general understanding of the water level fluctuations at each well. Transient events, such as major precipitation events, or the immediate change in water levels due to RIB loading may not be captured by this approach. It is recommended that automatic pressure transducers be installed at selected wells (e.g., OW1-86) to provide a higher frequency of water level measurements to aid in identification of short-term water level changes that may be affecting system performance.
- A relatively significant number of boreholes and test pits have been advanced as part of historical studies at the Site, however the results of the investigations, particularly the soil profile and classification details, were not available for the majority of the boreholes and test pits. Borehole log / test pit data, either historical or from new investigations, if available would aid in refining subsurface conditions at the Site and may aid in confirming groundwater conditions and functionality over the RIB system as a whole. In the event additional RIB installations are planned it is recommended that the subsurface conditions be characterized through intrusive investigation, rather than relying solely on historical reports.

- The annual monitoring reports provide a relatively cursory evaluation of the water quality monitoring data, and generally only comment on the relative change in water quality (i.e., parameter concentrations) between the upstream and downstream monitoring stations on the Rocky Saugeen River. The reports do not generally comment on differences in water quality between the monitoring wells, and it is not clear if trigger levels, or similar objective response limits, have been developed to determine what constitutes a change in conditions that requires a response or further investigation. It is recommended that the water quality component of the monitoring program be reviewed to determine the efficacy of the current plan, and to determine appropriate trigger limits for the program.
- Henderson Paddon (1981) identified the area between Cell 1 and the railway as having potential suitable physical conditions for use as a backup location in the event an increase in the treated discharge volumes required additional basins to be installed. Several natural “dry” kettles were noted in the area, which was considered indicative of “good permeability” and the depth to groundwater was estimated to be 4 m to 5 m below grade (Henderson Paddon, 1981). The geology at the Site, which suggests the surficial deposits between the lagoon and the river consists of sand and gravel, indicate it may be possible to install additional beds in the area of the existing RIB, however the current RIB are located on a (relative) topographic high where it may be expected that the water table is deepest. Moving west down the slope toward the river, the depth to the water table is expected to decrease, which may make it more difficult to maintain separation between the base of the RIB and the water table when loading the beds.

Closure

We trust that this information is sufficient for your present purposes. If we can be of additional assistance in this regard, please contact the undersigned.

Yours truly,

WSP Canada Inc.



Joel Robinson, P.Geo.
Hydrogeologist



David Dillon, M.Sc., P.Geo.
Senior Hydrogeologist

JR/DD/rk

Attachments: Figure 1 – Location Map
Figure 2 – Cross Section A-A'
Figure 3A – Well OW1-86 Groundwater Hydrograph
Figure 3B – Well OW2-86 Groundwater Hydrograph
Figure 3C – Well OW6-86 Groundwater Hydrograph
Figure 3D – Well OW13-86 Groundwater Hydrograph
Figure 3E – Well OW16-79 Groundwater Hydrograph
Figure 4 – Groundwater Mounding Estimate

References

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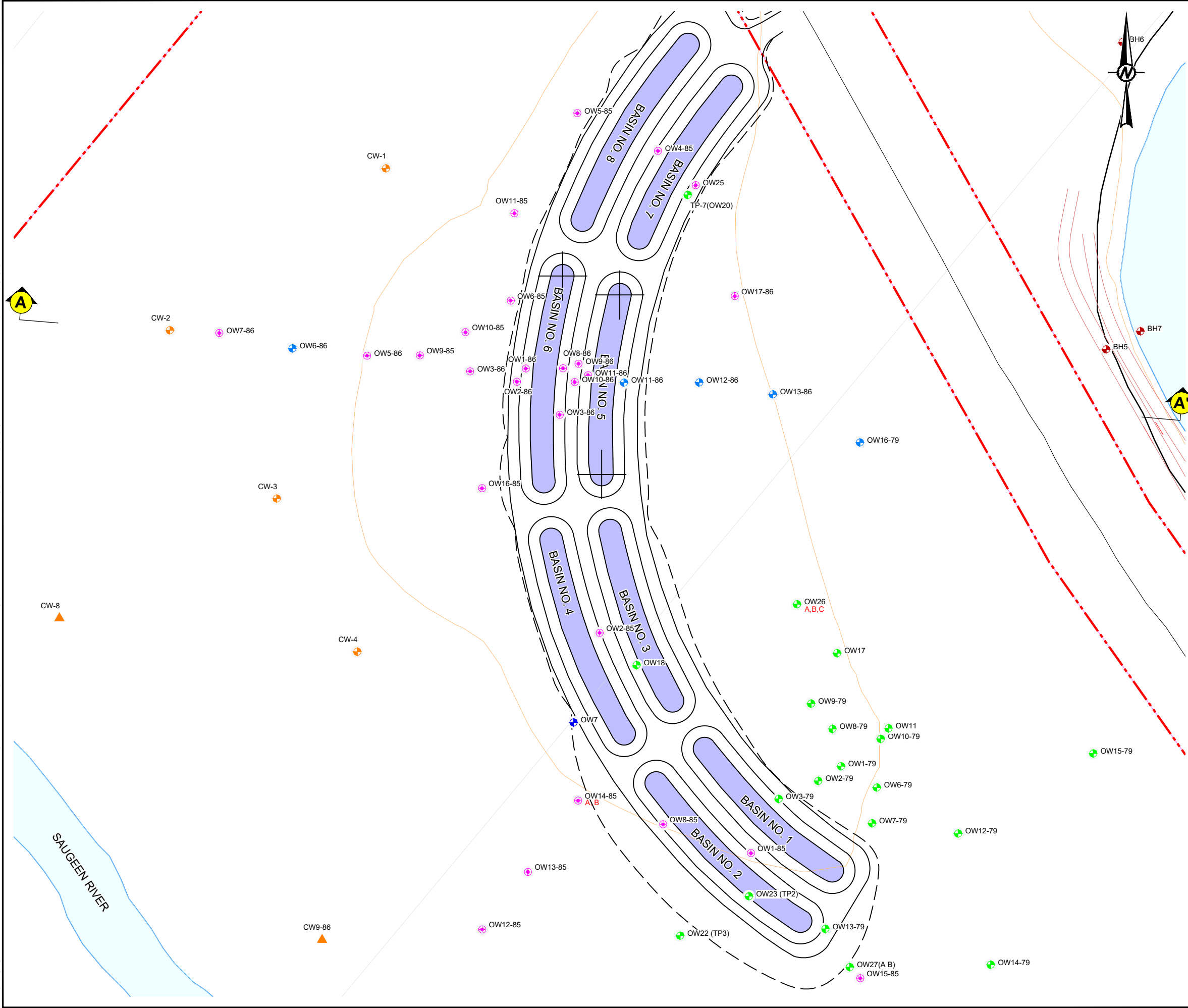
WSP Canada Inc., May 2022. Operations Manual – Markdale Wastewater Treatment Plant and Sewage Pumping Stations. Prepared for the Municipality of Grey Highlands, Project No. 02-702-14.

[https://golderassociates.sharepoint.com/sites/171351/project/files/6/deliverables/23599569 rep 20230726 markdale facility rev0.docx](https://golderassociates.sharepoint.com/sites/171351/project/files/6/deliverables/23599569%2020230726%20markdale%20facility%20rev0.docx)

FIGURES

Figures 1 to 4

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MAP KEY

PLAN LEGEND

- DEVELOPMENT BOUNDARY
- MORRISON BEATTY 1979
- SURFACE / EMERGING GROUNDWATER STATION
- 1985 / 1986 POST RIB CONSTRUCTION MONITOR (BY OTHERS)
- HENDERSON PADDON (WSP) HISTORICAL ANNUAL MONITOR
- GOLDER GEOTECHNICAL BOREHOLE 1984

REFERENCES & DISCLAIMERS

HENDERSON PADDON 1984 DESIGN DRAWING.
MORRISON BEATTY HYDROGEOLOGICAL INVESTIGATIONS 1979.
GOLDER ASSOCIATES GEOTECHNICAL INVESTIGATION, LAGOON VICINITY. 1984

ALIGNMENT OF DESIGN SCAN IS APPROXIMATED TO SELECT FEATURES ON DATUM. AWAY FROM POINTS OF ALIGNMENT FEATURES MAY BE DIMENSIONALLY SKEWED OR PROJECTED OFF ALIGNMENT.

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PROJECT

MARKDALE WASTEWATER FACILITY
HYDROGEOLOGICAL ASSESSMENT

TITLE

LOCATION MAP

CONSULTANT



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REVIEWED JER

APPROVED DPD

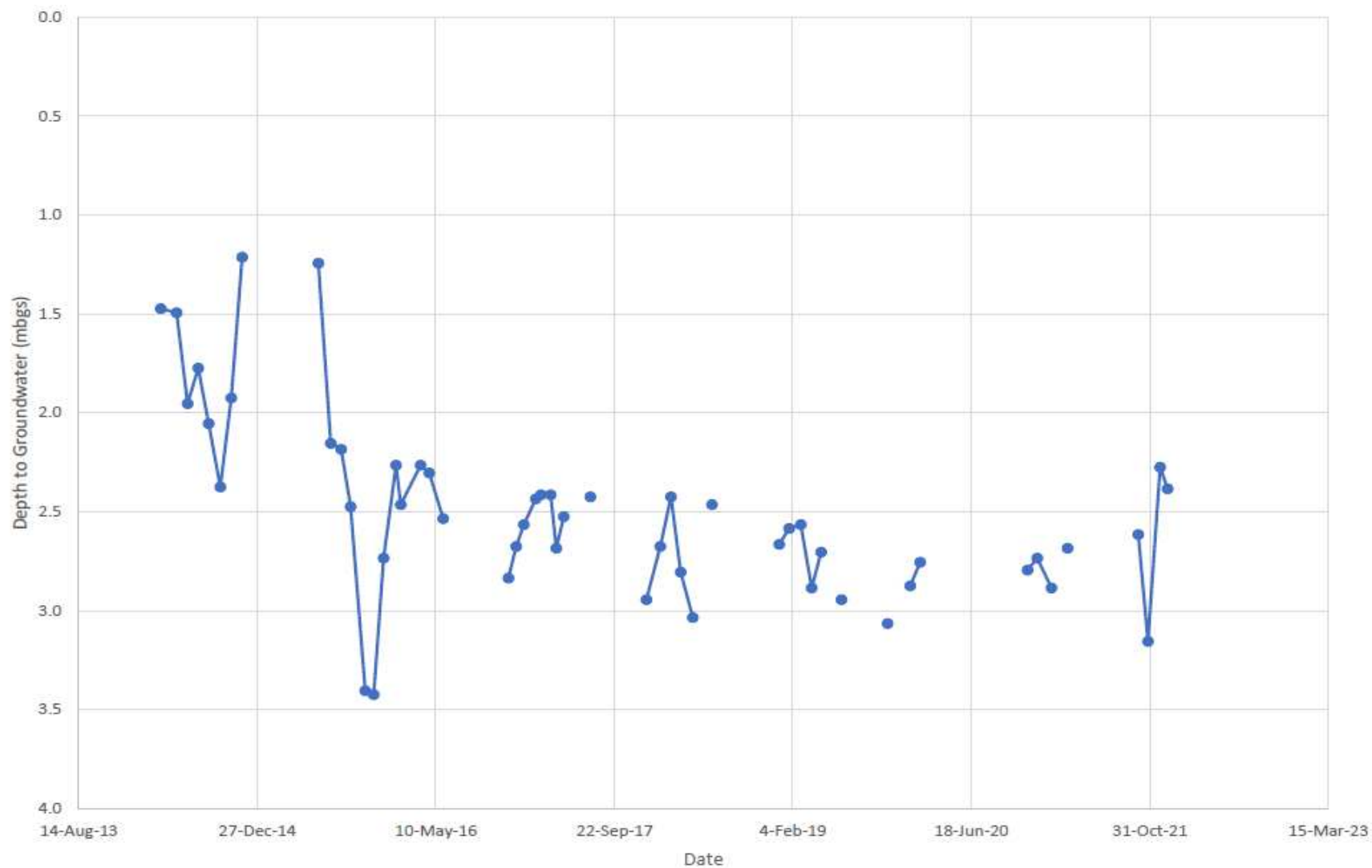
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FIGURE
1

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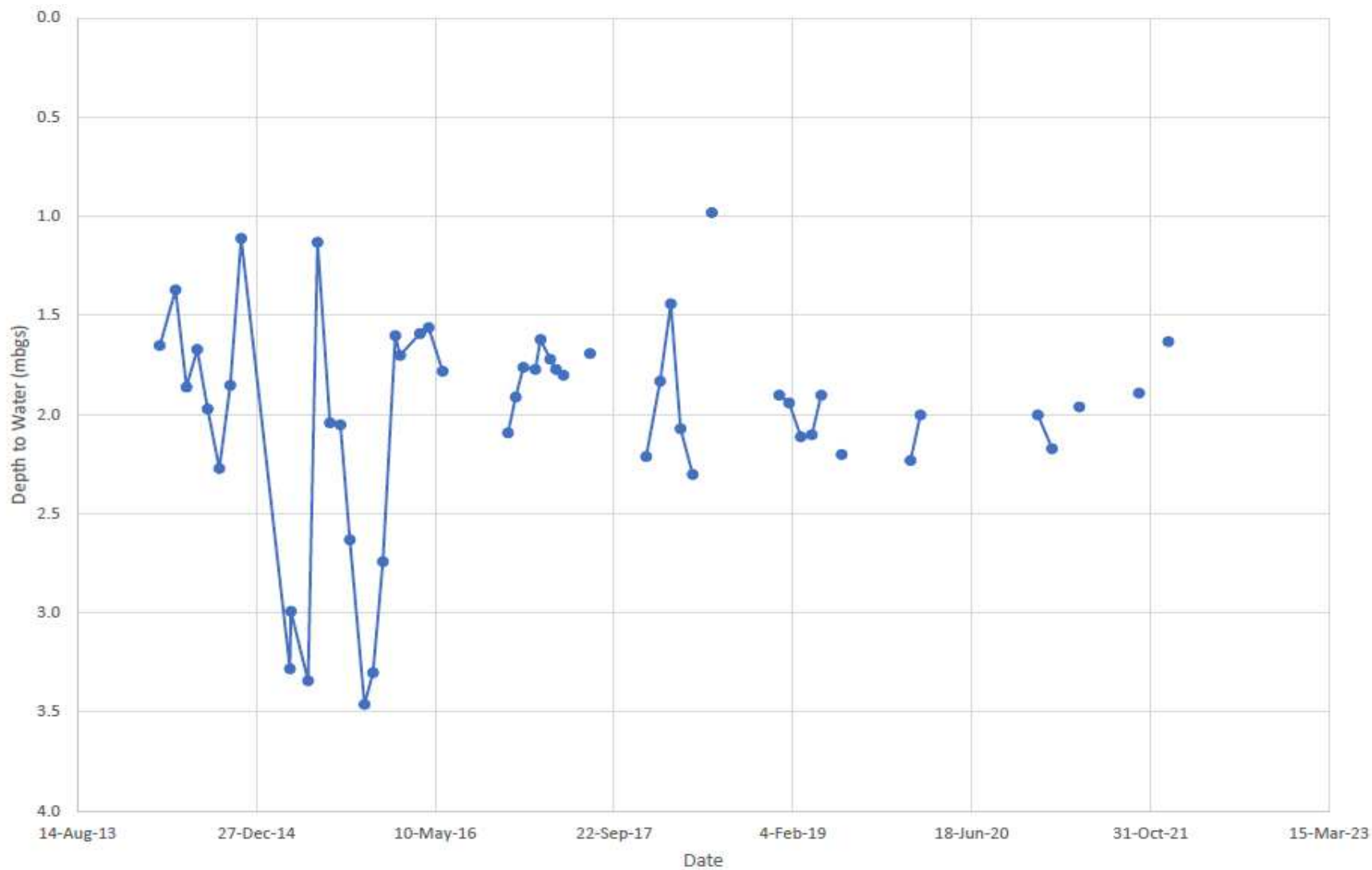
OW1-86 Groundwater Hydrograph

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FIGURE
3A



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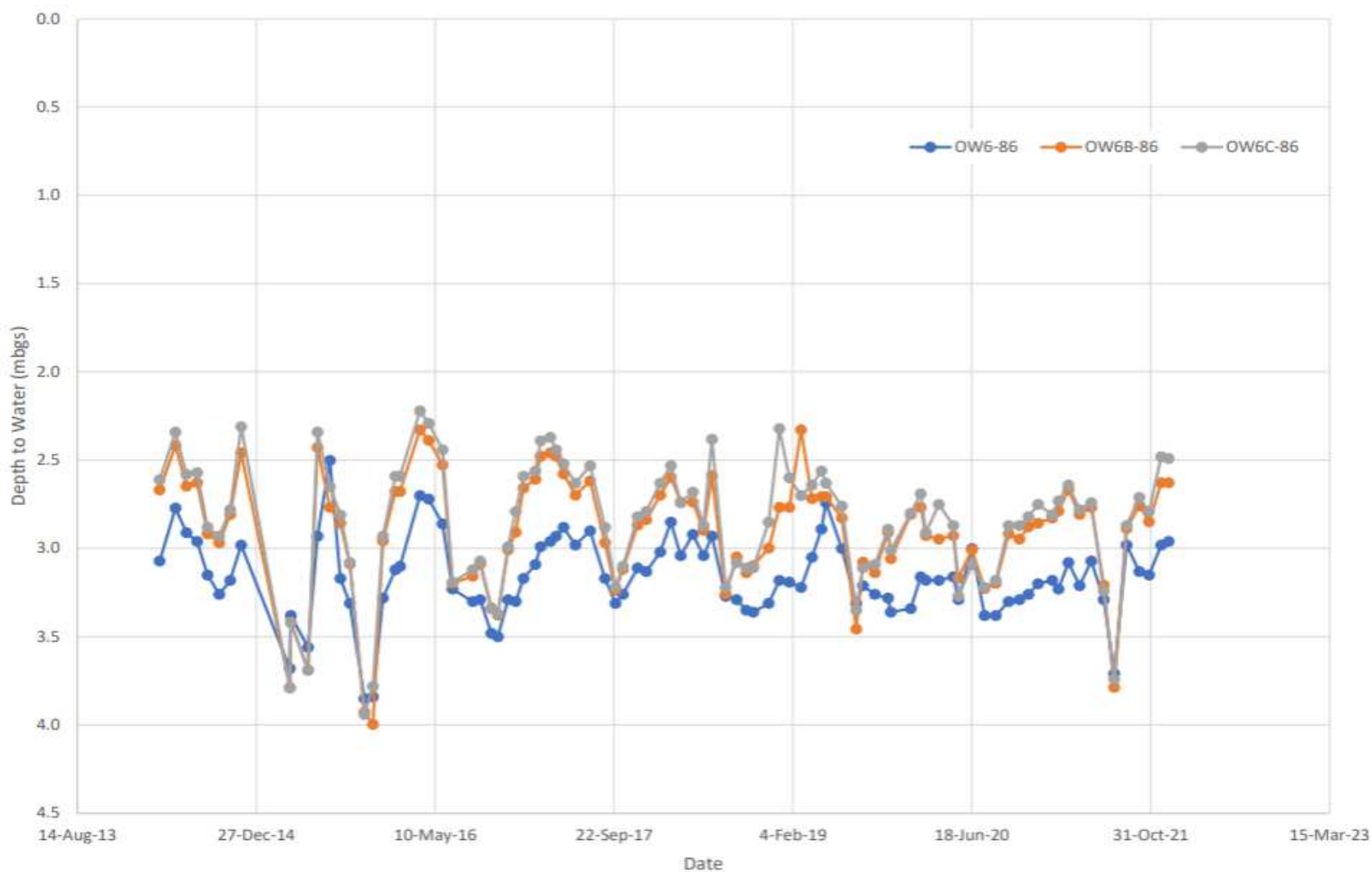
OW2-86 Groundwater Hydrograph

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FIGURE
3B



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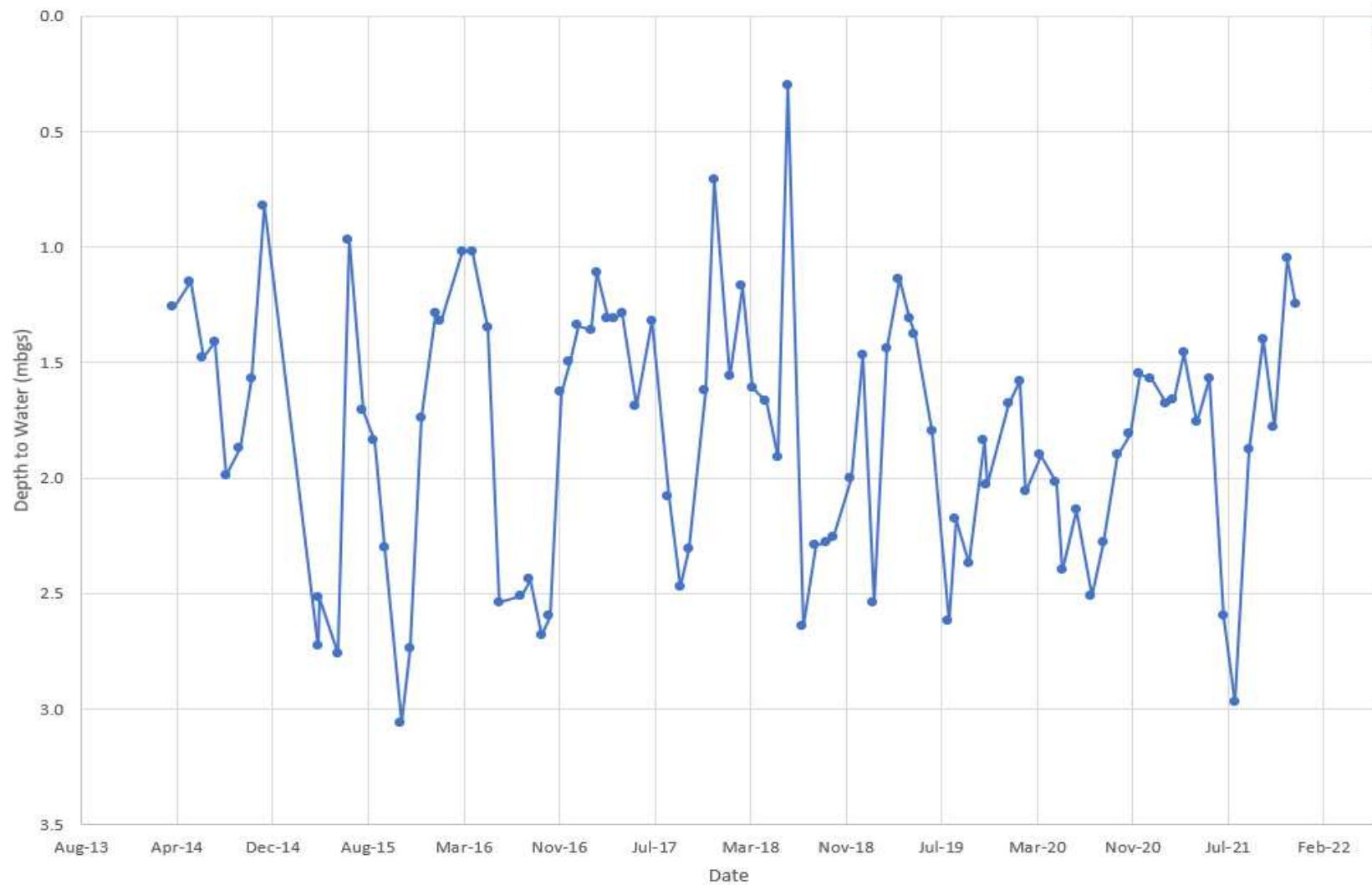
Well Nest OW6-86 Groundwater Hydrograph

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FIGURE
3C



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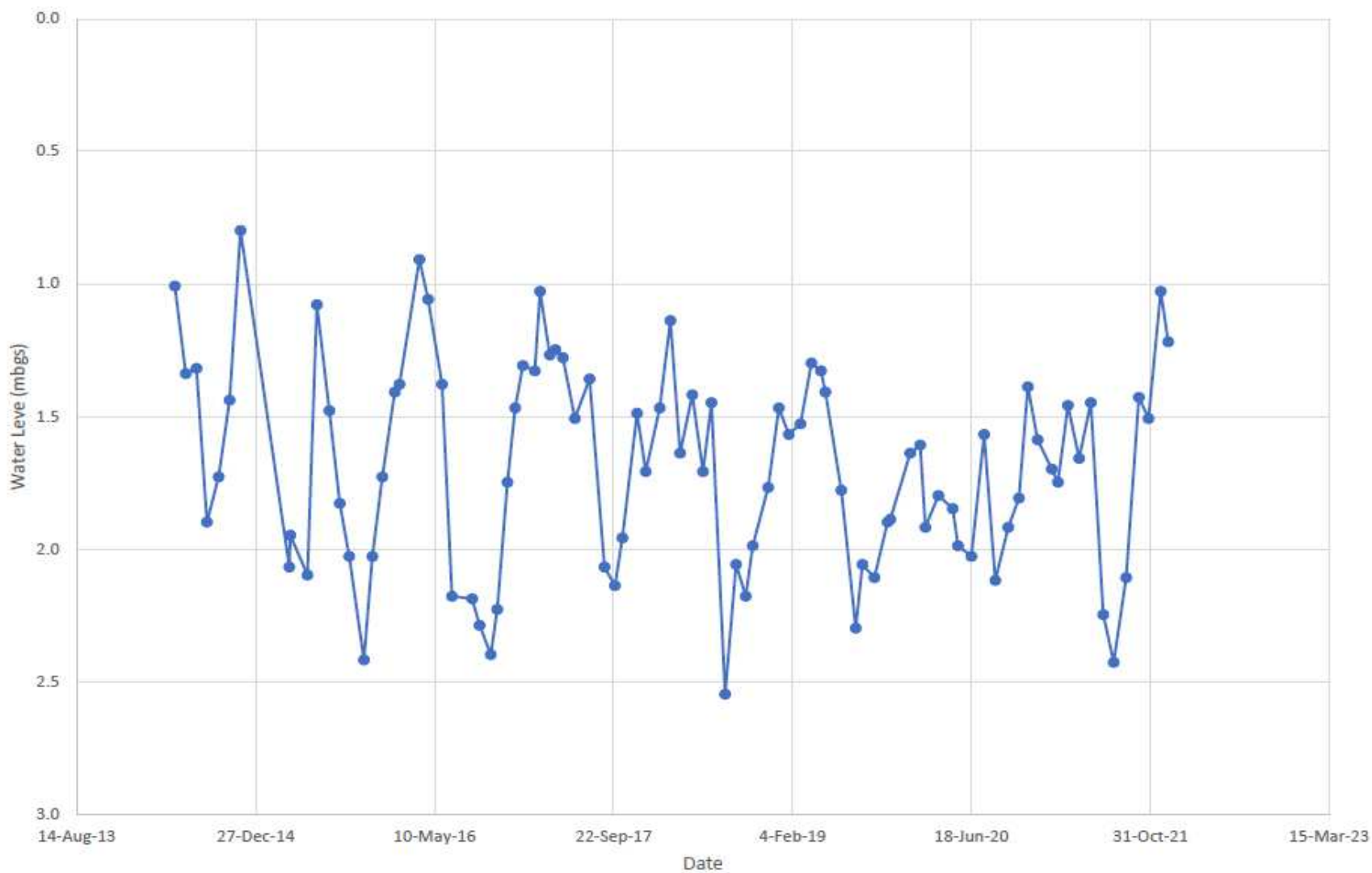
Well OW13-86 Groundwater Hydrograph

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CONTROL

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FIGURE
3D



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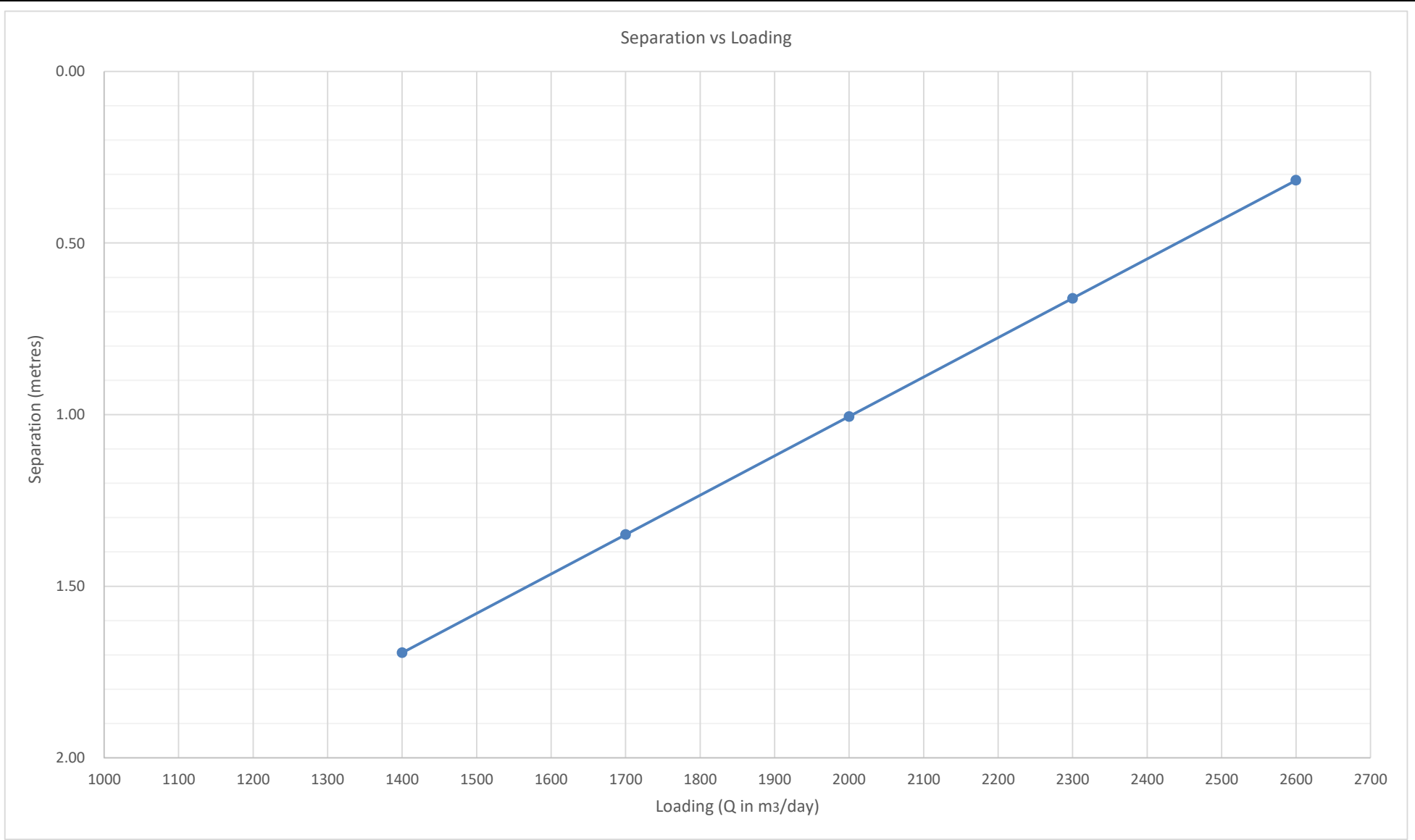
Well Nest OW16-79 Groundwater Hydrograph

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CONTROL

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FIGURE
3E



Separation - metres below base of Infiltration Bed

Loading - m³/day treated effluent

Note: Assessment based on Fielding Equation, MOE 1984 Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems.

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HYDROGEOLOGICAL ASSESSMENT

TITLE
GROUNDWATER MOUND SEPARATION

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CONTROL

REV.

FIGURE
4

