

# APPENDIX

# F

HYDROGEOLOGICAL  
REPORT



**Monarch Colony  
Wattsville Water Supply  
Hydrogeologic Assessment**

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# 1.0 Introduction

W.L. Gibbons & Associates Inc. (WLG) was retained by Monarch Colony to undertake investigations to establish a suitable groundwater supply for the Monarch Colony located in 35-17-27W. This investigation has proceeded in stages (see Section 1.1 for previous investigation summaries). The focus of this report is to document the results of investigations completed in the Wattsvie area located in 17-16-27W (Figures 1 and 2).

Based on information provided by Monarch Colony, it is understood that the required water supply is 273 m<sup>3</sup>/day (60,000 lgpd) at a peak flow estimated to be 4.5 Lps (60 lgp). The total annual withdrawal is estimated to be 100 dam<sup>3</sup>.

## 1.1 Previous Work

A summary of the past investigations for a suitable water supply for the colony is as follows:

- In 2015, as part of the start of construction of the colony, a water well was installed at the site that was designed to withdraw water from the Odanah Shales. Information on the Driller's Report indicated that the well had a capacity of approximately 2.3 Lps (30 lgp). Subsequent water quality analysis determined the water quality to be very poor with sulphate at 1,110 mg/l, sodium at 533 mg/l, and chloride at 254 mg/l, all in excess of the Canadian Drinking Water Quality Guidelines. As the cost to treat water of such poor quality was significant, the decision was made to investigate potential alternate sources of water.
- Subsequently, Monarch Colony completed a water quality sampling program from existing wells at the locations shown on Figure 3 to determine if better quality water was available in the area. The results of that sampling found that the water quality was generally poor in the surrounding area.
- In 2020, Monarch Colony retained the services of Friesen Drillers to complete hydrogeologic test drilling. As part of that work program, six test holes were drilled primarily south and west of the colony site (26-29-17-27W and 32—17-27W). The results of this work program (Friesen Drillers letter report dated November 17, 2020) found that the overburden above the shale bedrock consists of a complex sequence of glacial tills with minor amounts of scattered sand and gravel. The report recommended further test drilling using an auger drilling rig to further test the overburden for sand and gravel deposits of potential suitable size to host an aquifer for this site.



- In 2021, Monarch Colony retained the services of W.L. Gibbons & Associates Inc. to provide hydrogeologic services in association with the investigation for a potentially suitable water supply for the colony. The scope of work for this investigation included a desk top assessment of the available information to identify potential areas warranting follow-up investigations, and the completion of an auger test hole program to investigate potentially suitable sand and gravel deposits in the general area of the colony. A total of 26 test holes were completed in 23, 26, 32, 35-36-17-27W. Based on the results of this work program (WLG letter report dated May 18, 2021), the following was noted:
  - While some small sand and gravel deposits were encountered, it was concluded that the potential to find a suitable groundwater supply within an approximate 3 mile radius of the colony was low and further efforts to investigate these deposits was not recommended.
  - Based on the unsuccessful results from the above test hole programs, the information from the desk top assessment of the available information was used to prepare the following list of potential areas for further groundwater exploration outside the 3 mile radius of the colony:
    - The Wattsvie Plain in the general area of 17-16-27W was identified as a known source of significant volumes of high quality groundwater supplies. The distance from the colony, the expense of connecting to that supply and other factors were considered to be an issue.
    - Potential alluvial aquifers in the Birdtail Creek valley were identified as a potential source. The aquifers consist of sand and gravel deposits within the valley such as at the Town of Birtle and a aggregate quarry at the Birdtail Creek and Highway 16 crossing. It was noted that past investigations within that valley were limited. Due to the presence of extensive cobbles and boulders and limited access to the valley, specialized and expensive drilling equipment would be required to investigate the valley with no guarantee of success.
    - Potential buried valley aquifers are known to be present, such as the buried valley aquifer that is the source of the Russell-Binscarth water supply. The available information suggested that a potential buried valley may be present on the west side of Birdtail Creek, approximately 5 miles east of the colony.
- The potential options for groundwater exploration outside the immediate area of the colony was reviewed with the colony and the municipality and the decision



made that the preferred option was to further explore the potential buried valley east of the colony.

- As a first step in following up on the potential for a buried valley aquifer, a water quality sampling program was undertaken of existing domestic wells installed along the alignment of that buried valley. It was found that the water quality from those wells was poor and would not be a significant improvement over the currently available water quality from the on-site shale well. As a result, there were concerns that the high expense of conducting deep test hole drilling into that buried valley might be unsuccessful in obtaining better quality water, and that a significant length of pipeline (5 miles or more) would be required to access that water.
- In follow-up to the above concerns about the water quality in the deep buried valley aquifers, and the significant length of pipeline that may be required, the available information was again reviewed. The review noted information from past test hole drilling for domestic wells approximately 1.5 miles south of the colony site (SE27-17-27W) indicated that the depth to the shales may be up to 372 feet, substantially deeper than the depth of shale at the colony site of approximately 50 feet. The information also indicated that sand deposits may be present at depth above the shales. The results suggested a potential deep buried valley style aquifer may be present. No domestic wells were installed in these deep deposits and therefore no existing wells were present to allow testing of this potential deep aquifer. The decision was made to proceed with the drilling of two deep test holes to confirm if a potentially suitable aquifer was present and if so, allow a water quality sample to be collected. Neither test hole encountered sands with the capability of supporting the installation of a well of suitable capacity for the colony requirements and the test holes were abandoned. These latest results further confirmed that no suitable sources of groundwater were available within a reasonable distance of the colony site.
- Based on this latest information, the decision was made by Monarch Colony, in consultation with the municipality, to proceed to the Wattsview area to develop a source of water for the colony. It is noted that this decision was made after 6 years of investigations, and considerable groundwater exploration expense.

Past investigations in the Wattsview area (17-16-27W) include:

- In 1985, a groundwater investigation was undertaken which led to the establishment of the Wattsview Loading Station in NE17-16-27W. This investigation confirmed the presence of a significant volume of groundwater of good quality at that location.
- In 2017, in response to the need to address long term issues with the former Town of Birtle water supply, an investigation was undertaken in the Wattsview



area that lead to the establishment of a new groundwater supply for the town in NE17-16-27W. The results of these additional investigations confirmed the presence of a significant high transmissivity aquifer capable of sustaining substantial withdrawals of good quality groundwater.

The following report documents the results of the subsequent investigations by Monarch Colony in the Wattsvie area.



## 2.0 Regional Setting

### 2.1 Physiography

The study area is located generally in T15 to 17, R26 to 27W which slopes southwest from Riding Mountain to the Assiniboine River Valley (Figure 3). The land surface varies from relatively flat upland areas with numerous sloughs and potholes to the steep slopes and incised gullies on the flanks of the Assiniboine River Valley, and the Birdtail and Snake Creek Valleys. The ground elevation in the Wattsview area uplands is on the order of 480 m. The base of the Assiniboine River Valley is at an elevation on the order of 380 m. Surface water drainage is towards the Assiniboine River Valley.

### 2.2 Landuse

The current land uses in the area include: agricultural, an airstrip used for cropdusting planes, and a number of oil wells/pipelines in the area. There are a number of inherent risks associated with these land uses, including:

- **Agricultural** – Activities associated with agricultural land-uses that are a potential risk include the fueling of agricultural equipment, loading and distribution of fertilizers, pesticides and herbicides. When handled properly, these activities are generally not of significant concern for the potential to impact an aquifer such as exists at this site. The presence of an approximately 6 meter (+/-) thick clay till layer at surface over most of the area limits the potential for surface discharges to directly impact the aquifer. In addition, the saturated portion of the aquifer is located at a depth of approximately 21.0 meters below grade, and as such a considerable travel distance would have to be overcome before the contaminants reach the aquifer.
- **Airstrip** – Along the south boundary of 17-16-27W, there is an east-west airstrip used by crop dusting planes. Activities at the airstrip include the fueling of planes and the loading of fertilizers, pesticides and herbicides. There is no substantive difference between this activity and normal agricultural activities. As such there are no extra concerns associated with the presence of this airstrip in the area.
- **Oil Production Facilities** – There are a number of oil production wells and distribution pipelines in the Wattsview area. Concerns associated with these facilities include the potential for leaks from either the oil wells or pipelines. These facilities are regulated by the Petroleum Resources Branch of Manitoba Growth, Enterprise and Trade which specify the construction standards for oil wells (including the sealing of the casing to prevent leaks) and pipelines (including leak detection). Provided these facilities are maintained in good working order and are operated in accordance with the regulations and guidelines, there should be no releases of hydrocarbons to the aquifer. In the event that a spill does occur, the oil facility owner would be responsible for the completion of the clean-up, including the provision of alternate water supplies to any parties impacted.



A key method of minimizing the risks associated with these land uses is informing and educating the land users of the presence of the aquifer and any water supply systems so that best practices in the handling of any hazardous materials can be implemented to minimize the potential for an inadvertent release of contaminants. Any releases of contaminants should be immediately reported to the relevant authorities, including the municipality, so that clean-up/remediation activities can be initiated and an upgraded groundwater quality program implemented to confirm that an adverse effect to groundwater quality has not occurred.

### **2.3 Bedrock Geology/Hydrogeology**

Bedrock in the general area occurs at depths ranging from 15 meters to in excess of 100 meters. The bedrock consists primarily of shales of the Millwood Member of the Riding Mountain Formation. These Millwood Member shales are considered to be aquitards. Locally, the more fractured Odanah Member shales of the Riding Mountain Formation are present and domestic scale volumes of groundwater can be obtained from these Odanah shales. The Odanah Member shales are rarely capable of producing volumes of water in excess of domestic well needs (1 to 5 lpm). Therefore, the top of the bedrock sequence is considered to be the base of exploration for significant potable groundwater supplies in this area.

### **2.4 Surficial Geology/Hydrogeology**

The surficial geology of the area is predominated by a veneer of clay till with colluvium and alluvium in the river and creek valleys. A large area of glaciofluvial sands and gravels is present to the southwest of Birtle on the north side of the Assiniboine River Valley. This sand and gravel deposit extends from the Beulah area northwest towards St. Lazare and is generally referred to as the Wattsvie Plain.

The review of the water well logs for the region has found that the stratigraphy at depth is a complex assemblage of till, intertill sand and gravel deposits, and clay. The information from the water well logs indicates that groundwater can sometimes be developed in the intertill sand and gravel deposits but the volumes of water are generally low and only suitable for domestic purposes. The deeper intertill sand and gravel deposits are intermittent and are not encountered at every location tested. While some water is available from these deposits, the quality of the water is generally poor.

Water supplies, including a loading station and the Birtle water supply have been established at Wattsvie in the glaciofluvial sands and gravels (Figure 3). Shallow to surficial deposits such as this typically have good quality water due to the strong interaction with surface water recharge and subsequent discharge which regularly replenishes the aquifer. Common concerns with this style of aquifer that need to be investigated before developing them include: a) the aquifer needs to have sufficient water in storage to sustain the required withdrawal during periods of drought; and, b)



the proposed groundwater withdrawal will not adversely affect existing groundwater users or the environment.

## 3.0 Groundwater Exploration Program

The information from past investigations in the Wattsvie area was used to develop a groundwater exploration program designed to enhance the knowledge of the aquifer properties and to determine a suitable location for a follow-up test well program. Prior to the initiation of the groundwater exploration program, a Groundwater Exploration Permit (copy in Appendix A) was obtained from the province.

Drillers Reports containing details of the results obtained are included in Appendix B. The locations of the test holes/monitoring wells are shown on Figures 1 and 2.

### 3.1 Groundwater Exploration Program

Two test holes (designated as MW 22-01 and 02) were drilled in NE17-16-27W on lands owned by the colony. Test hole locations were selected to enhance the knowledge of the stratigraphy east of the Birtle wells and to allow monitoring wells to be installed for use during the subsequent testing work, and as part of a long term groundwater level monitoring program.

Test hole MW 22-01 was drilled approximately 30 meters west of the undeveloped Road 160W road allowance and 55 meters south of the PR 568 road allowance on private lands purchased by the colony. The stratigraphy at the site consisted of an upper 9.1 meter (30 feet) thick layer of clay followed by sand and gravel to a depth of 52.1 meters (171 feet). The base of the observed stratigraphy consists of shale to a maximum drilled depth of 53.3 meters (175 feet). It was noted that from a depth of 33.5 meters (110 feet) to a depth of 52.1 meters (171 feet), the sand and gravel was very coarse and highly pervious. The coarse and pervious nature of those lower sands and gravels were suitable for the installation of a well with a capacity required for this project.

Test hole MW 22-02 was drilled approximately 320 meters west of the undeveloped Road 160W road allowance and 50 meters south of the PR 568 road allowance. The stratigraphy at the site consisted of an upper 6.1 meter (20 feet) thick layer of clay followed by sand and gravel to a depth of 45.7 meters (150 feet). The sands and gravels were underlain by a 2.7 meter (9 feet) thick layer of clay till followed by shale to a maximum drilled depth of 48.8 meters (160 feet). It was noted that the base of the sand and gravel layer was significantly shallower than the base at test hole MW 22-01, and that the sands and gravels were finer, and therefore less pervious. The MW 22-01 location was considered the preferred location for the subsequent test well due to its increased depth (and associated increase in available drawdown), and the more pervious nature of the materials at that location.

The results of the current test holes are illustrated in cross-section on Figures 4 and 5, with information from past investigations. In general, it was found that the stratigraphy in



the area consists of an upper clay till layer approximately 6 meters (+/-) thick which contains some small sand and gravel layers. The till is underlain by sand and gravel with clay layers to the bedrock surface. The bedrock encountered consists of Millwood Member shales. The depth to the bedrock varied from 16.8 to 51.8 meters (55 to 170 feet).

Permanent 50 mm (2 inch) diameter monitoring wells were installed in each test hole to provide locations for the monitoring of groundwater level changes at a distance from the subsequent test well. Construction details for each monitoring well are provided on the Driller's Reports in Appendix B. Each monitoring well was completed with a locked steel above ground protective cover. Solinst Levellogger Model 3000 digital water level monitoring transducers were installed in each monitoring well. The water level monitoring equipment is permanent and is intended to record water level changes over the long term in response to pumping by the colony and others from this aquifer. The transducers have been set to record the groundwater level changes on a daily basis.

Following completion of the monitoring wells, the wells were developed using air lift pumping to remove residual sediment and drilling fluids and to allow a water quality sample to be collected for laboratory analysis. The results of these analyses are compiled on Table 1 with past historical water quality data from this aquifer. Copies of the Laboratory Certificates of Analysis included in Appendix C. In general, the current water quality results were comparable to the historic water quality results, albeit with higher concentrations of conductivity, hardness, sulphate, total dissolved solids and nitrates. It is noted that samples from small diameter monitoring wells may not be fully representative as it is not possible to fully purge those monitoring wells (ie: a test pump to fully purge the monitoring well cannot be installed).

### **3.2 Test Well Installation and Pumping Test**

Follow-up work at the MW 22-01 site consisted of the installation of a 200 mm (8 inch) diameter pumping well (designated as TW 22-01), and the completion of a pumping test. The well location is illustrated on Figures 1 and 2. A copy of the Drillers Report with the well construction details is included in Appendix B.

The construction of the well consists of 46.0 meters (151 feet) of nominal 200 mm (8 inch) diameter SDR21 PVC casing followed by 4.6 meters (15 feet) of nominal 200 mm (8 inch), 30 slot, telescopic, stainless steel screen. The annulus around the screen was backfilled with a filter sand pack and the annulus around the casing was sealed using a combination of bentonite and drill cuttings. Following completion of the well construction, the wells were developed using surge blocks and air lift pumping until the discharge was clear and free of sediment.

A pumping test was completed on TW 22-01 on November 22, 2022. The test consisted of the pumping of the well at 10.5 Lps (138 lgpm) for a period of 4 hours. The groundwater level response was recorded at regular intervals in the pumping well, and



in monitoring wells MW 22-01, MW 22-02, and MW 17-01 (MW 17-01 is located at the Town of Birtle Pumping Well Site). Charts of the recorded response to pumping are included in Appendix D with the results of the analysis of the data. Based on these results, the following is noted:

- The pumping of well TW 22-01 at 10.5 Lps (138 lpm) resulted in a drawdown in that well of approximately 1.4 meters (4.6 feet). The indicated specific capacity of the well is 7.5 Lps/meter of drawdown (30 lpm/foot of drawdown). At the design 4.5 Lps (60 lpm), the drawdown would be 0.6 meters (2 feet) and approximately 14.6 m (48 feet) of residual drawdown above the top of the screen would remain, and would be available to accommodate seasonal/long term natural fluctuations in groundwater levels, and the typical loss of well capacity over time as iron/manganese precipitates accumulate in the screen.
- It is noted that the well has the capability to be pumped at up to 22.7 Lps (300 lpm), the typical largest pump that can be installed in a 200 mm (8 inch) diameter well. At that higher pumping rate, the drawdown would be 3.0 meters (10 feet) and approximately 12.2 m (40 feet) of residual drawdown above the top of the screen would remain.
- The recommended depth setting of the pump intake is 45.7 meters (150 feet) to maximize the amount of available drawdown above the pump intake. The pump intake should not be set below the top of the screen as that can lead to excessive precipitation of iron and manganese and premature loss of well capacity.
- The recorded response to the pumping of TW 22-01 in the other monitoring wells are as follows:
  - MW 22-01 at a distance of 5.8 meters – 0.18 meters of drawdown and water levels were stable after the first few minutes of pumping.
  - MW 22-02 at a distance of 300 meters – No discernable response to pumping.
  - MW 17-01 at a distance of 770 meters (Birtle Town Wells) – No discernable response to pumping of TW 22-01. A response to the pumping of the town wells is evident.
- Full recovery of the groundwater levels was achieved within 15 minutes of the cessation of pumping.

The data obtained from the aquifer pumping test was analyzed to estimate the values of transmissivity for the aquifer. Plots of the results are included in Appendix D and summarized below. Only the data from test well TW 22-01 and MW 22-01 could be analyzed as there was no response recorded at the other monitoring points.



Well	Transmissivity		Solution Method
	lgpd/ft	m <sup>2</sup> /s	
TW 22-01	49,860	8.6 x 10 <sup>-3</sup>	Neuman
MW 22-01	392,000	6.8 x 10 <sup>-2</sup>	Neuman

A transmissivity for this aquifer of 392,000 lgpd/ft (6.8 x 10<sup>-2</sup> m<sup>2</sup>/s) and a typical storativity of 1.0 x 10<sup>-4</sup> is considered appropriate for use in estimating the drawdown effects at a distance in this aquifer. Based on the results of the drawdown-distance analysis (Appendix D), the estimated radius of influence (drawdown of 0.1 meters or less) if the well is pumped at 10.4 Lps (140 lgpm) is approximately 15 meters (50 feet).

### 3.3 Water Quality

At the end of the pumping test on well TW 22-01, a water quality sample was collected and submitted for laboratory analysis. The results of this analysis are compiled on Table 1 with past historical water quality data from this aquifer. Copies of the Laboratory Certificates of Analysis included in Appendix C. The following is noted concerning the water quality results:

- Overall, the water quality results obtained from test well TW 22-01 after pumping the well at 10.5 Lps (138 lgpm) are similar to the results obtained previously from monitoring well MW 22-01. It is noted that the turbidity (0.46 NTU) is low and the UV Transmittance (91.4) is high, indicating that the sample was “clean” and was not exhibiting evidence of residual sediments from the drilling that may be affecting the results.
- Conductivity (1070 uS/cm), hardness (524 mg/l), sulphate (249 mg/l) and total dissolved solids (736 mg/l) are comparable to the results from nearby monitoring well MW 22-01, and higher than the results obtained from the Birtle town wells to the west. These results suggest that the groundwater in this portion of the aquifer is more mineralized than that further west at the core of the aquifer. Further long term pumping (days to weeks) of this well would be required to verify if the final water quality obtained from this well will remain stable or change as mineralized water is removed and better quality water drawn towards the well.
- Nitrates (10.4 mg/l) from TW 22-01 are slightly above the guideline of 10 mg/l, and comparable to the 8.72 mg/l obtained from nearby monitoring well MW 22-01. It is noted that nitrate concentrations from other parts of the aquifer are low to



non-detectable. It is noted that, per the test hole work at this site, an approximately 9.0 meter (+/-) thickness of clay till is present over the aquifer and that the saturated portion of the sands and gravels does not begin until a depth of approximately 30 meters. The presence of nitrates in this portion of the aquifer would therefore appear to not be likely due to surface contamination and may be a naturally occurring nitrate. Further sampling during long term pumping (days to weeks) of this well would be required to verify if this nitrate concentration remains stable.

- The iron (0.071 mg/l) and manganese (0.00266 mg/l) from TW 22-01 are well below the guidelines and substantially lower than the iron and manganese concentrations obtained from other portions of the aquifer. It is not uncommon to obtain elevated metals concentrations from newly drilled monitoring wells such as MW 22-01 and 22-02 as it is not practical to fully purge the wells of residual drilling effects before sampling. However, the results are considered anomalously low relative to the concentrations obtained further to the west at the Birtle wells. Further sampling during long term pumping (days to weeks) of this well would be required to verify if these concentrations remain stable.
- One other anomaly with the results from test well TW 22-01 is the detectable presence of carbonate alkalinity (7.8 mg/l as CO<sub>3</sub>). Similar detectable carbonate alkalinity was not detected at any other sample location, and is normally not detectable from groundwater samples. While the overall well drilling and sampling procedures and other results obtained suggest that the sample was “clean” and free of residual sediment, this elevated carbonate alkalinity result suggests that residual chemical effects on the water quality from the drilling may still be present (no additives other than standard bentonite drilling mud were used in the drilling of this well). Further pumping and sampling of this well would be required to confirm if the carbonate alkalinity remains stable or declines to the typical non-detectable level.

## 4.0 Assessment

### 4.1 Groundwater Level Monitoring

As part of the establishment of the Town of Birtle supply wells, a Solinst Levellogger digital water level transducer was permanently installed in monitoring well MW 17-01 at the Town of Birtle well site (Figure 1). The transducer had been set to record groundwater levels on a daily basis. A copy of the data from that transducer was obtained and the results of the monitoring over the period from 2017 to present are included in Appendix E (It is noted that data gaps exist. During these periods water levels were not recorded). Over this period, groundwater levels have declined by approximately 1.3 meters and there is evidence that groundwater levels were beginning to recover in 2022. A similar decline in groundwater levels have occurred across the province, such as at the Melita aquifer (chart in Appendix E). This decline is directly attributable to the relatively low precipitation that has occurred since 2017. The observed rise in groundwater levels at the Wattsvie Aquifer in 2022, as well as at the Melita Aquifer, are a strong indicator that the decline is directly attributable to naturally varying long term precipitation rates. There is no evidence in the monitoring record that the pumping of the Birtle wells has resulted in an artificial decline in groundwater levels, nor is there evidence that the rate of withdrawal is unsustainable. (Note: a daily fluctuation in water levels is evident in the long term monitoring record from monitoring well MW 17-01. This data has not been corrected for the effects of barometric pressure changes on the water levels and a significant component of the observed daily fluctuation is due to barometric pressure changes. A component of the fluctuation will be due to the cyclic pumping of the Birtle wells (see below)).

As part of the testing program, a second transducer was installed in monitoring well MW 17-01 and set to record water levels at 2 minute intervals. The purpose of this was to obtain detailed information on the near field effect of the pumping of the Birtle wells. The available data from November 5 to 7, 2022 is compiled on the chart in Appendix E. A cyclic response to the pumping of the Birtle wells is clearly evident as a 0.07 meter (0.2 foot) drawdown in water levels. The monitoring well is located approximately 20 meters from the pumping wells. The results are consistent with expectations from the initial Birtle well assessment (WLG report dated September, 2017) and consistent with expectations for a high transmissivity aquifer of this nature. A similar minor drawdown effect is expected for the new Monarch colony wells (see Section 3.2).

As part of the installation of monitoring wells MW 22-01 and 22-02, permanent digital water level transducers were installed and set to record the water levels on a daily basis. The results of this monitoring from September 23 to November 5, 2022 are provided on the charts in Appendix E. The data has not been corrected for barometric pressure effects and the daily fluctuation in water levels is attributable to changes in barometric pressure. Neglecting the barometric pressure effects, the water levels



remained stable over the period of record. It is noted that no evidence was found of a periodic fluctuation in water levels attributable to the pumping of the Birtle wells (consistent with the recorded minimal drawdown effect above).

## **4.2 Assessment of Sustainability**

The results of this investigation have demonstrated that a high transmissivity aquifer is present at the proposed Monarch Colony well site. At this site, the vertical saturated thickness of the aquifer is 20.7 meters which results in significant available drawdown before the ability of the wells to produce groundwater would be impaired. The drawdown which would be induced by the pumping of the Monarch Colony wells would be restricted to a radius of approximately 15 meters around the well, and as demonstrated by the aquifer pumping test, recovery of the groundwater levels occurs within minutes of the cessation of pumping.

Recharge to the aquifer is by direct infiltration of precipitation on to the surface of the aquifer, as well as run-on of surface water from the area to the north (Figure 3). The available information also indicates that recharge to the aquifer may also be occurring via the movement of groundwater within the shallow sand and gravel layers in the upper till from north to south (ie: Figure 5, the upper ground surface and the bedrock surface both slope to the south and would have the tendency to direct shallow groundwater towards the aquifer). The discharge of groundwater is likely to the east towards Birdtail Creek (Figure 4) and to the south towards the Assiniboine River. There are no concerns about the potential for the aquifer to sustain the proposed withdrawal of up to 4.5 Lps for the Monarch Colony water supply system, in conjunction with the existing design pumping rate of 12 Lps for the Birtle water supply system.

## **4.3 Potential Third Party Impacts**

The review of the provincial GWDriI database of water wells has found that the only third party wells that withdraw water from this aquifer within a distance of 1600 meters (one mile) are the Town of Birtle water supply and loading station wells located 770 meters west of the site, and a domestic well (PID 134437) located approximately 400 meters west of the site. As is documented in Section 3.2, at a distance of 15 meters (50 feet), the drawdown due to the pumping of the colony wells at 10.4 Lps (140 lpm) is negligible (drawdown of 0.1 meters or less). As such, no adverse impacts to existing third party water well users in the area are expected.

## 5.0 Conclusions and Recommendations

Based on the available information at the time of this assessment, the following conclusions can be made:

- The results of this investigation have demonstrated that a significant aquifer is present in the Wattsvie area. The aquifer may be subdivided into an upper and a lower aquifer by the presence of an intermittent clay layer (Figure 4). The existing Wattsvie Loading Station wells withdraw water from the upper aquifer. The Birtle wells withdraw water from the lower aquifer. The proposed Monarch Colony wells will withdraw water from the upper aquifer (Figure 4). The lower aquifer is contained within a north-south trending buried valley into the underlying shale bedrock.
- One 200 mm (8 inch) diameter well was installed and tested at this site. The well has a capacity in excess of the current 4.5 Lps requirement for this water supply system.
- There are only two existing groundwater users of this aquifer within 1600 meters of the proposed well site. The analysis of the testing results has found that neither existing user would be affected by the proposed withdrawal.

The following recommendations are made:

- The 200 mm (8 inch) diameter pumping well installed as part of this work program should be equipped with pumps capable of pumping the required 4.5 Lps, with the pump intake set at a depth of 45.7 meters (150 feet, above the top of the well screen).
- Per standard practice for water supply systems of this nature, it is recommended that a second well be installed at this site to allow water supply to be maintained should the pumping equipment (or well) fail and there is a potential extended loss of water supply while repairs are made.
- It is recommended that a program of annual sampling of the raw water from these wells be maintained. The samples should be submitted to a laboratory for analysis of the MUN-WTP72D analytical package. The results should be uploaded to a digital database for assessment of any water quality trends over time.
- Two new 50 mm diameter monitoring wells (designated as MW 22-01 and 22-02) were installed at the site and are equipped with a Solinst Levelogger digital pressure transducers. The transducer is currently set to record groundwater levels on a daily basis. The information on water levels over time should be downloaded twice per year and the information transferred to a digital database for assessment of the trends in groundwater levels relative to pumping.



- A suitable flow meter capable of recording the instantaneous flow rate and cumulative volumes must be installed on the raw water side of the water treatment plant. Cumulative volumes used should be recorded daily in a digital database, with statistics maintained on the daily, monthly and annual water use rates.
- A very common issue with the long term performance of wells is the rapid accumulation of iron and manganese in the well screen and the need for frequent and expensive well redevelopment. The cause of this rapid accumulation of iron and manganese is almost always the result of issues with the original pump installation and leaks in the assembly which aerates the water and causes the precipitation. It is therefore considered very important that care be taken during the initial pump installation to prevent these future problems from occurring. This would include:
  - Ensuring that when the pitless unit is installed it is vertical and remains vertical during the backfilling process. A pitless unit that is not vertical results in the pitless spool that holds the pump assembly not seating properly, and potentially leaking.
  - All drop pipe used should be stainless steel and the threading should be closely inspected to ensure it complies with the ASTM specification for NPT threading. In particular, if seamed drop pipe is used, flaws in the threading at the seam commonly result in leaks. Any flawed threading should be rejected and replaced.
  - To facilitate future pump removal and well maintenance, it is recommended that a minimum 46 cm (18 inch) nipple be installed at the base of the pitless spool. Shorter nipples should not be used as they have a tendency to become “egged” when pressure is applied by the chain wrenches needed to install and remove the pump assembly.
  - A stainless steel check valve should be installed directly above the pump. It is recommended that a minimum 46 cm (18 inch) nipple be installed above the pump and the check valve installed above that.
  - All drop pipe threading should be sealed using proper Teflon tape rated for stainless steel applications and stainless steel anti-seize pipe dope. The tape and anti-seize compounds should be installed in accordance with the supplier’s recommendations, and all joints torqued to the proper pressure. Failure to properly seal and torque the couplers is the most common source of leakage and subsequent ongoing issues with the well.
- The regular monitoring of the production wells specific capacity and a regular program of well/pump inspection and maintenance is recommended. The minimum frequency is every 5 years. Ongoing results may indicate that more frequent maintenance is required. The results of these inspections and maintenance programs should be documented and maintained in the files associated with the water system for future review and evaluation of trends.



An annual summary report on the status of the system operation and the results of all monitoring and maintenance should be prepared for internal Monarch Colony review relative to the status of the water supply and the need for repairs/upgrades and for other parties with an interest in the system (licensing agencies, etc.). A primary advantage of annual reports is that it ensures that regular reviews of the system status are conducted, and the reports would provide a database for future re-evaluations of the yield of the aquifer.

A copy of this report should be provided to the Water Licensing Section of Manitoba Water Stewardship and Conservation in partial fulfillment of the requirements to obtain a water rights license for this new well.



## 6.0 Closure

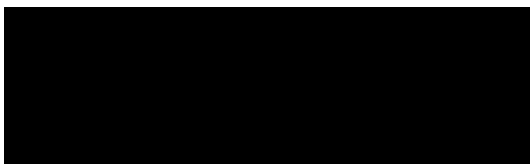
The information and data contained in this report, including without limitation the results of any sampling and analyses conducted by W.L. Gibbons & Associates Inc. (WLG) pursuant to its agreement with the Client, has been developed or obtained through the exercise of WLG's professional judgement and are set forth to the best of WLG's knowledge, information and belief. Although every effort has been made to confirm that this information is factual, complete, and accurate, WLG makes no guarantees or warranties whatsoever, whether expressed or implied, with respect to such information or data.

WLG shall not by act of issuing this report be deemed to have represented thereby that any assessment conducted by it have been exhaustive or will identify all risks associated with the development of water supplies within the study area. Persons relying on the results thereof do so at their own risk.

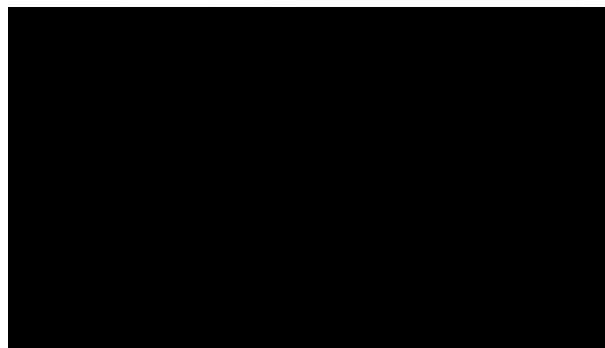
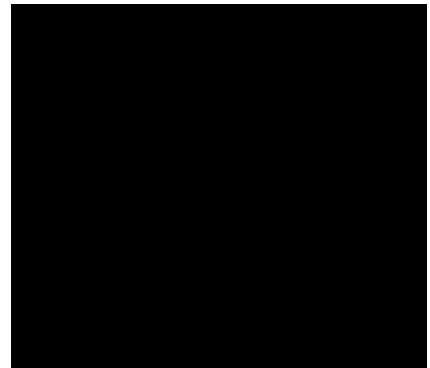
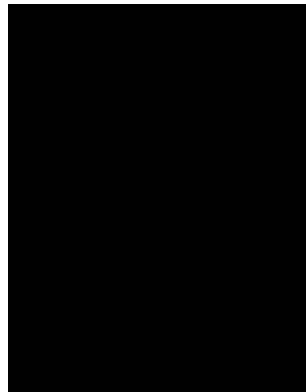
Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the Client, their officers and employees, and others having legitimate business relations with the Client. Any such use and reliance shall be subject to the limitations set forth in the preceding paragraphs.

Respectfully Submitted.

**W.L. Gibbons & Associates Inc.**



Steve Wiecek, P.Geo., P.Eng.  
Senior Geologic Engineer



## Table

**Table 1**  
**Monarch Colony**  
**Water Quality Data**  
**Sheet 1 of 2**

Parameters	Wattsvie LS	MW 17-01	TW 17-01	PW 17-02	MW 22-01	MW 22-02	TW 22-01	Canadian Drinking Water Quality Guidelines
	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	
	24/11/16	15/6/17	16/6/17	20/09/17	21/09/22	21/09/22	11/07/22	
	Shallow S&G	Deep S&G	Deep S&G	Deep S&G	Deep S&G	Deep S&G	Deep S&G	
Total Alkalinity (as CaCO <sub>3</sub> )	280	257	262	263	290	275	300	
Bicarbonate (as HCO <sub>3</sub> )	342	314	320	320	353	336	350	
Carbonate (as CO <sub>3</sub> )	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	7.8	
Hydroxide (OH)	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	<0.34	
Ammonia, Total (as N)	0.068	0.142	0.177	0.137	0.02	0.064	<0.01	
Total Carbon	50.7	49.6	54.5	58.1	59.8	55.2	56.3	
Total Inorganic Carbon	49.6	48.1	53.4	56.7	54.3	51.8	53.6	
Total Organic Carbon	1.08	1.49	1.08	1.34	5.51	3.39	2.68	
Chloride (Cl)	1.61	3.87	3.66	4.61	9.9	14	10.4	250
True Colour (CU)	<5	<5	<5	<5	<5	<5	<5	15
Conductivity (umhos/cm)	568	551	555	543	944	874	1070	
Fluoride (F)	0.178	0.138	0.137	0.132	0.158	0.176	0.127	1.5
Hardness (as CaCO <sub>3</sub> )	325	279	283	294	523	475	524	
Cation - Anion Balance	-2.4	-3.7	-3.3	-2.4	2.1	2.9	-1.8	
Anion Sum	7.01	6.6	6.67	6.78	11.5	10.1	12.2	
Cation Sum	6.67	6.13	6.24	6.46	12	10.7	11.8	
Langelier Index (4°C)	0.35	0.71	0.3	0.26	0.86	1	1.1	
Langelier Index (60°C)	1.1	1.5	1.1	1	1.6	1.8	1.9	
Nitrate-N	0.352	<0.02	<0.02	<0.02	8.72	0.034	10.4	10
Nitrate and Nitrite as N	0.352	<0.07	<0.07	<0.07	8.72	<0.07	10.4	10
Nitrite-N	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01		1
Sulphate (SO <sub>4</sub> )	63.5	64.4	63.1	67.4	230	202	249	500
Total Dissolved Solids	376	381	360	356	677	605	736	500
Total Kjeldahl Nitrogen	<0.2	0.2	36.5	0.34	<0.2	<0.2	0.4	
UV Transmittance (245nm)	96.2	94.4	94.8	95.5	87.3	87.5	91.4	
Turbidity (NTU)	6.05	2.83	1.15	14.3	36.2	0.6	0.46	
pH	7.67	8.14	7.72	7.66	8.11	8.23	8.38	

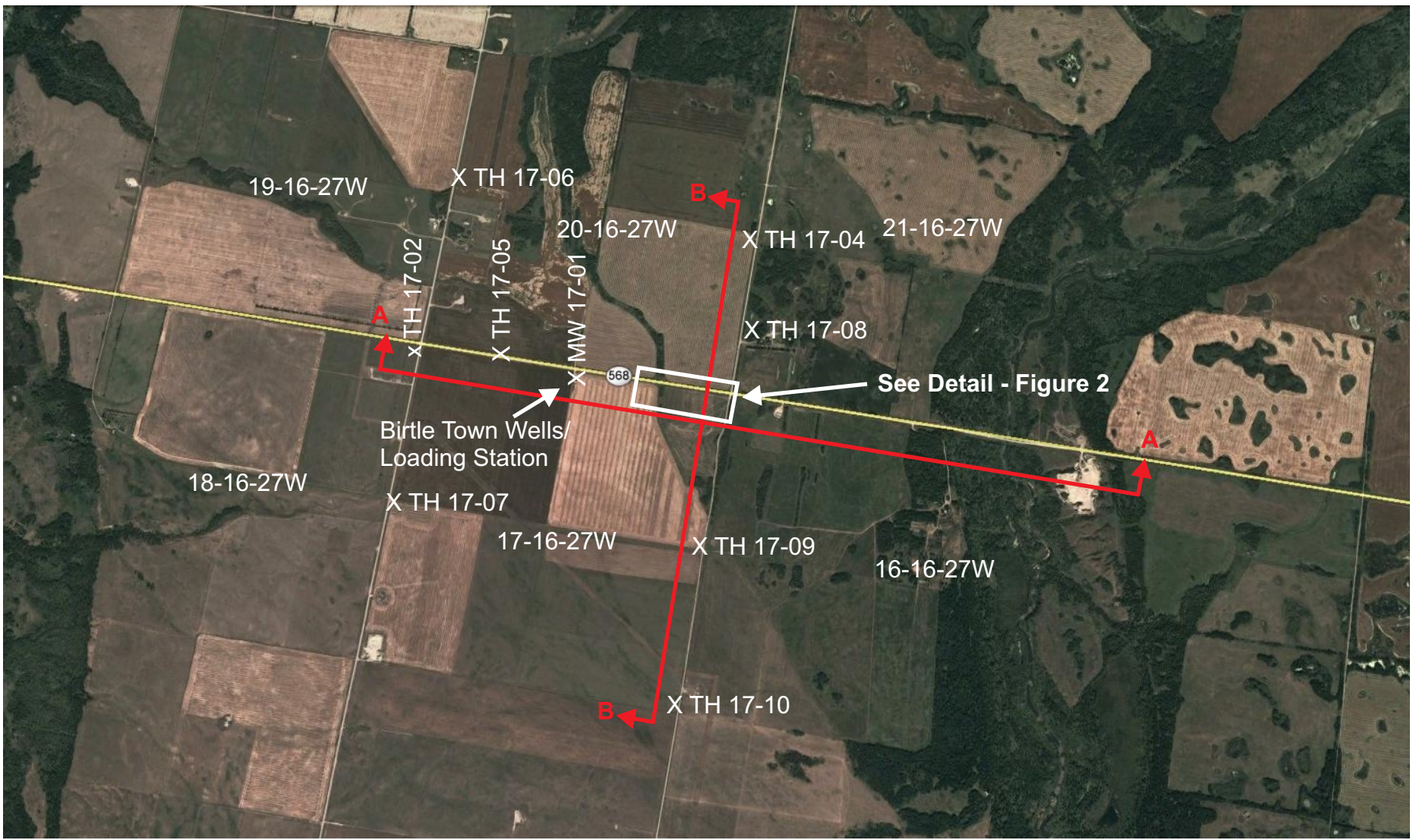
Note: All units in mg/l except as noted.

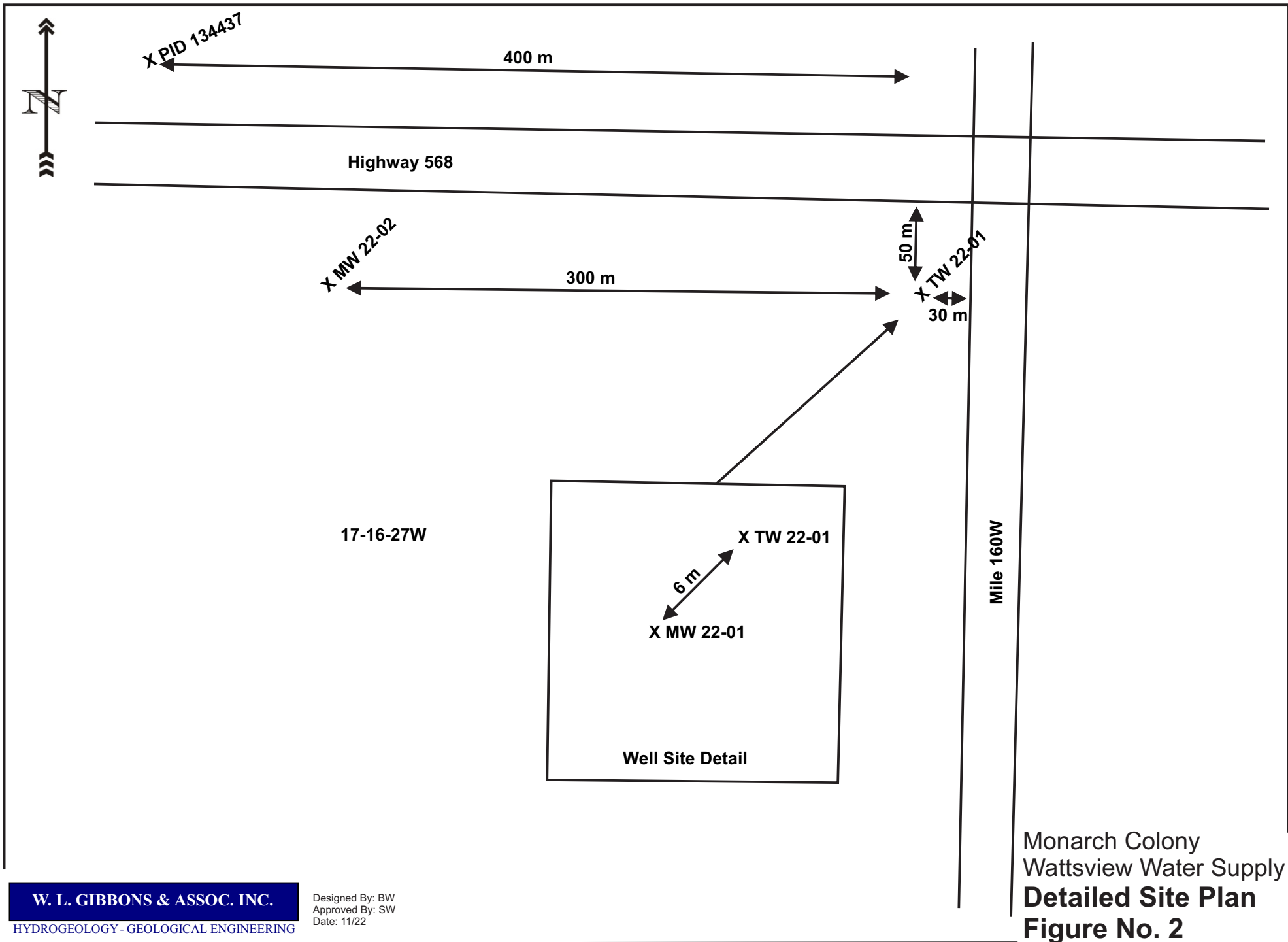
- denotes exceedance of guideline

**Table 1  
Monarch Colony  
Water Quality Data  
Sheet 2 of 2**

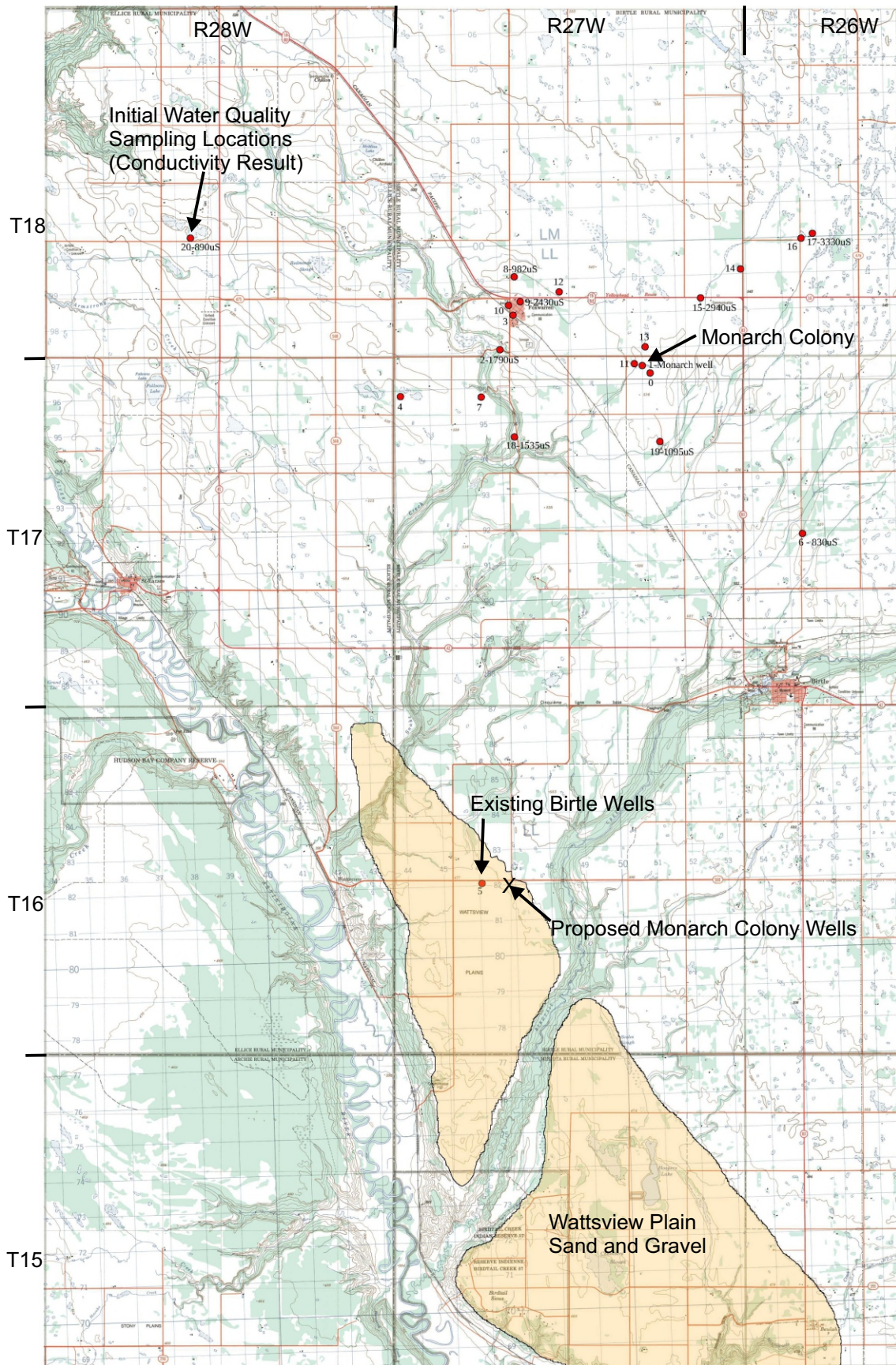
Parameters	Wattsvieview LS	MW 17-01	TW 17-01	PW 17-02	MW 22-01	MW 22-02	TW 22-01	Canadian Drinking Water Quality  Guidelines
	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	NE17-16-27W	
	24/11/16	15/6/17	16/6/17	20/09/17	21/09/22	21/09/22	11/07/22	
	Shallow S&G	Deep S&G	Deep S&G	Deep S&G	Deep S&G	Deep S&G	Deep S&G	
<b>Total Metals</b>								
Aluminum (Al)	<0.005	0.0181	0.0126	<0.003	0.543	0.0062	<0.003	0.1
Antimony (Sb)	<0.0002	<0.0002	<0.0002	<0.0001	0.00011	<0.0001	<0.0001	0.006
Arsenic (As)	0.00154	0.00311	0.00324	0.0042	0.00086	0.00311	0.00034	0.0100
Barium (Ba)	0.0939	0.685	0.0668	0.0705	0.0703	0.0633	0.031	1
Beryllium (Be)	<0.0002	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	
Bismuth (Bi)	<0.0002	<0.0002	<0.0002	<0.00005	<0.00005	<0.00005	<0.00005	
Boron (B)	0.033	0.034	0.034	0.035	0.07	0.058	0.075	5
Cadmium (Cd)	<0.00001	<0.00001	<0.00001	<0.000005	0.000024	0.000024	<0.000005	0.005
Calcium (Ca)	85.4	71.9	72.3	75.9	115	122	112	
Cesium (Cs)	<0.0001	<0.0001	<0.0001	<0.00001	0.000065	<0.00001	<0.00001	
Chromium (Cr)	<0.001	<0.0001	<0.001	<0.0001	0.00097	<0.0001	0.00012	0.05
Cobalt (Co)	<0.0002	0.00053	0.00023	0.0002	0.00062	0.0023	<0.0001	
Copper (Cu)	0.00049	0.00041	0.00467	<0.0005	0.00162	<0.0005	0.00053	1
Iron (Fe)	0.669	0.759	1.06	1.15	0.819	0.161	0.071	0.3
Lead (Pb)	<0.00009	<0.00009	0.000688	<0.00005	0.000453	<0.00005	<0.00005	0.01
Lithium (Li)	0.0164	0.0189	0.0193	0.0179	0.0683	0.0425	0.0757	
Magnesium (Mg)	27.2	24.1	24.8	25.3	57.4	41.4	59.4	
Manganese (Mn)	0.414	0.435	0.421	0.446	0.099	0.755	0.00266	0.050
Molybdenum (Mo)	0.0009	0.00124	0.00098	0.000964	0.00164	0.00102	0.000504	
Nickel (Ni)	0.0025	<0.002	<0.002	<0.0005	0.00163	0.00274	<0.0005	
Phosphorous (P)	<0.1	<0.1	<0.1	0.085	0.056	<0.03	0.048	
Potassium (K)	2.23	3.08	3.11	3.04	6.95	4.28	6.56	
Rubidium (Rb)	0.00048	0.00095	0.00085	0.00084	0.00196	0.00113	0.0005	
Selenium (Se)	<0.001	<0.001	<0.001	<0.00005	0.00334	0.000199	0.00349	0.01
Silicon (Si)	12.8	12.8	12.8	13.5	15.4	14.5	13.5	
Silver (Ag)	<0.0001	<0.0001	<0.0001	<0.00001	<0.00001	<0.00001	<0.00001	
Sodium (Na)	2.57	10.9	11.4	11.6	30.6	25.5	26.5	200
Strontium (Sr)	0.171	0.145	0.149	0.157	0.332	0.298	0.362	
Sulfur (S)							93.1	
Tellurium (Te)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	
Thallium (Tl)	<0.0001	<0.0001	<0.0001	<0.00001	0.000012	<0.00001	<0.00001	
Thorium (Th)	<0.0001	<0.0001	<0.0001	<0.0001	0.00027	<0.0001	<0.0001	
Tin (Sn)	<0.0002	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	
Titanium (Ti)	<0.0005	0.00059	<0.0005	<0.0003	0.016	<0.0003	<0.0003	
Tungsten (W)	<0.0001	<0.0001	0.00011	<0.0001	0.00027	0.00012	<0.0001	
Uranium (U)	0.00354	0.00255	0.0026	0.00276	0.0114	0.00725	0.0126	
Vanadium (V)	<0.0002	0.00025	<0.0002	<0.0005	0.00258	<0.0005	0.00057	
Zinc (Zn)	0.0025	0.0036	<0.002	<0.003	0.0049	<0.003	<0.003	
Zirconium (Zr)	<0.0004	<0.0004	<0.0004	<0.00006	0.00061	<0.0002	<0.0002	

Note: All units in mg/l except as noted.

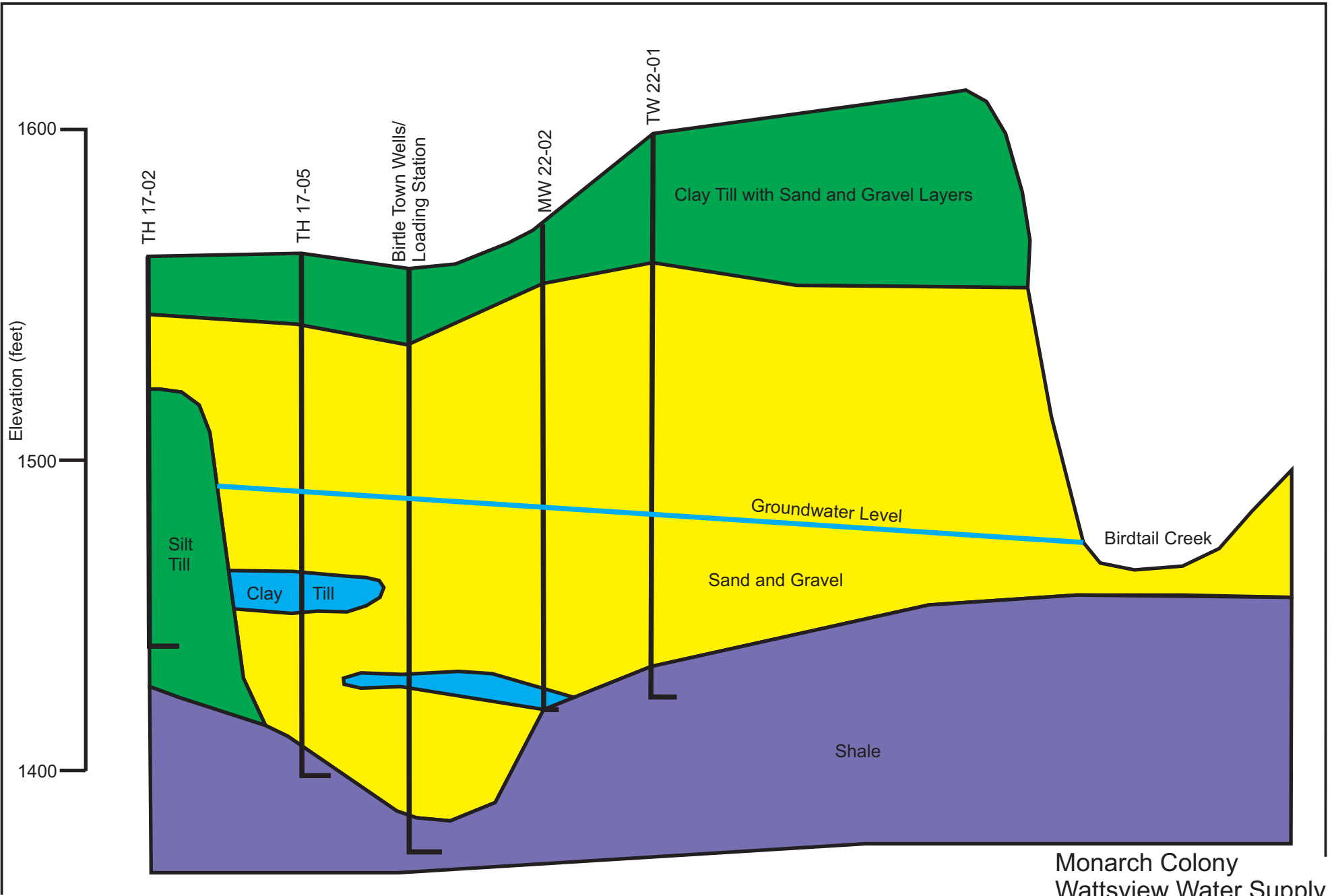


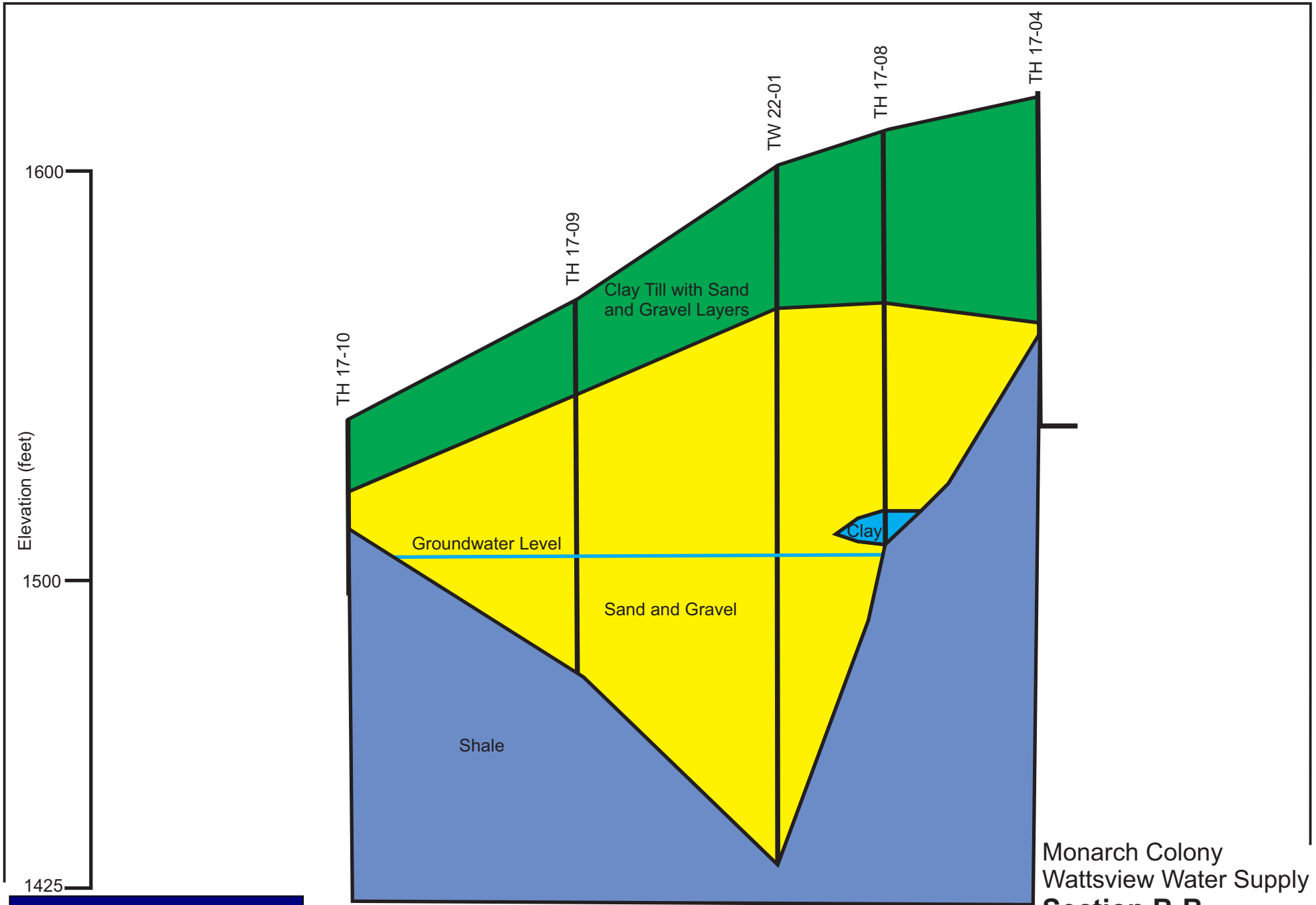


Monarch Colony  
 Wattsview Water Supply  
**Detailed Site Plan**  
**Figure No. 2**



Monarch Colony  
Wattsvie Water Supply  
**Regional Plan**  
**Figure No. 03**





**Appendix A**  
**Groundwater Exploration Permit**

# GROUNDWATER EXPLORATION PERMIT



Issued in accordance with the provisions  
**The Water Rights Act** and regulations made thereunder.

Subject to the terms and conditions contained in this Groundwater Exploration Permit, the Minister charged with administration of The Water Rights Act authorizes:

**Monarch Colony**  
In the **Prairie View Municipality**, in the province of Manitoba, to explore for groundwater, as well as construct water well(s), install pump(s) and transmittal pipeline(s) (the "WORKS") for **Agricultural** purposes on the following land:

## **34 of Township 16, Range 27 WPM**

### **Sections 23, 26, 33, 35 & 36 of Township 17, Range 27 WPM and Sections 17 - 21, 28 - 30, 32**

This Groundwater Exploration Permit does not authorize diversion and use of water for **Agricultural** purposes.

The WORKS shall be constructed in accordance with the terms and conditions described as follows:

1. This Permit expires within twenty-four (24) months of the date of issuance. Failure to construct all of the necessary WORKS and use water for **Agricultural** purposes prior to the permit expiry date may result in cancellation of the application for a Water Rights Licence.
2. This Permit is not transferable or assignable to any other party.
3. The Permittee must have legal access to all lands occupied by the project.
4. The Permittee must hold and maintain all regulatory approvals and requirements for the construction of the WORKS as provided by this Permit.
5. Prior to undertaking any work or construction of any WORKS authorized by this Permit, the Permittee must retain the services of a hydrogeologist registered with Engineers Geoscientists Manitoba, who is required to:
  - a. Plan and supervise the drilling of boreholes, test well(s), production well(s), observation well(s) and well pump testing.
  - b. Conduct a constant rate pumping test on the proposed production well(s) in accordance with Form H. ([https://www.gov.mb.ca/sd/pubs/water/form\\_h\\_july.pdf](https://www.gov.mb.ca/sd/pubs/water/form_h_july.pdf))
  - c. Conduct a recovery test for a period equal to pump test or 90% recovery, whichever comes first.
  - d. Conduct an inventory of private, agricultural and commercial wells within a one mile radius of the project well(s) site. The inventory may be expanded based on the assessment of the expected area of water level draw-down impact resulting from future pumping.
  - e. Install a lockable and permanent two-inch observation well with the location to be determined by the Hydrogeologist if the supply well(s) will be less than 800 m from any existing wells.
  - f. Prepare and submit to the Water Use Licensing Section a technical report on the drilling of boreholes and test wells, pump testing of wells, well inventory and water quality sampling. The report must contain: well driller's report for test well(s) production well(s) and observation well(s); a location plan of the well(s) on the property and/or GPS locations of the well(s); an analysis of aquifer pumping tests; and calculations of transmissivity. The report must also indicate if any local wells are expected to be adversely affected by the proposed use of water and where these wells are located. A digital copy of the report must be submitted.
6. The Permittee must cease pumping immediately if any local water supplies are negatively impacted as a result of the pumping tests. The Permittee is also responsible to correct any water supply problems or provide a temporary water supply to anyone whose water supplies are negatively impacted as a result of the tests.
7. The Permittee shall assume any liability that may result from the construction of the WORKS.
8. The Province of Manitoba shall hereby be released from any liability or claims for damages that may result from the construction of the WORKS.

9. The Minister or Minister's agents have the right of unrestricted access for the purpose of inspection of any WORKS constructed under this Permit.
10. The issuance of this Permit does not imply that the Department will extend or renew the Permit in subsequent years.
11. A water use monitoring device must be installed on the pipeline from the supply well(s), positioned to accurately measure instantaneous pumping rate and accumulative withdrawals.

**FOR OFFICE USE ONLY**

Issued at the City of Winnipeg, in the Province of Manitoba, this 23rd day of June A.D. 20 21.

Kylene Wiseman

Print Name

Signature

Signed by the Minister charged with the administration of The Water Rights Act (or her/his designate)

**Appendix B**  
**Drillers Reports**







**Appendix C**  
**Laboratory Certificates of Analysis**



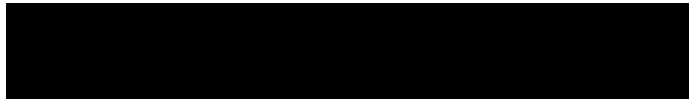
WL Gibbons & Associates Inc.  
ATTN: STEVE WIECEK  
64 St. Andrew Road  
Winnipeg MB R2M 3H6

Date Received: 23-SEP-22  
Report Date: 11-OCT-22 12:02 (MT)  
Version: FINAL

Client Phone: 204-771-4389

## Certificate of Analysis

Lab Work Order #: L2734061  
Project P.O. #: NOT SUBMITTED  
Job Reference: MONARCH  
C of C Numbers:  
Legal Site Desc:



Hua Wo  
Chemistry Laboratory Manager

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ADDRESS: 1329 Niakwa Road East, Unit 12, Winnipeg, MB R2J 3T4 Canada | Phone: +1 204 255 9720 | Fax: +1 204 255 9721  
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## ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L2734061-1	L2734061-2			
Description	WATER	WATER			
Sampled Date	21-SEP-22	21-SEP-22			
Sampled Time	12:00	16:00			
Client ID	MW 22-01	MW 22-02			
Grouping	Analyte				
<b>WATER</b>					
<b>Physical Tests</b>	Colour, True (CU)	<5.0	<5.0		
	Conductivity (umhos/cm)	944	874		
	Hardness (as CaCO3) (mg/L)	523 <sup>HTC</sup>	475 <sup>HTC</sup>		
	Langelier Index (4 C)	0.86	1.0		
	Langelier Index (60 C)	1.6	1.8		
	pH (pH units)	8.11	8.23		
	Total Dissolved Solids (mg/L)	677	605		
	Transmittance, UV (254 nm) (%T/cm)	87.3	87.5		
	Turbidity (NTU)	36.2	0.60		
<b>Anions and Nutrients</b>	Alkalinity, Total (as CaCO3) (mg/L)	290	275		
	Ammonia, Total (as N) (mg/L)	0.020	0.064		
	Bicarbonate (HCO3) (mg/L)	353	336		
	Carbonate (CO3) (mg/L)	<0.60	<0.60		
	Chloride (Cl) (mg/L)	9.9	14.0		
	Fluoride (F) (mg/L)	0.158	0.176		
	Hydroxide (OH) (mg/L)	<0.34	<0.34		
	Nitrate and Nitrite as N (mg/L)	8.72	<0.070		
	Nitrate (as N) (mg/L)	8.72	0.034		
	Nitrite (as N) (mg/L)	<0.020 <sup>DLM</sup>	<0.010		
	Total Kjeldahl Nitrogen (mg/L)	<0.20 <sup>TKNI</sup>	<0.20		
	Sulfate (SO4) (mg/L)	230	202		
	Anion Sum (me/L)	11.5	10.1		
	Cation Sum (me/L)	12.0	10.7		
	Cation - Anion Balance (%)	2.1	2.9		
<b>Organic / Inorganic Carbon</b>	Total Carbon (mg/L)	59.8	55.2		
	Total Inorganic Carbon (mg/L)	54.3	51.8		
	Total Organic Carbon (mg/L)	5.51	3.39		
<b>Total Metals</b>	Aluminum (Al)-Total (mg/L)	0.543	0.0062		
	Antimony (Sb)-Total (mg/L)	0.00011	<0.00010		
	Arsenic (As)-Total (mg/L)	0.00086	0.00311		
	Barium (Ba)-Total (mg/L)	0.0703	0.0633		
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050		
	Boron (B)-Total (mg/L)	0.070	0.058		
	Cadmium (Cd)-Total (mg/L)	0.0000242	0.0000238		
	Calcium (Ca)-Total (mg/L)	115	122		

\* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L2734061-1 WATER 21-SEP-22 12:00 MW 22-01	L2734061-2 WATER 21-SEP-22 16:00 MW 22-02		
Grouping	Analyte				
<b>WATER</b>					
<b>Total Metals</b>	Cesium (Cs)-Total (mg/L)	0.000065	<0.000010		
	Chromium (Cr)-Total (mg/L)	0.00097	<0.00010		
	Cobalt (Co)-Total (mg/L)	0.00062	0.00230		
	Copper (Cu)-Total (mg/L)	0.00162	<0.00050		
	Iron (Fe)-Total (mg/L)	0.819	0.161		
	Lead (Pb)-Total (mg/L)	0.000453	<0.000050		
	Lithium (Li)-Total (mg/L)	0.0683	0.0425		
	Magnesium (Mg)-Total (mg/L)	57.4	41.4		
	Manganese (Mn)-Total (mg/L)	0.0990	0.755		
	Molybdenum (Mo)-Total (mg/L)	0.00164	0.00102		
	Nickel (Ni)-Total (mg/L)	0.00163	0.00274		
	Phosphorus (P)-Total (mg/L)	0.056	<0.030		
	Potassium (K)-Total (mg/L)	6.95	4.28		
	Rubidium (Rb)-Total (mg/L)	0.00196	0.00113		
	Selenium (Se)-Total (mg/L)	0.00334	0.000199		
	Silicon (Si)-Total (mg/L)	15.4	14.5		
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	30.6	25.5		
	Strontium (Sr)-Total (mg/L)	0.332	0.298		
	Sulfur (S)-Total (mg/L)	91.1	76.5		
	Tellurium (Te)-Total (mg/L)	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	0.000012	<0.000010		
	Thorium (Th)-Total (mg/L)	0.00027	<0.00010		
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.0160	<0.00030		
	Tungsten (W)-Total (mg/L)	0.00027	0.00012		
	Uranium (U)-Total (mg/L)	0.0114	0.00725		
	Vanadium (V)-Total (mg/L)	0.00258	<0.00050		
	Zinc (Zn)-Total (mg/L)	0.0049	<0.0030		
	Zirconium (Zr)-Total (mg/L)	0.00061	<0.00020		

\* Please refer to the Reference Information section for an explanation of any qualifiers detected.

## Reference Information

### QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Total Inorganic Carbon	MS-B	L2734061-1, -2
Matrix Spike	Boron (B)-Total	MS-B	L2734061-1, -2
Matrix Spike	Calcium (Ca)-Total	MS-B	L2734061-1, -2
Matrix Spike	Copper (Cu)-Total	MS-B	L2734061-1, -2
Matrix Spike	Iron (Fe)-Total	MS-B	L2734061-1, -2
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2734061-1, -2
Matrix Spike	Manganese (Mn)-Total	MS-B	L2734061-1, -2
Matrix Spike	Potassium (K)-Total	MS-B	L2734061-1, -2
Matrix Spike	Sodium (Na)-Total	MS-B	L2734061-1, -2
Matrix Spike	Strontium (Sr)-Total	MS-B	L2734061-1, -2
Matrix Spike	Sulfur (S)-Total	MS-B	L2734061-1, -2
Matrix Spike	Zinc (Zn)-Total	MS-B	L2734061-1, -2
Matrix Spike	Ammonia, Total (as N)	MS-B	L2734061-1, -2

### Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
HTC	Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
TKNI	TKN result may be biased low due to Nitrate interference. Nitrate-N is > 10x TKN.

### Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
<b>ALK-CO3CO3-CALC-WP</b>	Water	Alkalinity, Carbonate	CALCULATION
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by carbonate is calculated and reported as mg CO<sub>3</sub> 2-/L.</p>			
<b>ALK-HCO3HCO3-CALC-WP</b>	Water	Alkalinity, Bicarbonate	CALCULATION
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by bicarbonate is calculated and reported as mg HCO<sub>3</sub>-/L</p>			
<b>ALK-OHOH-CALC-WP</b>	Water	Alkalinity, Hydroxide	CALCULATION
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by hydroxide is calculated and reported as mg OH-/L.</p>			
<b>ALK-TITR-WP</b>	Water	Alkalinity, Total (as CaCO <sub>3</sub> )	APHA 2320B
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO<sub>3</sub>- and H<sub>2</sub>CO<sub>3</sub> endpoints indicated electrometrically.</p>			
<b>C-TC-CALC-WP</b>	Water	Total Carbon by Calculation	CALCULATED
<p>Total carbon represents the sum of total inorganic carbon and total organic carbon. For the purpose of calculation, results less than the detection limit (DL) are treated as zero.</p>			
<b>C-TIC-HTC-WP</b>	Water	Total Inorganic Carbon by Combustion	APHA 5310 B-WP
<p>Sample is injected into a heated reaction chamber where it is acidified converting all inorganic carbon to CO<sub>2</sub>, which is then transported in the carrier gas stream and measured via a non-dispersive infrared analyzer.</p>			
<b>C-TOC-HTC-WP</b>	Water	Total Organic Carbon by Combustion	APHA 5310 B-WP
<p>Sample is acidified and purged to remove inorganic carbon, then injected into a heated reaction chamber where organic carbon is oxidized to CO<sub>2</sub> which is then transported in the carrier gas stream and measured via a non-dispersive infrared analyzer.</p>			
<b>CL-IC-N-WP</b>	Water	Chloride in Water by IC	EPA 300.1 (mod)
<p>Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</p>			
<b>COLOUR-TRUE-WP</b>	Water	Colour, True	APHA 2120C
<p>True Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method (450 - 465 nm) after filtration of sample through a 0.45 um filter. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.</p>			

## Reference Information

<b>EC-WP</b>	Water	Conductivity	APHA 2510B
Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.			
<b>ETL-LANGELIER-4-WP</b>	Water	Langelier Index 4C	Calculated
<b>ETL-LANGELIER-60-WP</b>	Water	Langelier Index 60C	Calculated
<b>F-IC-N-WP</b>	Water	Fluoride in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
<b>HARDNESS-CALC-WP</b>	Water	Hardness Calculated	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO <sub>3</sub> equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
<b>IONBALANCE-CALC-WP</b>	Water	Ion Balance Calculation	APHA 1030E
Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.			
Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance (as % difference) cannot be calculated accurately for waters with very low electrical conductivity (EC), and is reported as "Low EC" where EC < 100 uS/cm (umhos/cm). Ion Balance is calculated as:			
Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]			
<b>MET-T-CCMS-WP</b>	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020B (mod.)
Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.			
Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.			
<b>N-TOTKJ-WP</b>	Water	Total Kjeldahl Nitrogen	APHA 4500 NorgD (modified)
Aqueous samples are digested in a block digester with sulfuric acid and copper sulfate as a catalyst. Total Kjeldahl Nitrogen is then analyzed using a discrete analyzer with colorimetric detection.			
<b>NH3-COL-WP</b>	Water	Ammonia by colour	APHA 4500 NH3 F
Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.			
<b>NO2+NO3-CALC-WP</b>	Water	Nitrate+Nitrite	CALCULATION
<b>NO2-IC-N-WP</b>	Water	Nitrite in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
<b>NO3-IC-N-WP</b>	Water	Nitrate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
<b>PH-WP</b>	Water	pH	APHA 4500H
The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.			
<b>SO4-IC-N-WP</b>	Water	Sulfate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
<b>TDS-WP</b>	Water	Total Dissolved Solids (TDS)	APHA 2540 SOLIDS C,E
A well-mixed sample is filtered through a glass fiber filter paper. The filtrate is then evaporated to dryness in a pre-weighed vial and dried at 180 – 2C. The increase in vial weight represents the total dissolved solids.			
<b>TURBIDITY-WP</b>	Water	Turbidity	APHA 2130B (modified)
Turbidity in aqueous matrices is determined by the nephelometric method.			
<b>UV-%TRANS-WP</b>	Water	UV Transmittance (Calculated)	APHA 5910B
Test method is adapted from APHA Method 5910B. A sample is filtered through a 0.45 um polyethersulfone (PES) filter and its UV Absorbance is measured in a quartz cell at 254 nm. UV Transmittance is calculated from the UV Absorbance result and reported as UV Transmittance per cm. The analysis is carried out without pH adjustment.			

\*\* ALS test methods may incorporate modifications from specified reference methods to improve performance.

## Reference Information

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The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

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Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

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### Chain of Custody Numbers:

#### GLOSSARY OF REPORT TERMS

*Surrogate* - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

*mg/kg* - milligrams per kilogram based on dry weight of sample.

*mg/kg wwt* - milligrams per kilogram based on wet weight of sample.

*mg/kg lwt* - milligrams per kilogram based on lipid-adjusted weight of sample.

*mg/L* - milligrams per litre.

*<* - Less than.

*D.L.* - The reported Detection Limit, also known as the Limit of Reporting (LOR).

*N/A* - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



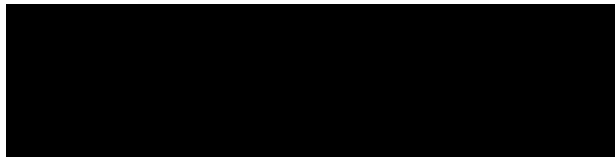
WL Gibbons & Associates Inc.  
ATTN: STEVE WIECEK  
64 St. Andrew Road  
Winnipeg MB R2M 3H6

Date Received: 08-NOV-22  
Report Date: 25-NOV-22 17:42 (MT)  
Version: FINAL

Client Phone: 204-771-4389

## Certificate of Analysis

Lab Work Order #: L2739579  
Project P.O. #: NOT SUBMITTED  
Job Reference: MONARCH  
C of C Numbers:  
Legal Site Desc:



Craig Biddell, B.Sc.Ag  
Account Manager

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# ALS ENVIRONMENTAL ANALYTICAL REPORT

	<b>Sample ID</b> <b>Description</b> <b>Sampled Date</b> <b>Sampled Time</b> <b>Client ID</b>	L2739579-1			
		WATER	07-NOV-22	16:00	TW22-01
Grouping	Analyte				
<b>WATER</b>					
<b>Physical Tests</b>	Colour, True (CU)	<5.0			
	Conductivity (umhos/cm)	1070			
	Hardness (as CaCO3) (mg/L)	524 <sup>HTC</sup>			
	Langelier Index (4 C)	1.1			
	Langelier Index (60 C)	1.9			
	pH (pH units)	8.38			
	Total Dissolved Solids (mg/L)	736			
	Transmittance, UV (254 nm) (%T/cm)	91.4			
	Turbidity (NTU)	0.46			
<b>Anions and Nutrients</b>	Alkalinity, Total (as CaCO3) (mg/L)	300			
	Ammonia, Total (as N) (mg/L)	<0.010			
	Bicarbonate (HCO3) (mg/L)	350			
	Carbonate (CO3) (mg/L)	7.80			
	Chloride (Cl) (mg/L)	10.4 <sup>DLM</sup>			
	Fluoride (F) (mg/L)	0.127 <sup>DLM</sup>			
	Hydroxide (OH) (mg/L)	<0.34			
	Nitrate and Nitrite as N (mg/L)	10.4			
	Nitrate (as N) (mg/L)	10.4 <sup>DLM</sup>			
	Nitrite (as N) (mg/L)	<0.020 <sup>DLM</sup>			
	Total Kjeldahl Nitrogen (mg/L)	0.40 <sup>TKNI</sup>			
	Sulfate (SO4) (mg/L)	249 <sup>DLM</sup>			
	Anion Sum (me/L)	12.2			
	Cation Sum (me/L)	11.8			
	Cation - Anion Balance (%)	-1.8			
<b>Organic / Inorganic Carbon</b>	Total Carbon (mg/L)	56.3			
	Total Inorganic Carbon (mg/L)	53.6			
	Total Organic Carbon (mg/L)	2.68			
<b>Total Metals</b>	Aluminum (Al)-Total (mg/L)	<0.0030			
	Antimony (Sb)-Total (mg/L)	<0.00010			
	Arsenic (As)-Total (mg/L)	0.00034			
	Barium (Ba)-Total (mg/L)	0.0310			
	Beryllium (Be)-Total (mg/L)	<0.00010			
	Bismuth (Bi)-Total (mg/L)	<0.000050			
	Boron (B)-Total (mg/L)	0.075			
	Cadmium (Cd)-Total (mg/L)	<0.0000050			
	Calcium (Ca)-Total (mg/L)	112			

\* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

	<b>Sample ID</b> <b>Description</b> <b>Sampled Date</b> <b>Sampled Time</b> <b>Client ID</b>	L2739579-1 WATER 07-NOV-22 16:00 TW22-01			
Grouping	Analyte				
<b>WATER</b>					
<b>Total Metals</b>	Cesium (Cs)-Total (mg/L)	<0.000010			
	Chromium (Cr)-Total (mg/L)	0.00012			
	Cobalt (Co)-Total (mg/L)	<0.00010			
	Copper (Cu)-Total (mg/L)	0.00053			
	Iron (Fe)-Total (mg/L)	0.071			
	Lead (Pb)-Total (mg/L)	<0.000050			
	Lithium (Li)-Total (mg/L)	0.0757			
	Magnesium (Mg)-Total (mg/L)	59.4			
	Manganese (Mn)-Total (mg/L)	0.00266			
	Molybdenum (Mo)-Total (mg/L)	0.000504			
	Nickel (Ni)-Total (mg/L)	<0.00050			
	Phosphorus (P)-Total (mg/L)	0.048			
	Potassium (K)-Total (mg/L)	6.56			
	Rubidium (Rb)-Total (mg/L)	0.00050			
	Selenium (Se)-Total (mg/L)	0.00349			
	Silicon (Si)-Total (mg/L)	13.5			
	Silver (Ag)-Total (mg/L)	<0.000010			
	Sodium (Na)-Total (mg/L)	26.5			
	Strontium (Sr)-Total (mg/L)	0.362			
	Sulfur (S)-Total (mg/L)	93.1			
	Tellurium (Te)-Total (mg/L)	<0.00020			
	Thallium (Tl)-Total (mg/L)	<0.000010			
	Thorium (Th)-Total (mg/L)	<0.00010			
	Tin (Sn)-Total (mg/L)	<0.00010			
	Titanium (Ti)-Total (mg/L)	<0.00030			
	Tungsten (W)-Total (mg/L)	<0.00010			
	Uranium (U)-Total (mg/L)	0.0126			
	Vanadium (V)-Total (mg/L)	0.00057			
	Zinc (Zn)-Total (mg/L)	<0.0030			
	Zirconium (Zr)-Total (mg/L)	<0.00020			

\* Please refer to the Reference Information section for an explanation of any qualifiers detected.

## Reference Information

### QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Total Inorganic Carbon	MS-B	L2739579-1
Matrix Spike	Total Organic Carbon	MS-B	L2739579-1
Matrix Spike	Barium (Ba)-Total	MS-B	L2739579-1
Matrix Spike	Boron (B)-Total	MS-B	L2739579-1
Matrix Spike	Calcium (Ca)-Total	MS-B	L2739579-1
Matrix Spike	Lithium (Li)-Total	MS-B	L2739579-1
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2739579-1
Matrix Spike	Manganese (Mn)-Total	MS-B	L2739579-1
Matrix Spike	Silicon (Si)-Total	MS-B	L2739579-1
Matrix Spike	Sodium (Na)-Total	MS-B	L2739579-1
Matrix Spike	Strontium (Sr)-Total	MS-B	L2739579-1
Matrix Spike	Uranium (U)-Total	MS-B	L2739579-1
Matrix Spike	Ammonia, Total (as N)	MS-B	L2739579-1
Matrix Spike	Sulfate (SO4)	MS-B	L2739579-1

### Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
HTC	Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
TKNI	TKN result may be biased low due to Nitrate interference. Nitrate-N is > 10x TKN.

### Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
<b>ALK-CO3CO3-CALC-WP</b>	Water	Alkalinity, Carbonate	CALCULATION
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by carbonate is calculated and reported as mg CO3 2-/L.</p>			
<b>ALK-HCO3HCO3-CALC-WP</b>	Water	Alkalinity, Bicarbonate	CALCULATION
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by bicarbonate is calculated and reported as mg HCO3-/L</p>			
<b>ALK-OHOH-CALC-WP</b>	Water	Alkalinity, Hydroxide	CALCULATION
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by hydroxide is calculated and reported as mg OH-/L.</p>			
<b>ALK-TITR-WP</b>	Water	Alkalinity, Total (as CaCO3)	APHA 2320B
<p>The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically.</p>			
<b>C-TC-CALC-WP</b>	Water	Total Carbon by Calculation	CALCULATED
<p>Total carbon represents the sum of total inorganic carbon and total organic carbon. For the purpose of calculation, results less than the detection limit (DL) are treated as zero.</p>			
<b>C-TIC-HTC-WP</b>	Water	Total Inorganic Carbon by Combustion	APHA 5310 B-WP
<p>Sample is injected into a heated reaction chamber where it is acidified converting all inorganic carbon to CO2, which is then transported in the carrier gas stream and measured via a non-dispersive infrared analyzer.</p>			
<b>C-TOC-HTC-WP</b>	Water	Total Organic Carbon by Combustion	APHA 5310 B-WP
<p>Sample is acidified and purged to remove inorganic carbon, then injected into a heated reaction chamber where organic carbon is oxidized to CO2 which is then transported in the carrier gas stream and measured via a non-dispersive infrared analyzer.</p>			
<b>CL-IC-N-WP</b>	Water	Chloride in Water by IC	EPA 300.1 (mod)
<p>Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</p>			
<b>COLOUR-TRUE-WP</b>	Water	Colour, True	APHA 2120C
<p>True Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method (450 - 465 nm) after</p>			

## Reference Information

filtration of sample through a 0.45 um filter. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

**EC-WP** Water Conductivity APHA 2510B

Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.

**ETL-LANGELIER-4-WP** Water Langelier Index 4C Calculated

**ETL-LANGELIER-60-WP** Water Langelier Index 60C Calculated

**F-IC-N-WP** Water Fluoride in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

**HARDNESS-CALC-WP** Water Hardness Calculated APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO<sub>3</sub> equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

**IONBALANCE-CALC-WP** Water Ion Balance Calculation APHA 1030E

Cation Sum, Anion Sum, and Ion Balance (as % difference) are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Because all aqueous solutions are electrically neutral, the calculated ion balance (% difference of cations minus anions) should be near-zero.

Cation and Anion Sums are the total meq/L concentration of major cations and anions. Dissolved species are used where available. Minor ions are included where data is present. Ion Balance (as % difference) cannot be calculated accurately for waters with very low electrical conductivity (EC), and is reported as "Low EC" where EC < 100 uS/cm (umhos/cm). Ion Balance is calculated as:

Ion Balance (%) = [Cation Sum-Anion Sum] / [Cation Sum+Anion Sum]

**MET-T-CCMS-WP** Water Total Metals in Water by CRC ICPMS EPA 200.2/6020B (mod.)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

**N-TOTKJ-WP** Water Total Kjeldahl Nitrogen APHA 4500 NorgD (modified)

Aqueous samples are digested in a block digester with sulfuric acid and copper sulfate as a catalyst. Total Kjeldahl Nitrogen is then analyzed using a discrete analyzer with colorimetric detection.

**NH3-COL-WP** Water Ammonia by colour APHA 4500 NH3 F

Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.

**NO2+NO3-CALC-WP** Water Nitrate+Nitrite CALCULATION

**NO2-IC-N-WP** Water Nitrite in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

**NO3-IC-N-WP** Water Nitrate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

**PH-WP** Water pH APHA 4500H

The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

**SO4-IC-N-WP** Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

**TDS-WP** Water Total Dissolved Solids (TDS) APHA 2540 SOLIDS C,E

A well-mixed sample is filtered through a glass fiber filter paper. The filtrate is then evaporated to dryness in a pre-weighed vial and dried at 180 – 2C. The increase in vial weight represents the total dissolved solids.

**TURBIDITY-WP** Water Turbidity APHA 2130B (modified)

Turbidity in aqueous matrices is determined by the nephelometric method.

**UV-%TRANS-WP** Water UV Transmittance (Calculated) APHA 5910B

Test method is adapted from APHA Method 5910B. A sample is filtered through a 0.45 um polyethersulfone (PES) filter and its UV Absorbance is measured in a quartz cell at 254 nm. UV Transmittance is calculated from the UV Absorbance result and reported as UV Transmittance per cm. The

## Reference Information

analysis is carried out without pH adjustment.

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\*\* ALS test methods may incorporate modifications from specified reference methods to improve performance.

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*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

---

Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

---

### Chain of Custody Numbers:

#### GLOSSARY OF REPORT TERMS

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*

*mg/kg - milligrams per kilogram based on dry weight of sample.*

*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*

*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*

*mg/L - milligrams per litre.*

*< - Less than.*

*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*

*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*

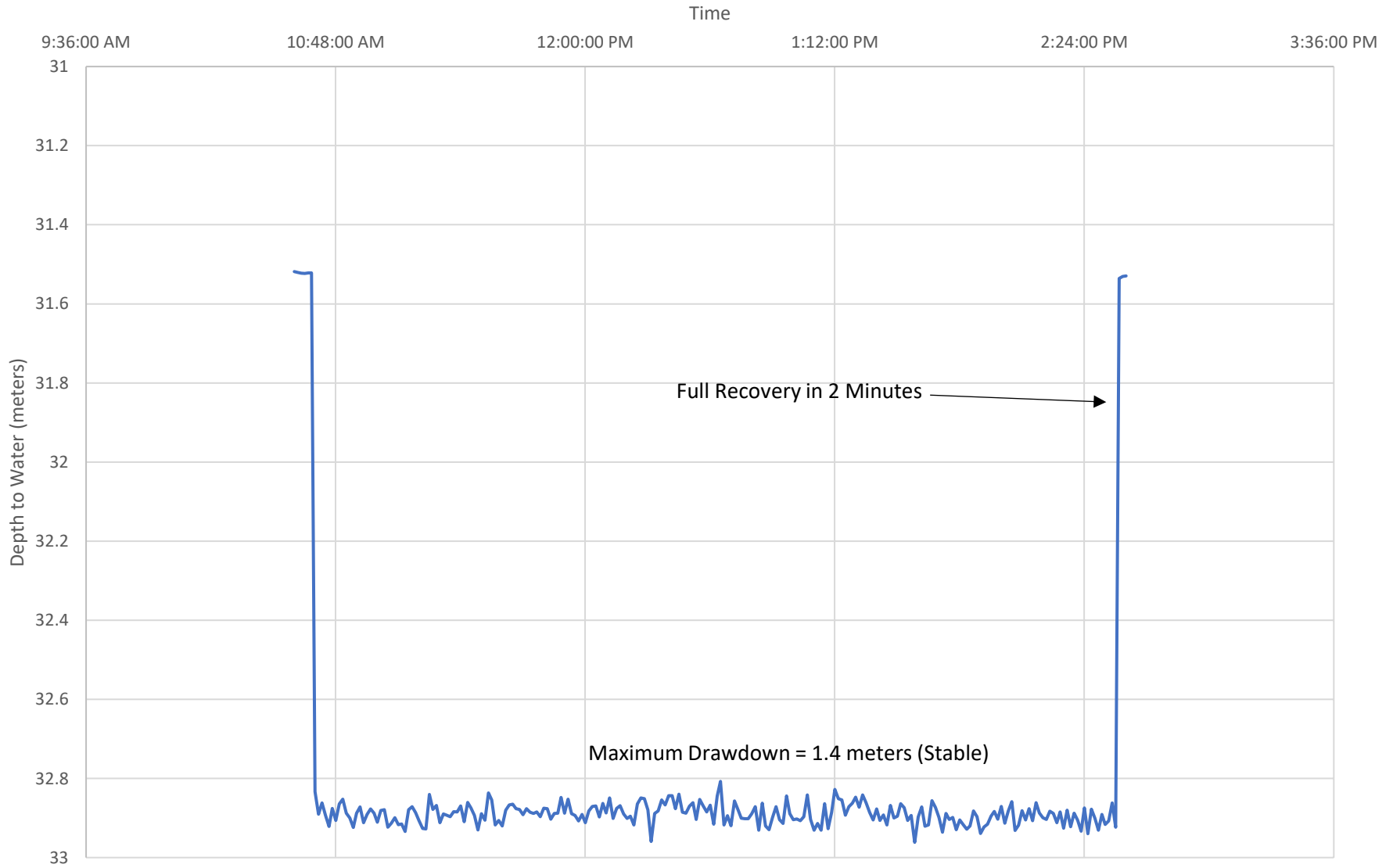
**UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.**

*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

**Appendix D**  
**Pumping Test Results and Analysis**

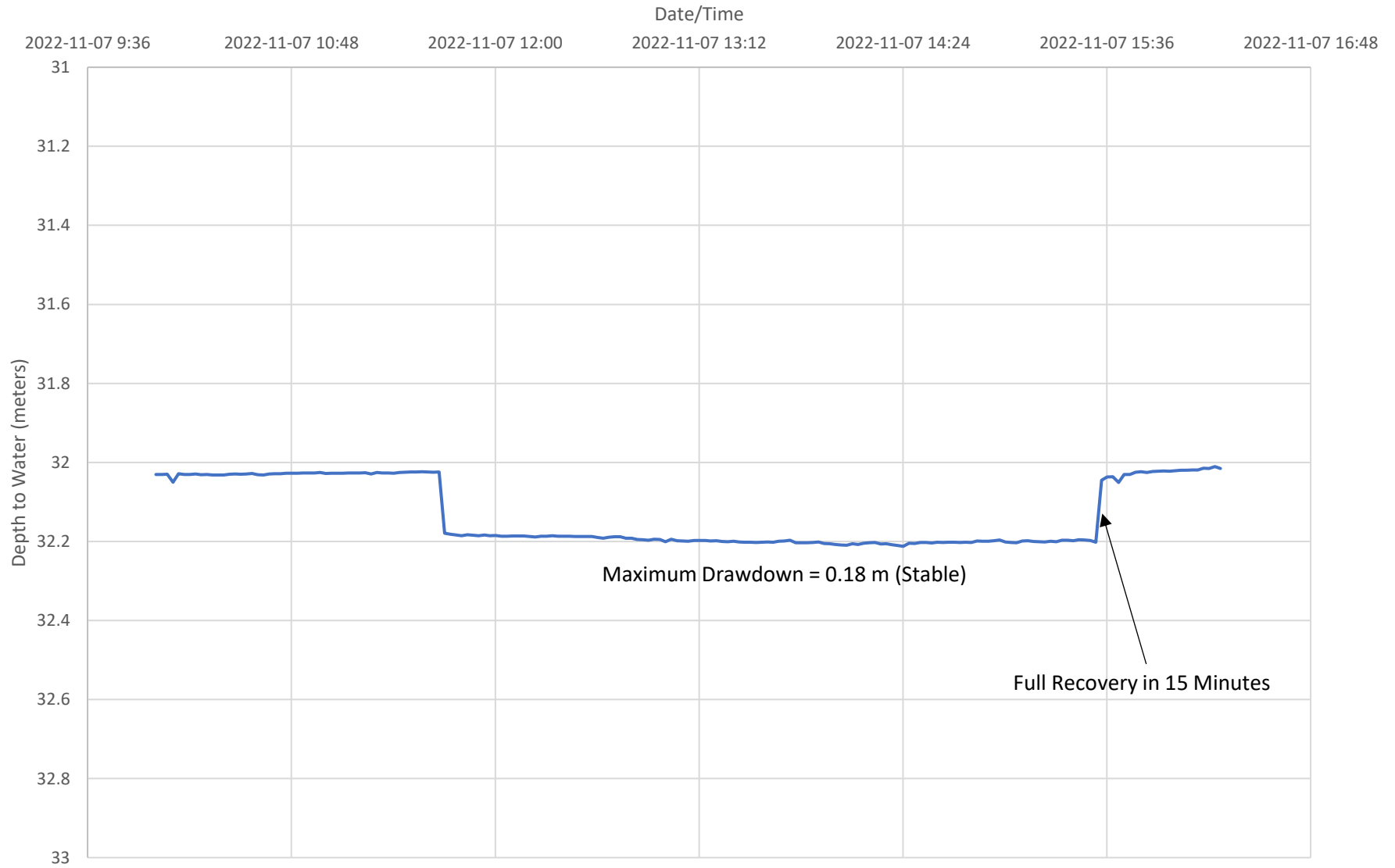
Date of Test: 07/11/2022  
Pumping Rate: 10.5 Lps (138 lpm)  
Measurements in Pumping Well  
Data is Corrected for Barometric Pressure

### Monarch Colony Test Well TW 22-01 TW 22-01 Pumping Test Results



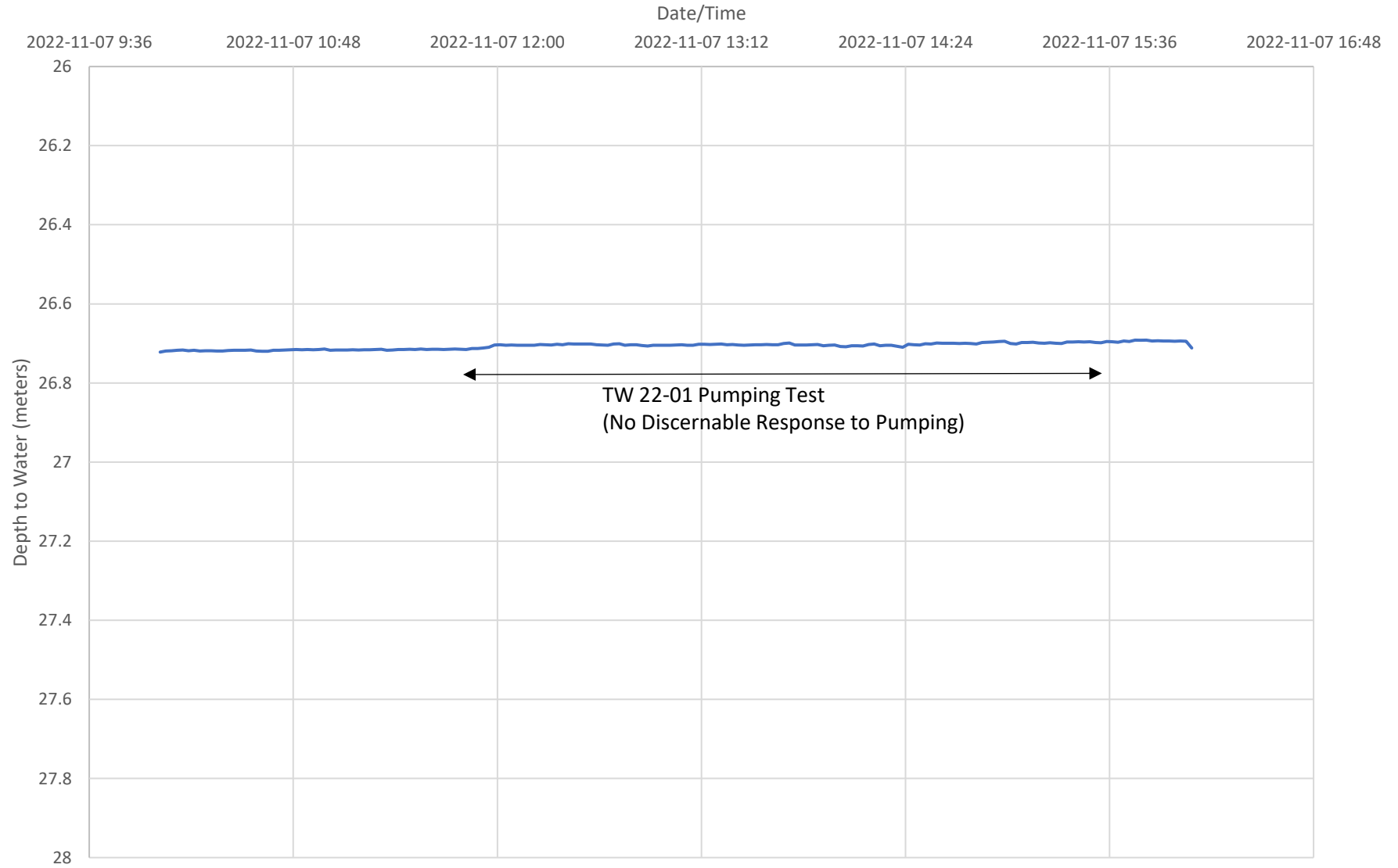
Date of Test: 07/11/2022  
Pumping Rate: 10.5 Lps (138 lpm)  
Distance From Pumping Well: 5.8 m  
Data is Corrected for Barometric Pressure

### Monarch Colony Monitoring Well MW 22-01 TW 22-01 Pumping Test Results



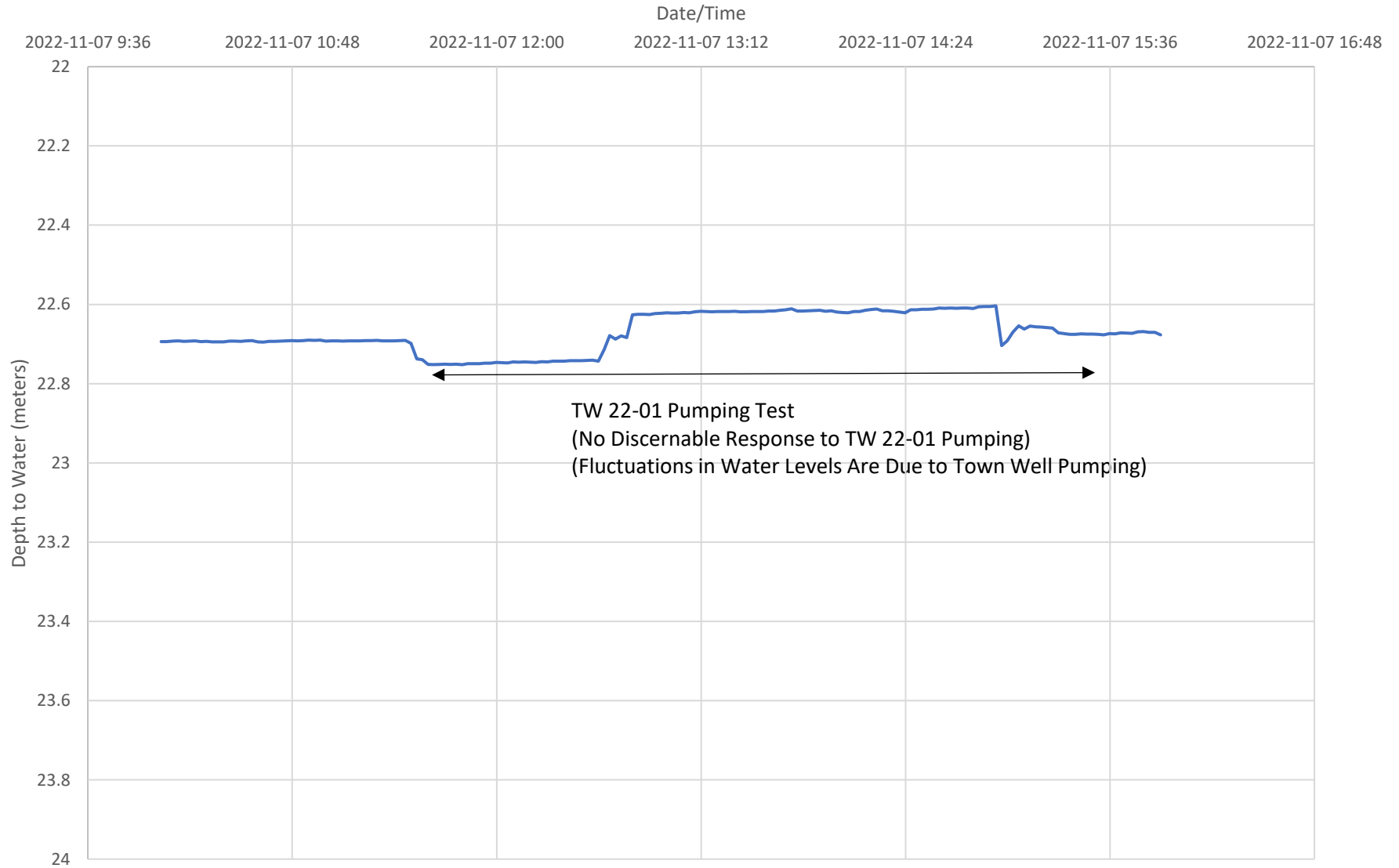
Date of Test: 07/11/2022  
Pumping Rate: 10.5 Lps (138 lpm)  
Distance From Pumping Well: 300 m  
Data is Corrected for Barometric Pressure

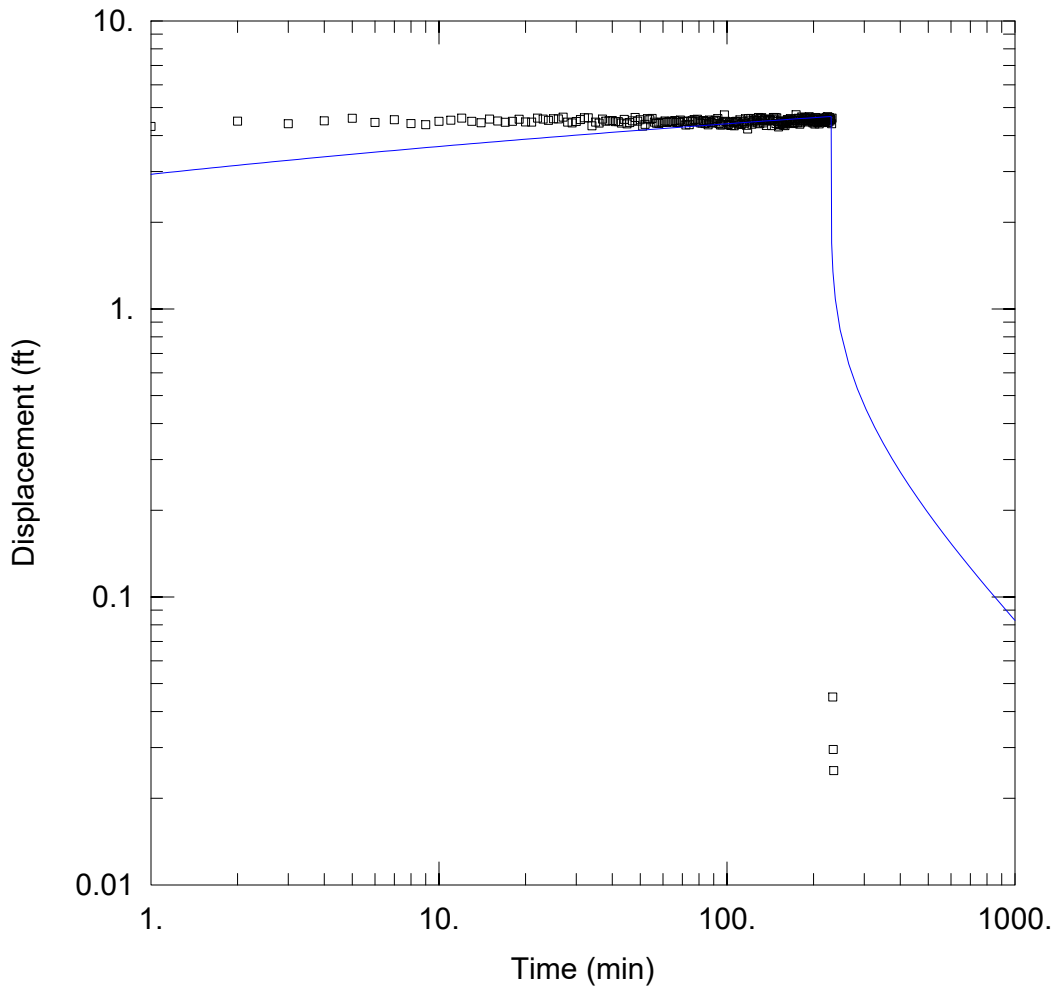
### Monarch Colony Monitoring Well MW 22-02 TW 22-01 Pumping Test Results



Date of Test: 07/11/2022  
Pumping Rate: 10.5 Lps (138 lpm)  
Distance From Pumping Well: 770 m  
Data is Corrected for Barometric Pressure

Monarch Colony  
Monitoring Well MW 17-01 (Birtle Town Wells)  
TW 22-01 Pumping Test Results





WELL TEST ANALYSIS

Data Set: C:\...\TW 22-01 AQTE Neuman.aqt

Date: 12/05/22

Time: 11:28:22

PROJECT INFORMATION

Company: W.L. Gibbons & Associates Inc.

Client: Monarch Colony

Test Well: TW 22-01

Test Date: November 7, 2022

AQUIFER DATA

Saturated Thickness: 170. ft

WELL DATA

Pumping Wells

Observation Wells

Well Name	X (ft)	Y (ft)
TW 22-01	0	0

Well Name	X (ft)	Y (ft)
□ TW 22-01	0	0

SOLUTION

Aquifer Model: Unconfined

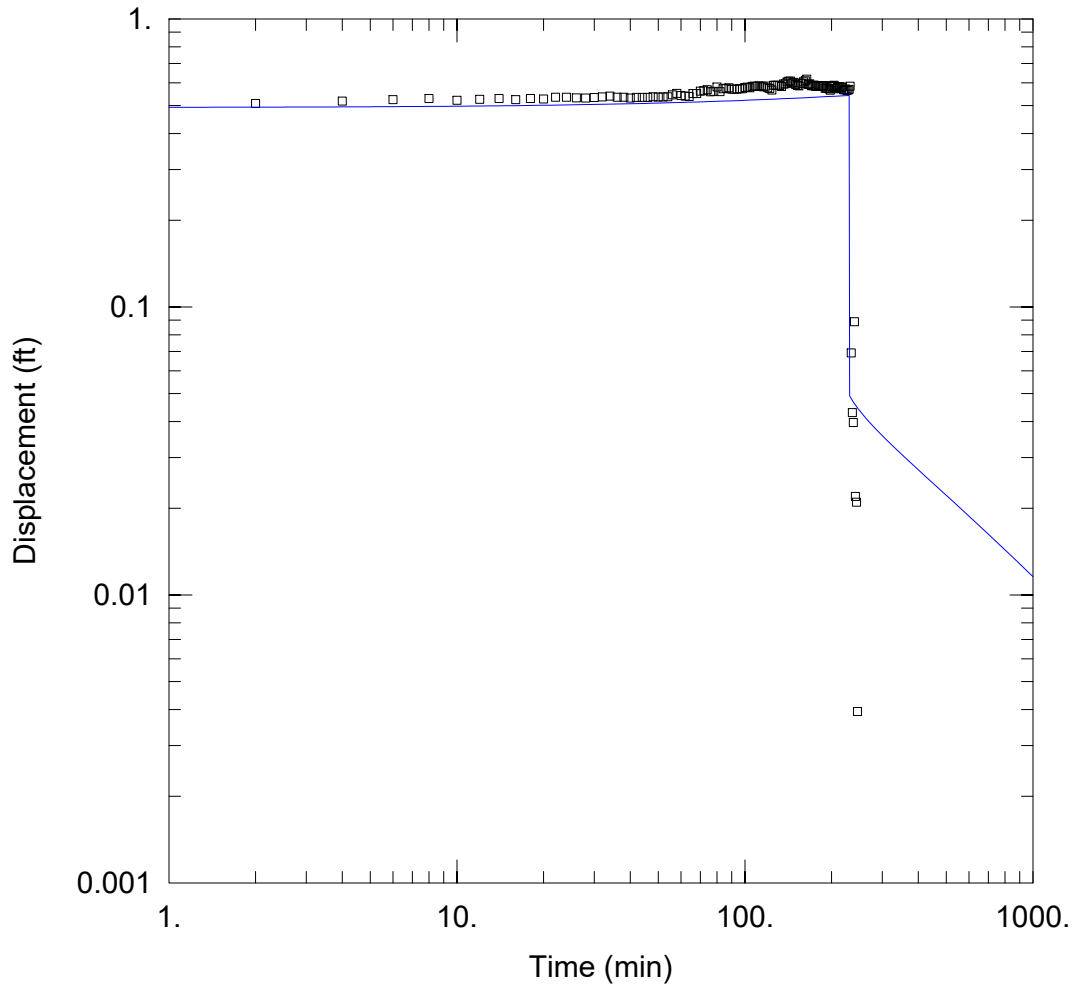
Solution Method: Neuman

T = 4.986E+4 gal/day/ft

S = 9.278E-209

Sy = 0.001

β = 2.225



WELL TEST ANALYSIS

Data Set: C:\...\\MW 22-01 AQTE Neuman.aqt  
 Date: 12/05/22

Time: 11:28:55

PROJECT INFORMATION

Company: W.L. Gibbons & Associates Inc.  
 Client: Monarch Colony  
 Test Well: TW 22-01  
 Test Date: November 7, 2022

AQUIFER DATA

Saturated Thickness: 170. ft

WELL DATA

Pumping Wells

Observation Wells

Well Name	X (ft)	Y (ft)
TW 22-01	0	0

Well Name	X (ft)	Y (ft)
□ MW 22-01	19	0

SOLUTION

Aquifer Model: Unconfined

Solution Method: Neuman

T = 3.92E+5 gal/day/ft  
 Sy = 0.001

S = 4.926E-212  
 $\beta$  = 1.0E-5

**Distance-Drawdown Calculation**

**Source Equation: Theis Nonequilibrium Well Equation**

Reference: Driscoll, 1986, pg. 218

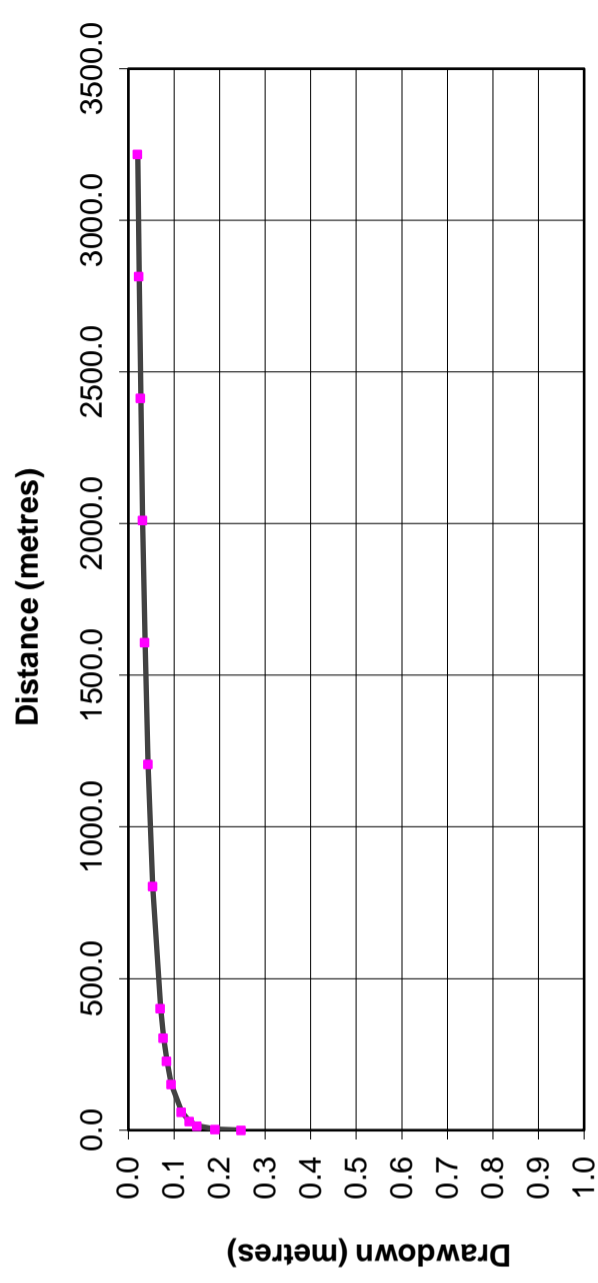
Assumptions as listed on pg. 218

Enter the following values in **red** squares: **NOTE UNITS**

Pumping Rate =	166 USgpm
Transmissivity =	470,000 USgpd/ft
Specific Yield/Storativity =	0.1 dimensionless
time =	365 days

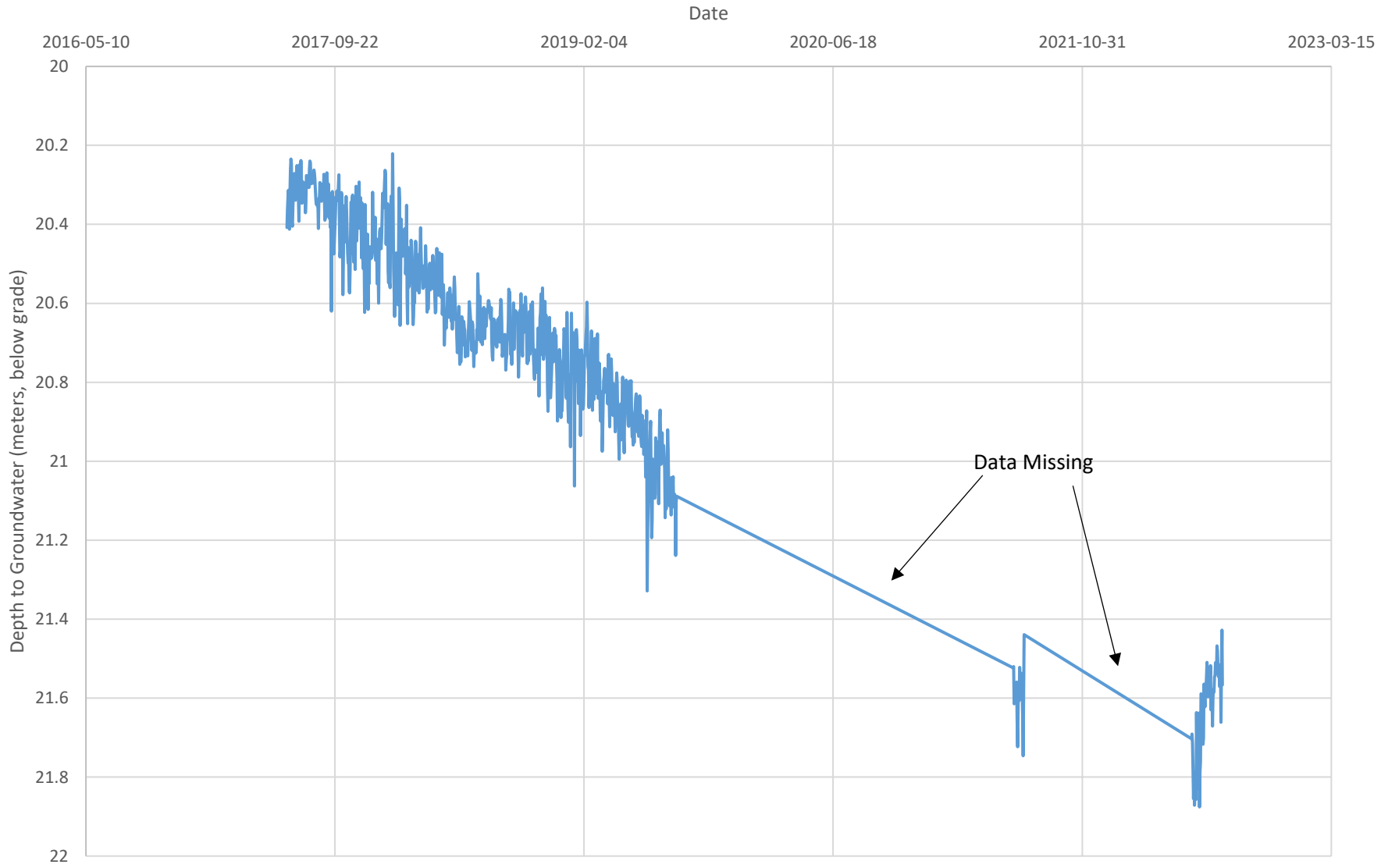
Distance (miles)	Distance (feet)	Distance (metres)	Drawdown (feet)	Drawdown (metres)
	1	0.3	0.81	0.2
	10	3.0	0.63	0.2
	50	15.2	0.50	0.2
	100	30.5	0.44	0.1
	200	61.0	0.38	0.1
	500	152.4	0.31	0.1
	750	228.6	0.28	0.1
	1000	304.8	0.25	0.1
0.25	1320	402.3	0.23	0.1
0.50	2640	804.7	0.18	0.1
0.75	3960	1207.0	0.14	0.0
1.00	5280	1609.3	0.12	0.0
1.25	6600	2011.7	0.10	0.0
1.50	7920	2414.0	0.09	0.0
1.75	9240	2816.4	0.08	0.0
2.00	10560	3218.7	0.07	0.0

**Predicted Drawdown Effects vs Distance**

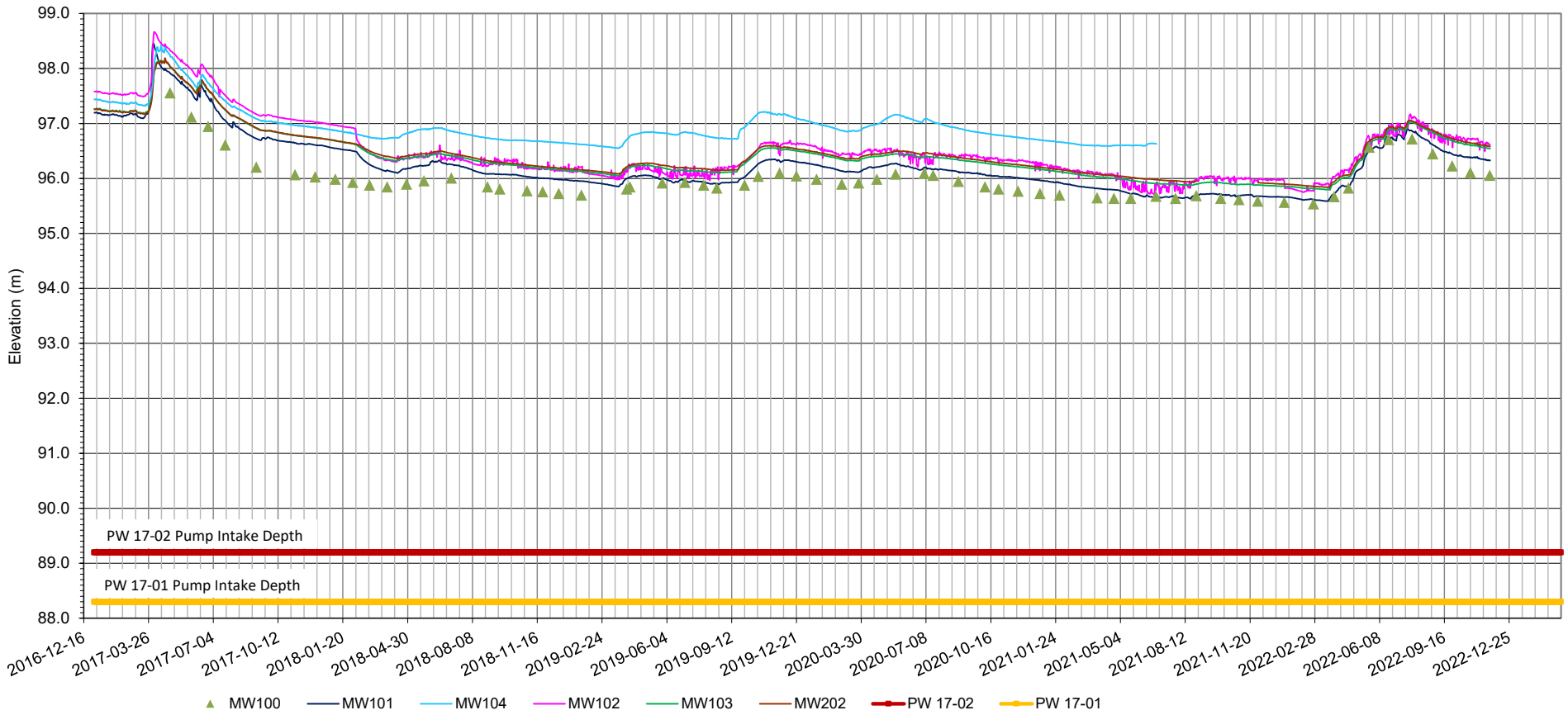


**Appendix E**  
**Groundwater Monitoring Data**

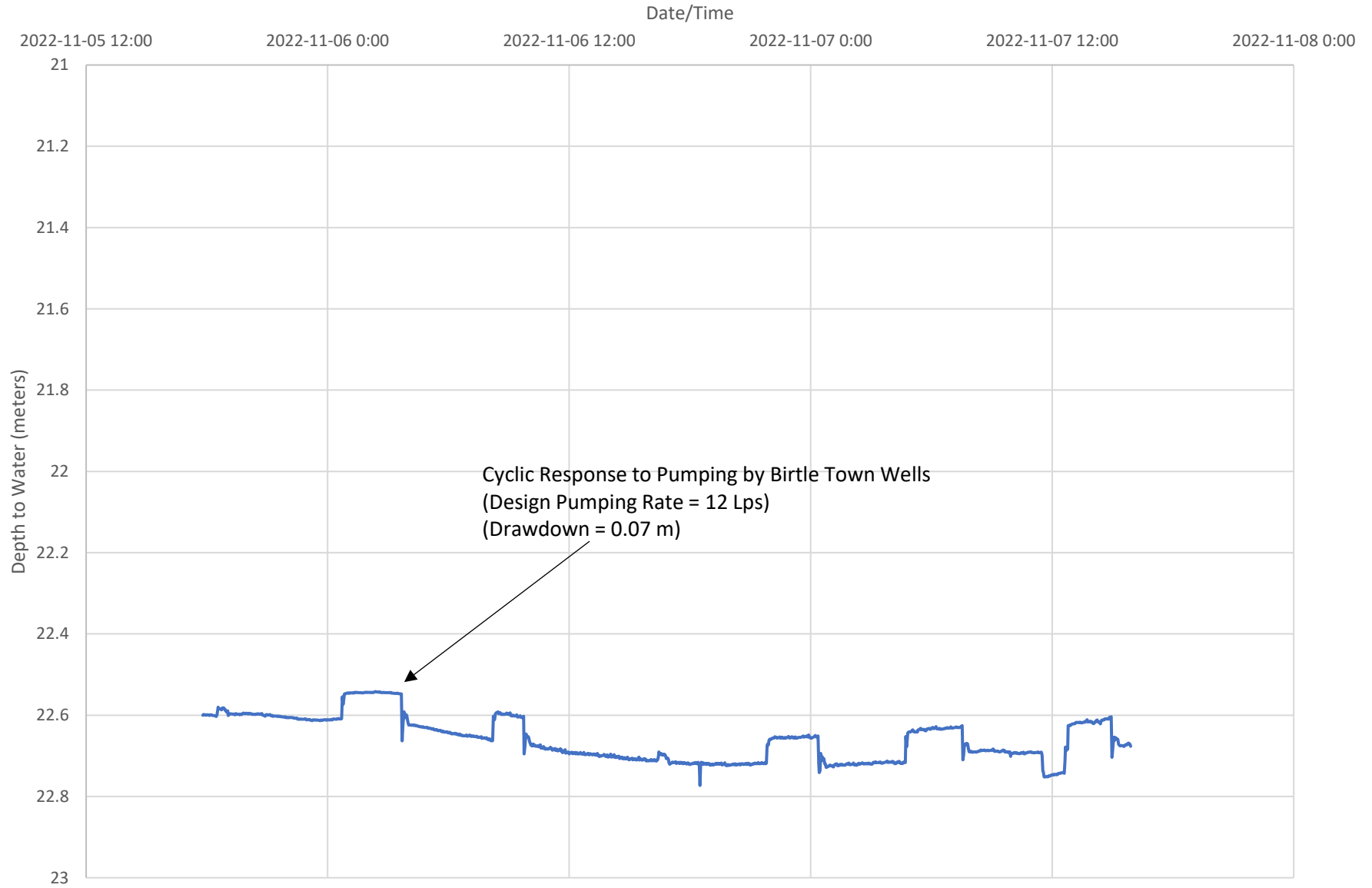
Birtle Town Wells/Loading Station  
Monitoring Well MW 17-01  
Period of Record



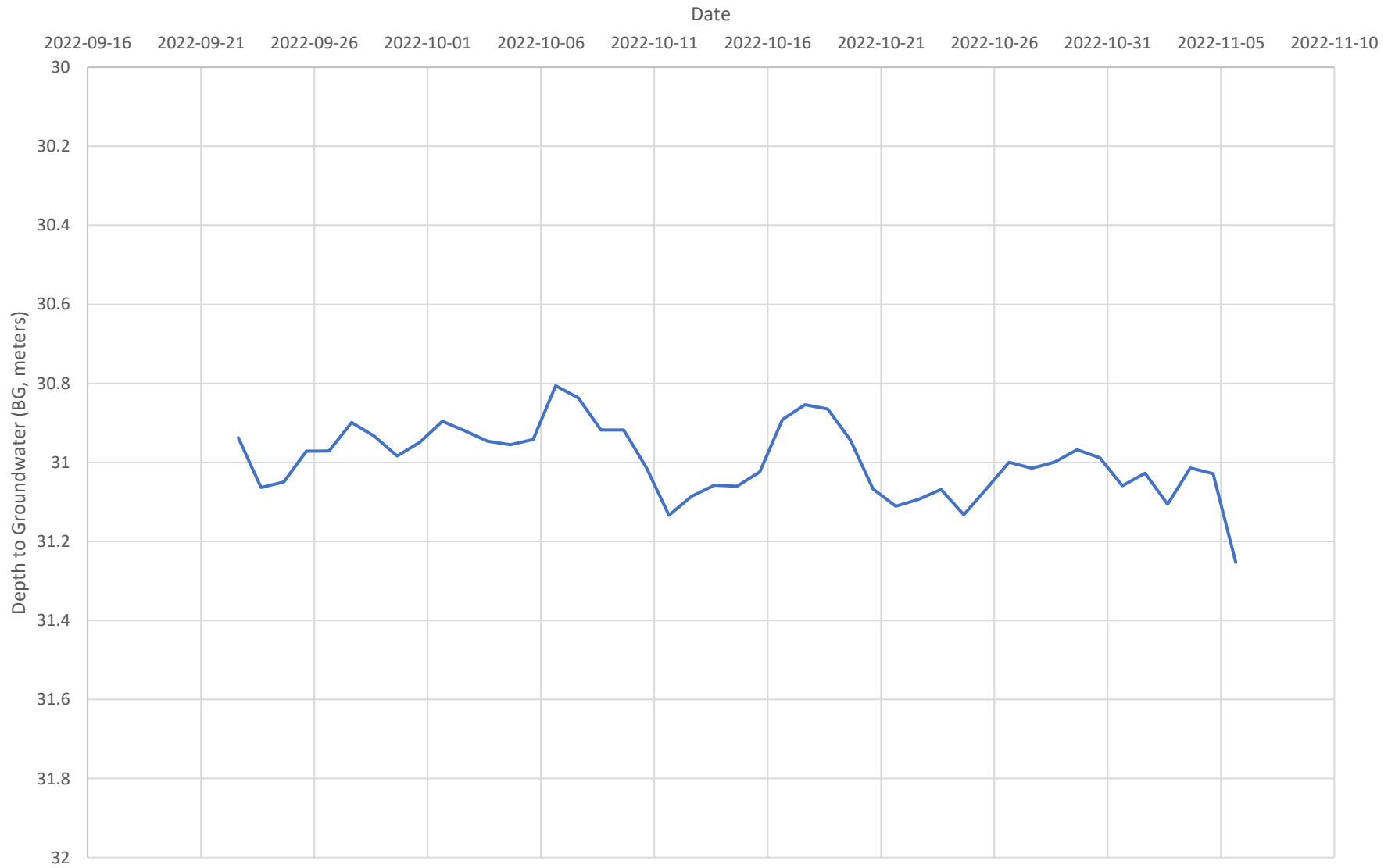
### Melita East Well Field (PW Ground Elevation ~ 99.3 m)



# Monarch Colony Monitoring Well MW 17-01 Record (Birtle Town Wells)



Monarch Colony  
Monitoring Well MW 22-01  
Period of Record



Monarch Colony  
Monitoring Well MW 22-02  
Period of Record

