Inland Bays Regional Wastewater Facility - Hydrogeologic Report

In Support of the Submerged Gravel Wetland Project as an Alternative Effluent Disposal System

Project 18208.002

Prepared for:

Sussex County, Delaware

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EXECUTIVE SUMMARY

The Inland Bays Submerged Gravel Wetland (SGW) is an innovative land application enhanced treatment and disposal option for domestic effluent. Although this project does not conform to the standard wastewater disposal paradigm, for ease of regulatory review, the "demonstration & research project" hereinafter the **Project** described in the following sections attempts to follow applicable existing regulations for wastewater disposal. The process described herein may provide more effective treatment of the discharge water in terms of nutrient uptake while using a smaller, more controlled footprint.

BACKGROUND AND SITE DESCRIPTION

On behalf of Sussex County, RK&K submitted a Construction Permit application on June 1, 2020, for a Submerged Gravel Wetland to the Groundwater Discharges Section (GDS) of the Delaware Department of Natural Resources and Environmental Control (DNREC) Division of Water. Upon review, the DNREC GDS provided a response as a Request for Additional Information (RAI), dated October 30, 2020. Phase I of the Project includes a newly constructed submerged gravel wetland consisting of four (4) cells on the North Burton spray field on the northeastern section of the Inland Bays Regional Wastewater Facility. Since the proposed source water for the Project includes wastewater effluent, the facility falls under the large on-site wastewater treatment and disposal systems (LOWTDS) regulations.

Sussex County currently operates and maintains the Inland Bays Regional Wastewater Facility (IBRWF) under State Permit No. LTS 5004-90-12. This facility provides treatment of domestic wastewater and uses spray irrigation to dispose of the treated effluent on 433 acres of irrigated agricultural land adjacent to the treatment plant. The treatment plant property and spray irrigation lands are owned by Sussex County.

IBRWF is located in Millsboro, Delaware, west of the intersection of John J. Williams Highway (Route 24) and Indian Mission Road (Route 23). IBRWF serves the Sussex County Uniform Sanitary District and has a design treatment capacity of 2.0 MGD. Effluent from the plant will be pumped to the SGW from a new pump station located directly downstream of the chlorine contact chamber utilizing the existing water transmission line for the North Burton Field center pivot. The new pump station will be designed to adequately convey the design flow to the SGW (for both phases of the Project) and for the delivery of effluent to Artesian's rapid infiltration basin (RIB) facility. The modified withdrawal point will improve the water quality deliveries and enhance the operation of both the SGW and RIB systems by reducing algae and delivering effluent with residual chlorine.

This report presents the assessments performed on site to evaluate the site for the proposed modification of the North Burton Field, originally permitted for spray application in 2009 to an SGW. The onsite assessment includes relevant supporting background information and data, with the objective of providing better understanding of site-specific geology, groundwater quality, groundwater transport, and anticipated operational conditions of the proposed facility.

Proposed Demonstration

The Project will be designed and constructed in coordination with DNREC under a 5-year "operational testing" program. A standard wastewater construction permit application will be submitted concurrently with this request for "operational testing".

Proposed wastewater system details

The Project consists of a 14.5-acre wetland area supplied by a combination of treated effluent and shallow groundwater. The system will be constructed in two phases with each of the two (2) phases consisting of

a single rectangular cell of 300 by 900 feet or about 6.24 acres. Refer to Appendix A for a plan and cross-sectional views of the SGW. Once the Project commences spray irrigation on the North Burton Field will cease and the center pivot equipment removed. Hence, the water balance calculations submitted in the DNREC permit renewal application did **not** include the North Burton field (WRA, 2021).

The objective of the Project is to test the nutrient removal performance of a SGW under staged hydraulic loading scenarios by measuring the total nitrogen (TN) and total phosphorus (TP) delta between the SGW influent and the monitoring wells in the infiltration gallery. The hydraulic loading will start at 0.6 MGD (0.5 MGD effluent – 0.1 MGD groundwater) representing the minimum required to support the plant water balance. Under the initial loading no mounding in the infiltration gallery is expected. The loading will be increased in five (5) 0.1 MGD increments to a maximum of 1.0 MGD during the last test year using groundwater from two proposed shallow well field downgradient of the SGW. Flows will be evaluated annually with operational status reports filed with DNREC by March 31 for the preceding calendar year. Monthly nutrient testing will be conducted and summarized in a final report after conclusion of the program. The nutrient data is intended to allow DNREC to issue a 5-year SGW Operating Permit after conclusion of the initial testing period.

Runoff from the SGW is only expected during storm events exceeding the Cv under DNREC's Sediment and Stormwater Regulations. Any water leaving the SGW during such an event will be discharged through a bioswale in accordance with the stormwater management plan approved by the Sussex Conservation District. This bioswale will capture, treat, and infiltrate stormwater runoff from the fallowed agricultural field. The bioswale terminates at a storm drain crossing Cannon Road, which outfalls to the upper reaches of Guinea Creek in the Herring Creek-Rehoboth Bay watershed (USGS/NHD Water FirstMap – online mapping tool).

The soils within the Project area are Hydrologic Soil Group A and A/D, indicative of high infiltration rates. A soils report prepared by Eastern Soil Science Services (ESSS) as a subconsultant to RK&K was completed which provided a high-resolution evaluation of the soils within the footprint of the SGW facility.

System type

The original SGW was designed according to EPA Handbook of Constructed Wetlands and EPA Constructed Wetlands Treatment of Municipal Wastewaters Manual, September 1999. It will consist of a bioretention soil media mix, underlain with a choker stone, with a larger aggregate below. The surface of the SGW, as currently proposed, will be planted with Phragmites *australis subs. americanus*, better known as the American Common Reed. This a native grass that can grow up to seven feet high in dense stands.

System dimensions

The Project consists of 14.5 acres of improvements which include regrading of the existing agricultural fields. Soils with restrictive characteristics removed during the excavation of the SGW basin will be used as to the greatest extent possible as liner or as fill material in accordance with the Sussex Conservation District approved site stormwater management plan. The cross-sectional profiles based on the soil borings is presented in Appendix A.

Design flow

Design flow is based on a maximum (1.0 MGD) pass through however, the Project will be tested and monitored on the 5-year staggered dosing schedule. If the proposed dosing schedule cannot maintain a hydrated wetland, annual increases may have to be accelerated.

Testing Water Source

Two (2) water sources will supply the SGW. The primary source will be treated effluent supplied by the IBRWF. Additional water will be supplied from two (2) temporary shallow wellfields located on the North Burton Field. Please refer to Water Quality Section for details of the effluent and ambient groundwater quality. Groundwater will be supplied from two temporary wellfields as described in Section titled Temporary Groundwater Dewatering Wellfields.

Dosing schedule or loading rates

The loading rate is anticipated to range between 0.6 and 1.0 MGD. These rates were developed based on groundwater evaluation conducted as a part of this evaluation. Please refer to Groundwater Mounding Analysis Section for model details. The dosing schedule for the Project will follow the schedule provided below.

Dosing Schedule					
Year(s)	Flow Rate (gpd)	Effluent Flow (gpd)	Groundwater Flow (gpd)	Precentage Effluent (%)	Precentage Groundwater (%)
1	**600,000**	500,000	100,000	83%	17%
2	**700,000**	500,000	200,000	71%	29%
3	**800,000**	500,000	300,000	63%	38%
4	**900,000**	500,000	400,000	56%	44%
5	**1,000,000**	500,000	500,000	50%	50%

Level and type of treatment

For treatment process details, refer to the Inland Bays Regional Wastewater Facility, Agricultural Distribution Treated Wastewater Permit Application dated February 24, 2021, as submitted by Whitman, Requardt and Associates (WRA) on behalf of Sussex County.

SITE DESCRIPTION

The site is located in Millsboro, Delaware, west of the intersection of John J. Williams Highway (Route 24) and Indian Mission Road (Route 23). The Tax Parcel: 234-22.00-11.00, 234-22.00-12.00 Millsboro, Sussex County. Please refer to Figure 1 for a map showing the Project location, and Figure 2 for specific project details. Figure 3 shows the pre-development hypsography.

The topography, soil, and hydrologic characteristics of the site have been described in detail in various submittals to DNREC, such as the November 27, 2006 Hydro-geologic Report for the Expansion of the Inland Bays Regional Wastewater Facilities; the October 18, 2005 Soil Investigations for the Inland Bays Regional Wastewater Facilities Expansion Tracts; and the February 24, 2021 Permit Application for the Distribution of Treated Wastewater for Agricultural Use, as submitted by WRA. This document will summarize the previous work and expand the site-specific soils understanding.

SITE LAYOUT

Based on the soil borings performed by ESSS X and Y profiles were prepared to show the top of the restrictive layer, referenced to land surface elevation, and are included in Appendix A. The site grading plan will be provided under a separate cover.

SOIL REPORT

Please refer to Appendix B for a report entitled "Detailed Soil Investigation Report for Large Flow Wastewater Disposal, Sussex County, Inland Bays WWTF TM# 2-34-22.00-10.00", prepared by Eastern Shore Soil Services and dated June 18, 2021.

HYDROGEOLOGIC REPORT

Area of Review

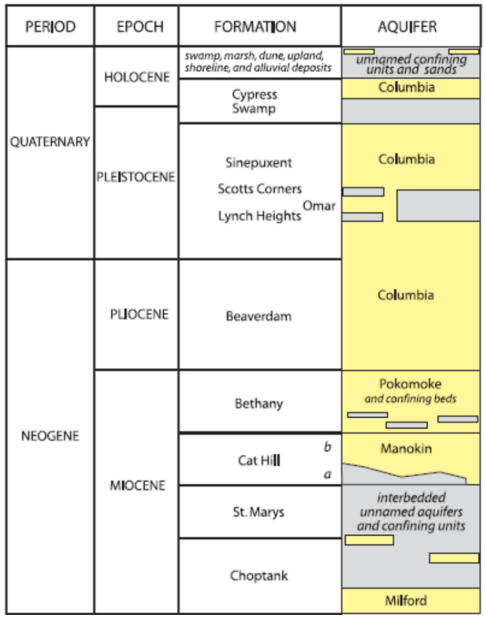
RK&K assembled data on wells located within 1,000 feet of the site. We obtained well data from the DNREC well database and from the report by WRA (2021). The existing groundwater allocation permits within 2,500 feet were previously provided (WRA, 2021). The available State Well Completion reports were previously submitted by WRA (2021) and the well locations are shown on Figure 4. Within this area of review there are 130 wells, of which 81 serve as irrigation wells and 11 are domestic supply wells. Table 1 summarizes the data we obtained in the well inventory for the wells within 1,000 feet of the SGW as identified by DNREC permit number. A large majority of the wells classified as "monitoring" are owned by Sussex County or the United States Geological Service (USGS).

Two residential communities north of the Project site account for a large majority of the wells within the area of review. The small diameter irrigation wells located at each residence are generally 50 to 70 feet deep and have estimated 10 to 20 gallon per minute flow capacities. The Domestic supply wells generally tap a ten (10) foot interval with top of screen depths ranging between 47 and 75 feet below land surface and completed with 2-inch or 4-inch diameter PVC pipe.

Geology and Hydrogeology

Geologic Profile

The geology of southeastern Delaware is a complex system of unconsolidated sediments that have been worked and reworked through various glacial minimums and maximums. The unconsolidated sediments that form the lithologic profile are predominantly sands, clays, and silts from land surface to the deep Paleozoic/Precambrian basement. The unconsolidated sediments lie in wedge-shaped layers upon the sloping basement. Generally, the thickness of the unconsolidated layers increases southeastward from the fall line in the direction of regional dip as is common along the coastal plains of the mid-Atlantic and the southeast.



Generalized Stratigraphic Column for Study Area (Source Andres and Klingbeil, 2006)

The geologic profile provides the framework for the hydrostratigraphic column which bounds various water-bearing sequences by layers of poor to low vertical permeabilities. The focus of this report will be the shallow Pliocene, Pleistocene and Holocene sediments which are referred to in ascending order as the Beverdam, Lynch Heights and Scotts Corners Formations (Report of Investigation No.79, He and Andres, 2015). The underlying Miocene age Bethany Formation is generally described as very similar to the Beverdam, except that there is a shallower gamma log signature (Report of

Investigations No.70, Andres and Klingbeil, 2006). A series of cross-sections were prepared based on local drillers logs to show the local heterogeneity of the surficial aquifer. Please refer to Figures 5 and 6, respectively, for the west-to-east and north-to-south cross-sections previously prepared for the site by WRA. Refer to Figure 7 for a map showing the location of the SGW footprint on Delaware Geological Survey (DGS) Map No. 16 (Fairmont Rehoboth Beach Quadrangles) Dataset.

Soil Borings – Transect 1

A series of soil borings were conducted on a 25-foot spacing by Hillis-Carnes Engineering Associates (HCA) along the northern transect of the SGW. These borings were completed to between 20 and 25 feet below land surface (bls). The soil borings were advanced to evaluate the thickness and elevation of the restrictive sediments. Deeper advancement of the borings was prevented due to collapsing sands. Refer to Figure 8 for a map showing the location of the soil borings on Transect 1. A cross-section (Refer to Figure 9) was prepared to graphically evaluate subsurface conditions. Generally, the restrictive sediments deepened and thinned from west to east from Boring 1 to Boring 13. Between Boring 13 and Boring 17, the restrictive sediments thin further and are generally non-existent between Boring 15 and Boring 17. The transect has two unique hydrogeological flow conditions; a semi-confined and unconfined. A copy of the HCA report including boring logs is provided in Appendix C. A detailed Summary Letter detailing the results of Subsurface Investigation is provided in Appendix D. The Summary Letter also details the modifications to the Basin Testing plans based on the results of the investigation.

Soil Chemistry

ESSS completed six (6) composite samples for nutrient and metal composition analyses of the restrictive sediments. The results of this testing are provided in Appendix B. Composite samples 1A and 1B were taken from multiple points at depths of 0 and 12 inches and 12 and 24 inches in the OxPA unit, respectively. Composite samples 2A and 2B were taken from multiple points at 0 and 12 inches and 12 and 24 inches in the LHB unit. Composite samples 3A and 3B were taken from multiple points at 0 and 12 inches and 12 and 24 inches in the LHA unit. Please refer to section Soil Testing for additional details.

HCA completed three (3) composite samples for nutrient and metal composition analyses of the restrictive sediments. The result of this testing event is provided in Appendix C. Composite sample S-1 was recovered from B1 between 60 and 84 inches and B2 from between 60 and 120 inches. Composite sample S-2 was recovered from B7 between 60 and 120 inches, B8 from between 60 and 120 inches and B10 between 84 and 120 inches. Composite sample S-3 was recovered from B12 between 132 and 144 inches, B15 from between 144 and 156 inches and B16 between 144 and 156 inches. Please refer to section Soil Testing for additional details.

Hydrogeologic Profile

The Coastal Plain of Delaware consists of several water bearing aquifers from the surficial Columbia Aquifer to the Waste Gate Aquifer, the deepest water bearing zone. The second aquifer underlying the site is the Pocomoke Aquifer, which is associated to the Bethany Fm. The Bethany Fm. is characterized as (Report of Investigations No.70, 2006) having limited areal confinement and generally homogenous to the Beverdam Formation. The unconfined Columbia Aquifer receives recharge from precipitation recharge from IBWRF, transmits water to the deeper aquifers, and maintains baseflow.

Data for the Columbia Aquifer were gathered from various publications and maps published by the Delaware Geological Survey, well completion report and site testing. Andres (1987) shows the base of the unconfined aquifer at the IBRWF is 75 to 100 feet below sea level. Assuming that the base of the

unconfined aquifer is at 90 feet below sea level and based on a representative water table elevation of 20 feet above sea level, the estimated saturated thickness of the unconfined aquifer at the IBRWF is 110 feet. Since the purpose of this research is to study the impacts of wastewater reuse on the shallow aquifers, only the aquifers that overlie the site to a depth of about 100 feet are considered. The unconfined, surficial Columbia aquifer system is the only aquifer that meets this condition.

The restrictive soils observed during the advancement of the soil borings will act as a semi-confining/leaky confining unit which will perch water above the Columbia Aquifer during heavy precipitation events due to the lower vertical hydraulic conductivity. It is expected that nearly all areas will exhibit transient perched groundwater immediately after heavy periods of precipitation due to the presence of shallow restrictive soils. However, during dry periods, when recharge is lower than infiltration, this perched water will infiltrate to and interact with the Columbia Aquifer. Groundwater levels within the Columbia Aquifer follow a seasonal pattern dependent on precipitation. Continuing spray irrigation to the immediate west of the study area is likely to influence the piezometric surface on the North Burton Field.

The June 2018 SIR report (Appendix B) indicates that the restrictive soils are expected to exhibit infiltration rates of less than 0.2 inches per hour based on observations in the soil borings and test pits. However, the soil materials above the restrictive layer range from 4 - 20+ inches per hour vertical hydraulic conductivity. The November 2006 Hydrogeologic Report prepared by WRA included hydraulic conductivity testing conducted by Geo-Science Consultants. Figure 18 of that report indicates that the most restrictive soils in the area have a vertical hydraulic conductivity of 0.3 inches per hour in the Rockawalking and Pepperbox soils. Infiltration rates ranged from 0.3 to 27.9 inches per hour in the aforementioned report. Given the leaky confining properties of the restrictive layer, it is expected that loading of the SGW will result in higher horizontal groundwater flow and a broad shaped mound. The proposed Infiltration Gallery (IG) will be constructed to fully penetrate the restrictive soils and replace the insitu soils (Appendix A) with a direct connection to allow recharge to the Columbia Aquifer.

Piezometric Surface

Water levels of the unconsolidated, unconfined sediments of the Project are dependent on precipitation and loading of the spray fields. Precipitation records between January 2011 and December 2020 are presented in Table 2. During the period of record, a minimum of 44.05 (2011) and a maximum of 61.38 (2018) inches of precipitation has fallen at the site. A Hydrograph for Monitor Well 16 (MW-16) and Observation Well 17 (OW-17) is provided as Figure 10. These two facilities were selected based on their downgradient locations relative to the SGW.

Piezometric surfaces of the site were interpreted using geographic information system (GIS) system which allowed for the preparation of monthly snapshots of water level changes over the site. The water level elevations associated with individual well data points were analyzed with the IDW (Inverse distance weighting) process (geoprocessing tool via ArcGIS). The IDW with a power of 1 (the power controls the significance of surrounding points on interpolated values, a lower value reduces the significance). For each date, a raster was generated that simulated the Water Elevation (FAMSL). Contours were then derived from the raster at a 0.5-foot interval. These contours simulate the potentiometric surface at each of the five observation dates.

Twenty-nine wells in proximity to the site were utilized for the development of the piezometric surface. Refer to Table 3 for groundwater monitoring facility information. Data for the last 5 years was reviewed and graphed in time series to identify periods of high and low seasonal water levels. Refer to Table 4 for the groundwater level data. The high and low water levels were derived from MW-16 and OW-17 (DNREC Permit #s 228543 and 228544) time-series data since these facilities are local to the proposed SGW. The

March and April 2021 data reflect water levels on the North Burton Field without spray application being administered.

The five (5) key dates were identified as high and low observation points (at OW-17 and MW-16) for the piezometric surface:

- September 14, 2015
- November 30, 2018
- January 21, 2020
- March 25, 2021
- April 06, 2021

The site water level elevation data indicates that the general gradient is to the east with a slight northerly component towards the outfall structure at Cannon Road which controled by the local geology.

Water Quality

Water quality testing of both the effluent (discharge water) and groundwater are presented in the following sections. The data sets for the key indicator parameters of Nitrogen and Phosphorus:

- Effluent data extends from June 2006 to July 2020
- Monitor Well 12 data extend from March 2006 to June 2019
- Monitor Well 16 data extend from September 2009 to June 2019

Effluent Water Quality

Improvements to the treatment process are planned and ongoing at the IBWWTP with the goal of continued improvement of the wastewater system; these plans and goals are detailed in Phase 2 IBRWF Upgrade and Expansion Project permit application documents (previously submitted in Feb. 2021). A summary of the average effluent wastewater quality for 2017, 2018 and 2019 was presented as Table 6.2 of the WRA report. From Table 6.2 the average effluent wastewater concentrations:

- Biochemical Oxygen Demand, 5-Day 8.1 milligrams per liter (mg/l)
- Total Suspended Solids 11.9 mg/l
- Total Nitrogen 5.6 mg/l
- Total Phosphorus 5.4 mg/l
- Chlorides 160 mg/l

Effluent water quality has generally improved during the period of record. As the 12-month moving average effluent discharge increased from about 0.8 MGD to about 1.5 MGD the nutrient levels observed in the monitoring wells improved. The data indicate that concentrations of the major nutrients, including Nitrogen, have declined consistently since 2012. Phosphorus levels have generally stayed range bound between 2.3 and 8.4 mg/l over the same period of record.

The historical data was plotted from January 2010 through July 2020. The data indicate a distinct trend of nitrogen concentrations. Please refer to Figures 11 and 12 for time-series, water quality graphs showing Nitrogen and Phosphorus levels. Between 2010 and 2102, Nitrogen concentrations ranged between approximately 24 and 60 mg/l. Starting in mid-2012, and early 2013, Nitrogen concentrations in the effluent show a marked improvement and have been consistently bound in a range below 10 mg/l since November 2012. Phosphorous concentrations have averaged 5.0 mg/l, with a maximum concentration of 8.4 mg/l over the period of record.

Ambient Groundwater Quality

Groundwater quality data for monitor wells MW-12 and MW-16 were reviewed and plotted against the effluent water quality for a period between January 2010 and July 2020. These two monitor wells were selected as they represent areas just outside and downgradient of the spray field. The data show Nitrogen levels range from 3.5 mg/l to 75.6 mg/l over the period of record. It is likely that this elevated reading is the result of either laboratory or sampling methodology related or a transcription error during data entry. To support the potential "error" it is important to note that the nitrogen sample (recorded on March 3, 2015, at MW-16 (75.6 mg/l)) was bracketed it time by sample results at half the concentration. Although nitrogen is very mobile in groundwater it is unlikely that concentrations would deviate with this magnitude month over month. Phosphorus levels ranged between 0.37 mg/l and non-detect. Previous sampling at off-site locations conducted in 2013 showed nitrogen concentration in domestic wells between 4.4 mg/l and 113 mg/l (Weston Solution, 2013).

Please refer to Table 5 for Nitrogen and Phosphorus data between March 2018 and 2021 for the twenty-nine (29) monitor wells. Please refer to Figures 13 and 14 which show the average nitrogen concentrations for the north and south sections of the spray fields. The averages were used as individual sampling date data was highly variable and not as instructive. Since March 2018 through March 2021, the number of monthly exceedances (Nitrogen Concentration above 10 mg/l) ranged from 3 to 10 per month. The recent trend is for fewer monthly exceedances. During the period of record, MW-12 had four (4) exceedances which has been followed by nine (9) straight quarters of no exceedance. Well MW-16 also had four (4) exceedances, but these are more randomly spaced.

During the basin testing (described below), water quality testing was conducted for evaluation of both metals, and nutrients (W-1) metals, in accordance with 7 Del.C. 7101 6.2.3.5.2. Samples were taken from the restrictive unit and Columbia Aquifer before, during and after testing. The result of the testing is provided in Table 6.

Temporary Groundwater Dewatering Wellfields

Two temporary groundwater dewatering wellfields will be installed to support the groundwater component of the SGW water supply. Please refer to Figure 13 for a graphical representation of the proposed alignments. These alignments were selected, in part, due to:

- the observance of higher levels of nitrogen in the ambient groundwater,
- the location of existing groundwater monitor wells, and
- connectivity to the SGW facility

As proposed, Phase 1 of the Project will include 10 dewatering wells in each wellfield based on an estimated capacity of 10 gpm per well (100 gpm per wellfield). The actual number of wells installed in each alignment will be determined in the field during construction to ensure a proper balance between supply and demand requirements. It is anticipated that additional wells may be required in Year 4 of the testing program.

The proposed groundwater dewatering system will include shallow 1.5 to 2-inch diameter wellpoints installed in a linear alignment with wells installed every 20-feet. These wells will be permitted and constructed in accordance with Section 7301 of the Delaware Administrative Code. The proposed shallow construction would include approximately 15-feet of casing attached to 5 feet of screen. Wells in each alignment will be manifolded in series into a single transmission line that will be discharged to the SGW intake header. A trailer mounted vacuum suction pump will be utilized to periodically rotate the groundwater withdrawals between the two wellfields.

Basin Testing – General Information

Two (2) basin tests were conducted to evaluate the infiltration capacity of the Columbia Aquifer and the unconfined and semi-confined sediments that overlie the Columbia Aquifer. Basin testing was conducted along the northern most transect. Please refer to Figure 8 for a map showing the locations of the basin tests. The monitoring well layouts for the basin tests are provided in Figure 15. In preparation for the testing events, a water tank was placed within approximately 50 yards of each cell that could be refilled with treated, irrigation-quality effluent on-demand or at automatic intervals. Water was conveyed through polyvinyl chloride (PVC) pipes connecting the water tank to three pipes: one to each cell and one that discharged about 50 yards north for excess disposal. The PVC pipes were outfitted with butterfly valves that could regulate the flow of water between the cells and with 8-inch diameter Mag-meters that could measure the discharge flowing to each cell. The initial flowmeters were not sensitive enough, so the devices were replaced with 2-inch diameter Mag-meters. Since water delivery was gravity-fed from the onsite tank, water flow to the cells fluctuated within a small, head-dependent range during the testing. As the tank discharged, lower head conditions resulted in lower flow. Refilling the tank was based on a 30-minute timer system which delivered 1,000 gallons to the tank in each pulse. The timing was fine-tuned during the first day of testing and then was allowed to run overnight without issue.

The testing of the two basins was conducted simultaneously which provided a conservative approach to the assessment of mounding at the two basins. Basin testing was conducted over three distinct operational and monitoring phases: 1) Background, 2) Discharge and 3) Recovery. During the three phases of the testing, pressure transducers were set to record data at a scan/logging frequency of one (1) minute. It is relevant to note that wells OW-17 and MW-12 were fitted with Hobo Onset pressure transducers collecting water level data every 30 minutes in order to observe "Far field" piezometric surface conditions.

Background data collection at the basins commenced on November 15th, 2021. Earlier data collected at a 30-minute frequency between November 10th and the 15th is available but is not reported or presented as various pre-test and equipment challenges resulted in a delay in commencement of testing. Water-level data recorders were placed into service at various times over a 1-hour period of deployment. Active discharge of stored water to the two basins commenced at 9:05 AM on November 17th. At the start of the testing event and at the beginning and end of each day, manual water level measurements were taken at each well. During the duration of the testing event, the discharge from the flowmeter to Cell 1, the discharge from the flowmeter to Cell 2, and a water level measurement from W-4 were recorded, repeating every 15-minutes. The discharge phase lasted 54-hours, or 3,240 minutes. The recovery phase was initiated at 3:05 PM November 19th and was terminated on November 22nd. During recovery, on November 19th a precipitation event of 0.09 inches of rain was recorded. Pressure transducer data recording was terminated and downloaded at various times on November 22nd. Refer to Figures 16 through 20 for graphical presentations of the background data. Figures 16 and 17 show background water level conditions at each of the cells. Monitoring of the existing wells (OW-17 and MW-12 – "Far field wells") extended throughout the entire testing event (Figure 18). Figure 19 shows the water levels of the Far field wells during the testing event. The Far field wells show a general decline in water levels throughout the testing period of about 0.3 inches over the 12-day monitoring period. Figure 19 shows the water levels at the Far field wells, indicating that no measurable response occurred due to the basin testing event.

During the basin testing, various water quality testing events were conducted to evaluate attenuation of nutrients in the aquifer over time. These testing events and data are presented in the following "Groundwater Quality Testing" section.

Discussion

Basin Cell No. 1 – Specific Information

Basin Cell No. 1 was a 10 ft x 10 ft x 12 ft (lwd) cell filled with septic sand (see Figure 16) and surrounded by a gravel berm, which was itself ringed by a geotextile fence to prevent significant water loss from overflow. See Figure 16 for a well layout diagram and Northing/Easting locations.

Before testing began, the cumulative discharge volume during background/pre-testing was recorded at 591 gallons and the water level at W-4 was recorded at 8.97 feet below measuring point (bmp). The testing event commenced at 9:05 AM on November 17th. The target discharge rate was 25 gallons per minute (gpm). During the morning, discharge was observed at approximately 25 gpm. To maintain desired flow rates, the butterfly valves were opened, and Inland Bays representatives reduced the water tank refill interval. This resulted in an increased discharge around 27.5 gpm. However, at 1:30 PM, overflow at Cell 1 was observed, so the valve heading towards Cell 1 was closed slightly. This resulted in a shift from 27.5 gpm to 20 gpm. In conjunction with changes to Cell 2 and a re-increase in the water tank refill interval to 30 minutes, a satisfactory equilibrium was observed between the discharge of 20 gpm, the tank water level, and the infiltration rate in Cell 1 as the day approached its end. At 5:15 PM, the cumulative volume was recorded at 11,895 gallons and the water level at W-4 was recorded at 8.51 ft bmp. From 9:05 AM to 5:15 PM, the average flow rate for the first day of testing was 23.1 gpm (11,304 gallons / 490 minutes). The testing event then continued through the night.

On the morning of November 18th (day two of the testing event), recording started at 8:45 AM. The cumulative volume was recorded at 30,581 gallons, the discharge rate was recorded at 21 gpm, and the water level at W-4 was recorded at 5.60 ft bmp. However, Cell 1 overflowed overnight, and the valves were temporarily shut to allow for the ponded water to infiltrate into the cell. After some infiltration, the valve was reopened, but at a reduced flow rate to match the loading of the cell more closely to the cell's infiltration capacity. After reduction, the discharge was recorded at approximately 14 gpm. The discharge rate of 14 gpm was maintained through the rest of the day. Water quality samples were taken from W-1 at 12:00 PM; from W-2 at 12:20 PM; and from the effluent discharge point at 1:20 PM. The times for W-1 and W-2 correspond with the recorded water elevation decrease in those wells. The presence of algal buildup was observed in the cell on the second day of testing. At the end of the day, the cumulative discharge was recorded at 36,989 gallons and the water level at W-4 was recorded at 8.64 ft bmp. Between 8:45 AM and 4:30 PM, the average flow rate for the second day of testing was 13.8 gpm (6,408 gallons / 465 minutes). The testing event continued through the night.

On the morning of November 19th (day three and the final day of the testing event), the testing event was visually monitored until test termination. Similar to the previous day, overflow was observed in Cell 1, but was more pronounced. However, no change in the discharge rate was implemented. Algal buildup was observed in the cell and was more prominent than was observed on day two. As conditions for the test had been sufficiently met, the test was terminated at 3:05 PM on November 19th. Upon termination, the cumulative volume was recorded at 54,843 gallons. From 4:30 PM on November 18th to 3:05 PM on November 19th, the average flow rate was 13.2 gpm (17,854 gallons / 1,355 minutes).

For Cell 1, the cumulative volume discharged for the duration of the background and pre-testing events was 591 gallons and the cumulative volume discharged for the duration of the testing period was 54,252 gallons – for a total of 54,843 gallons over the periods of record. While the initial target flow rate was 25 gpm, the average flow rate for the testing period was about 16.7 gallons per minute (54,252 gallons / 3240 minutes). The observed algal buildup is likely to have caused some loss of infiltration capacity on day two and day three of the testing event. Over the course of the testing period, the filter media was raked,

creating furrows into dry media and leveling off uneven sections, to enhance infiltration across all parts of the cell. Additionally, the thick unit of restrictive soils reduced the flow through the side walls of the cell, limiting infiltration capacity to just head-dependent flow into the Columbia Aquifer. Overflow conditions were observed on day two and day three and operations were modified to reduce the reoccurrence of overflow situations and limiting the impact to the testing period dataset. Raw data (Appendix E) will be provided upon request due to the large data set and electronic format.

Basin Cell No. 2 – Specific Information

Basin Cell No. 2 was a 10ft x 10 ft x 7 ft (lwd) cell filled with concrete sand (see Figure 16) and surrounded by a gravel berm, which was itself ringed by a geotextile fence to prevent significant water loss from overflowing. Basin Cell No. 2 was constructed at a slightly higher elevation than Cell No. 1. See Figure 15 for a well layout diagram and Northing/Easting locations.

Before testing began, the cumulative discharge volume during background/pre-testing was recorded at 342.5 gallons. The testing event commenced at 9:05 AM on November 17th. The target discharge rate was estimated to be 25 gpm. During the morning, discharge was observed at approximately 22 gpm. To maintain desired flow rates, the butterfly valves were opened, and Inland Bays representatives reduced the water tank refill interval. This resulted in a discharge rate increase to approximately 23 gpm. Since Cell 2 was constructed at a higher elevation than Cell 1, water preferentially flowed towards Cell 1. To maintain desired flow rates, the valve leading to Cell 2 was opened. For reference, no overflow was observed in Cell 2 at 1:30 PM when Cell 1's valve was closed slightly. These factors resulted in a shift from approximately 23 gpm to 26 gpm. The first stages of overflow were observed in Cell 2 after a couple hours, so the valve leading to Cell 2 was then closed slightly. A satisfactory equilibrium was observed in Cell 2 as the day approached its end. At 5:30 PM, the cumulative volume was recorded at 11,303 gallons. From 9:05 AM to 5:15 PM, the average flow rate for the first day of testing was 22.4 gpm (10,960.5 gallons / 490 minutes). The testing event would continue to run through the night.

On the morning of November 18th (day two of the testing event), recording started at 8:45 AM. The cumulative volume was recorded at 31,545 gallons and the discharge rate was recorded at 23 gpm. Similar to Cell 1, Cell 2 also overflowed overnight, but to a lesser extent. The valves were temporarily shut to allow for the ponded water to infiltrate into the cell. After some infiltration, the valve was reopened, but at a reduced flow rate to match the loading of the cell more closely to the cell's infiltration capacity. After reduction, the discharge rate was recorded at approximately 18 gpm, which would be maintained through the rest of the day. Water quality samples were taken from P-4 at 12:40 PM and from P-5 at 1:00 PM. The time for P-4 corresponds with a recorded water elevation decrease in those wells; P-5 was unaffected during this time. The presence of algal buildup was observed in the cell on the second day of testing. At the end of the day, the cumulative discharge was recorded at 39,943 gallons. Between 8:45 AM and 4:30 PM, the average flow rate for the second day of testing was 18.1 gpm (8,398 gallons / 465 minutes). The testing event continued through the night.

On the morning of November 19th (day three and the final day of the testing event), the testing event was visually monitored until test termination. Similar to the previous day, overflow was observed in Cell 2, but was minimal. No change to the discharge rate was made on November 18th. Algal buildup was observed in the cell on day three of testing and was more prominent than observed on day two. As conditions for the test had been sufficiently met, the test was terminated at 3:05 PM on November 19th. Upon termination, the cumulative volume was recorded at 63,798 gallons. From 4:30 PM on November 18th to 3:05 PM on November 18th, the average flow rate was 17.6 gpm (23,855 gallons / 1,355 minutes).

For Cell 2, the cumulative volume discharged for the duration of the background and pre-testing events was 342.5 gallons and the cumulative volume discharged for the duration of the testing period was 63,798 gallons – for a total of 64,140.5 gallons over the periods of record. While the initial target flow rate was 25 gpm, the average flow rate for the testing period was about 19.7 gallons per minute (63,798 gallons / 3240 minutes). Over the course of the testing periods, the filter media was raked, creating furrows into dry media and leveling off uneven sections, to enhance infiltration across all parts of the cell. The observed algal buildup is likely to have caused some loss of infiltration capacity on day two and day three of the testing event. Additionally, the thick unit of restrictive soils reduced the flow through the side walls of the cell limiting infiltration capacity to just head-dependent flow into the Columbia Aquifer. Limited overflow conditions were observed starting on day two and day three and operations were modified to reduce the reoccurrence of overflow situations and limiting the impact to the testing period dataset. Raw data (Appendix F) will be provided upon request due to the large data set and electronic format.

Groundwater Quality Testing

Groundwater quality samples were recovered from various wells in all three phases of testing. Additionally, a water sample of the effluent was recovered and sent for analysis. All water quality analysis was conducted by "Water Quality Testing Labs of Maryland" located in Salisbury, Maryland. The laboratory analysis data reports are provided in Appendix G.

Columbia Aquifer groundwater quality sampling was conducted at the following locations at various phases of the testing event. Well W-1 was sampled during the background, discharge, and recovery phases. Wells W-2, P-3 and P-4 were sampled during the discharge phase. During sampling field water quality analysis was conducted, these data are presented in Table 6 along with the analytical results. The background sample from W-1 was collected using a bailer. All other sampling was conducted using a low-flow peristaltic GeoPump™. Field water quality was analyzed using a YSI multiprobe with a flow-through cell. During the sampling at P-4, the well was completely dewatered during the initial purging and had to recover. Produced groundwater from P-4 was very turbid which may have contributed to the extremely high total suspended solids analytical results. Piezometers P-4 and P-5 may have not been fully developed at the time of installation due to low water levels.

The analytical results showed significant attenuation of coliform concentrations in the basin. Using the effluent total coliform of ~1,414 MPN as the baseline. A sampling in Cell 1 (at PT-3 = ~260) shows about an 80% decrease. During the testing event, total coliform concentrations improved over background (18.9 MPN) at site W-1 (1 MNP) and W-2 (Non-detect). Several analytes showed increasing concentrations above background that could not be directly associated with the effluent, such as arsenic, chloride, hardness, sodium, TDS, and sulfate. Three parameters of interest are arsenic, chloride and sodium.

Arsenic concentrations were observed in all the testing and recovery samples; however, were absent in the background analysis. The observed range was between 1.1 (effluent) and 3.9 (W-2 recovery sample) parts per billion (ppb) and the increased concentrations (above the effluent) could be attributed to increased dissolved oxygen in the aquifer and resultant leaching/mobilization. It is also possible that effluent concentrations varied over the testing event and the water quality sampling program did not fully account for the changes in the wastewater treatment process.

Chloride concentrations also increased over background concentrations and above the effluent results, and one sample was recorded at 349 mg/l (above the MCL). Like chloride, sodium concentrations increased during the testing event, and after recovery concentrations remained elevated. A firmer understanding of chloride concentrations at the site should be a part of the future development which

may include semiannual chloride sampling of the existing monitor wells. Unlike chloride, sodium levels remained consistent with the effluent sample results.

Hydraulic Analysis

Ground water hydraulic data was assessed using AQTESOLV (hydrogeological analysis software) and standard MS™ Excel software to perform both a distance drawdown and composite plots for each cell. Numerous testing events have been completed on the North Burton Field since 2005. The work completed by WRA included testing at various locations and depths. These data are presented in Table 7 with the new data produced during the Basin testing event is as summarized below.

Methodology

Logging data was obtained from the pressure transducers (PT). Seametrics PTs were placed in Cell 1, while Hobo Onset PTs were placed in Cell 2 and the two "Far-field" wells, OW-12 and MW-17. The Hobo Onset PTs recorded pressure inclusive of atmospheric pressure, so the atmospheric pressure needed to be removed from these datasets to calculate the hydraulic pressure of Cell 2 wells. Seametrics PTs were vented and did not need to be corrected. For the Background period, there was no active PT recording atmospheric pressure. However, before test start, P-6, the well within Cell 2, was recorded as dry. Thus, its dataset was considered suitable for calibrating the pressure at the other Cell 2 and Far field wells during the Background period. For the Testing Event and Recovery periods, a separate Seametrics PT measured the atmospheric pressure and served as the pressure calibration PT for the Cell 2 and Far-field wells.

Both datasets were converted into Excel and equalized for time. Temperature was converted to Celsius and pressure at each well was converted from atmospheric to hydraulic PSI. The hydraulic pressure, in PSI, was then converted to feet of head using the following relation for freshwater:

$$1\ PSI = 2.31\ feet\ of\ head$$

The resulting feet of head value was then added to the elevation of the PT within its respective well. This value equals the Water Elevation within the well at a specified time.

Two additional columns were added: "Elapsed Time" and "Pumping Rate". For AQTESOLV, the elapsed time would be 0 minutes at testing start. The testing period would continue for a total of 3,240 minutes, at which point recovery would continue for 4,273 minutes, for a total testing and recovery period of 7,513 minutes. Not all wells recorded data for the entire 7,513-minute period. The pumping rate was set at 2.63352 cubic feet per minute, or 19.7 gpm - the average discharge at Cell 2 - and was considered constant over the testing period (from 0 to 3,240 minutes elapsed time). At 3,240 minutes elapsed time, the pumping rate was set to 0 cubic feet per minute to simulate recovery.

The water elevation within each well was compared to the water elevations from the other wells. Data was recorded by the PT during WQ sampling and at the end of the recovery period - when the PT was removed and placed at land surface - which resulted in erroneous values during these times. Erroneous values could skew AQTESOLV results and were removed from the dataset, see Table 9. For the edited dataset, each well was split into three separate columns, one with no modifiers, one with inverted values (ie. *-1), and one with absolute values. The file was converted to a comma-delimited file for import into AQTESOLV.

For analysis in AQTESOLV, basic parameters would need to be established. The saturated aquifer thickness was determined to be 100 feet. Pumping wells were assumed to be vertical, fully penetrating wells, while observation wells were determined to be vertical piezometers at varying depths below land

surface. All wells were determined to be situated in the pumped aquifer. All wells are 2-inch diameter wells. Due to the heterogeneity, the analysis for each cell differed as noted in the Table below. A pumping well needed to be established for each cell (P-3 for Cell 1 and P-6 for Cell 2). These wells were located at approximately the center of their respective cells and were assigned the coordinates (0, 0) in AQTESOLV. The remaining wells were considered observation wells and their coordinates would vary. See the Table 9 and Figure 15 for the remaining coordinates of the observation wells.

Basin Cell No. 1 – Distance Drawdown and AQTESOLV Analysis

Water level responses in Cell 1 were analyzed using the United States Geological Survey (USGS) Spreadsheets for the Analysis of Aquifer-Test and Slug-Test Data, Version 1.2 (USGS, Open-File Report 02-197, 2002) via the Cooper and Jacob distance drawdown (DD) method. Additionally, the water level responses in Cell 1 were analyzed using AQTESOLV software via the preferred solution of Hantush-Jacob (1955)/Hantush Solution for a Pumping Test in a Leaky Aquifer (1964). The various solution methods provided a range of estimated transmissivity (T) and storativity (S) values. Refer to Table 8 for the results of the DD analysis and averaged hydraulic parameters. Refer to Table 9 for the input details and results of the AQTSOLV analysis.

Results - Distance Drawdown for W-1 and W-2

Please refer to Figure 21 for a graphical presentation of the distance drawdown observed in W-1 and W-2 on the first two days. On November 17th, the first day of testing, hydraulic conductivity (K) was estimated to be 26 feet per day (ft/day) and T was estimated to be 2,300 square feet per day (feet^2/day). On November 18th, the second day of testing, K was estimated to be 35 (ft/day) and T was estimated to be 3,100 feet^2/day. The aquifer material was estimated to be medium sand. The increase in K and T observed from day one to day two was not expected per field observation of infiltration rates.

Results - Distance Drawdown for P-1 and P-2

Please refer to Figure 22 for a graphical presentation of the distance drawdown observed in P-1 and P-2 on the first two days. On November 17th, the first day of testing, K was estimated to be 8.8 feet per day and T was estimated to be 790 feet^2/day. On November 18th, the second day of testing, K was estimated to be 12 (ft/day) and T was estimated to be 1,000 feet^2/day. The increase in K and T observed from day one to day two was expected as the early data shows a significant time lag between the start of the testing event and when the initial mounding is observed. Refer to Table 8 for the results of the distance drawdown method.

Mounding and Recovery P-3 and W-5

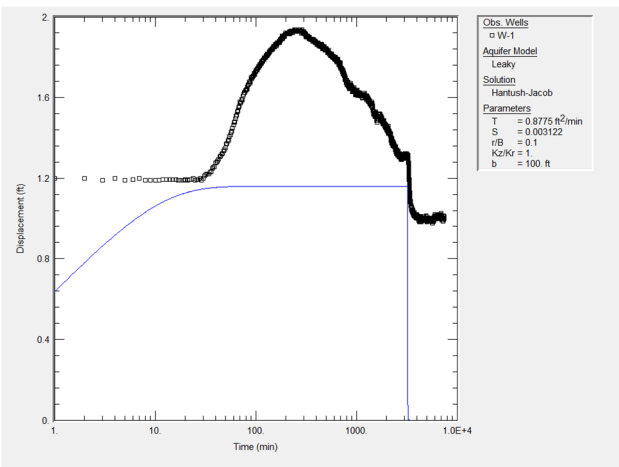
Please refer to Figure 24, for a graphical presentation of the testing and recovery data at the two monitoring locations within Cell 1. The lag between the start of the discharge and the first indication of water level rise was ~32 minutes in P-3 and ~37 minutes in W-5. As expected, the water level rise was much more extreme in P-3 (back fill material) then in W-5 (native sediments). The maximum water level rise in P-3 and W-5 was recorded at ~4.5 feet and ~0.8 feet, respectively. Data shows that full recovery was observed below the initial starting heads, which is supported by the Far-field water level measurements that showed a general water level decline over the period of record.

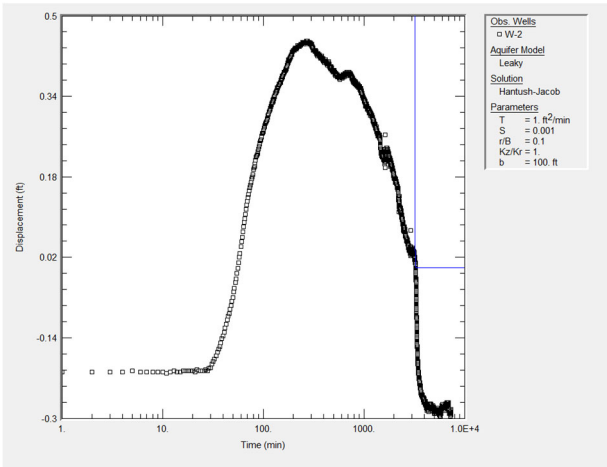
Individual Well Assessments - AQTESOLV

Individual AQTESOLV files were set up for each Cell 1 well using the edited dataset as shown on Table 9.

W-1 and W-2

Test start occurred at 9:05 AM on November 17th and the first occurrence of mounding was observed ~30 minutes after test start. A peak was recorded at approximately 12:20 PM on November 17th, ~200 minutes after test start, which corresponds to the highest recorded discharge period (avg. 28 gpm) for Cell 1. As discharge was reduced after this period, the displacement tapers off. The following diagram is the solution estimated by AQTESOLV for W-1 (and W-2). For W-1, T was estimated to be 0.8775 feet^2/min and S was estimated to be 0.003122. For W-2, T was estimated to be 1.0 feet^2/min and S was estimated to be 0.001. The vertical blue line represents 3:05 PM on November 19th, where the testing event concludes, and recovery begins.

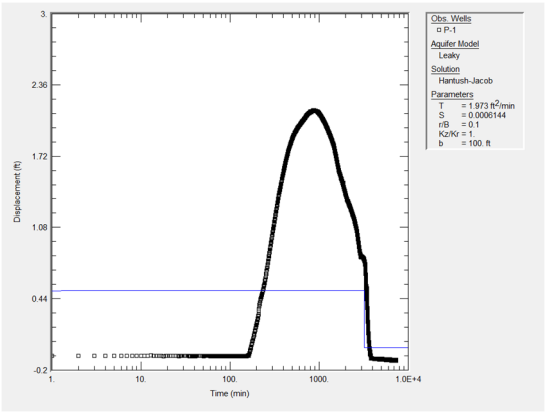


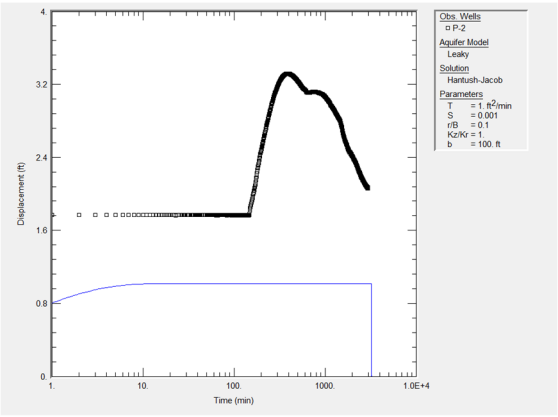


P-1 and P-2

Test start occurred at 9:05 AM on November 17th and the first occurrence of mounding was observed ~150 minutes after test start. For P-1, a peak was recorded at approximately 11:48 PM on November 17th, ~900 minutes after test start, which corresponds with the highest recorded pressure for Cell 1 (per Appendix H). For P-2, a peak was recorded at approximately 3:35 PM on November 17th, ~390 minutes after test start, and occurs during a period of reduced discharge (avg. 21 gpm). This delayed response within the piezometers was expected considering that water would preferentially discharge into the confined aquifer below the restrictive layer – requiring more time for a mounding effect to be observed in the two piezometers located in the upper restrictive layers. Unexpectedly, water levels in P-2 responded to the mounding about 20 minutes sooner than P-1 and with an overall higher magnitude. Additionally, and as expected, the piezometers P-1 and P-2 were dry at the start of the testing event. Since discharge was reduced to limit overflow conditions, the displacement continues to taper off. The following diagram is the solution estimated by AQTESOLV for P-1 (and P-2). For P-1, T was estimated to be 1.973 feet^2/min and S was estimated to be 0.0006144. For P-2, T was estimated to be 1.0 feet^2/min and S was estimated to be 0.001 (graphics provided below). The P-2 data is suspect because the end of the testing and the recovery data were not available. The vertical blue line represents 3:05 PM on November 19th, where the testing event concludes, and recovery begins. The pressure transducer in P-2 failed at 10:33 AM on November 19th, about 4.5 hours before recovery was initiated. The dataset was downloadable, but corrupted and, therefore; no recovery analysis could be conducted for P-2.

Multiple solutions were run, but it is likely that the AQTESOLV solution for P-2 runs into an error since data recovery unexpectedly terminated. Data collection for P-2 ended at elapsed time of 2,968 minutes from testing event start. Testing terminated at elapsed time of 3,240 minutes from test start.





Basin Cell No. 2 – Distance Drawdown and AQTESOLV Analysis

Water level responses in Cell 2 were analyzed using the United States Geological Survey (USGS) Spreadsheets for the Analysis of Aquifer-Test and Slug-Test Data, Version 1.2 (USGS, Open-File Report 02-197, 2002) via the Cooper and Jacob distance-drawdown method. Additionally, the water level responses in Cell 2 were analyzed using AQTESOLV software via the preferred solution of Cooper-Jacob (1946) Solution for a Pumping Test in an Unconfined Aquifer. The various solution methods provided a range of estimated T and S values.

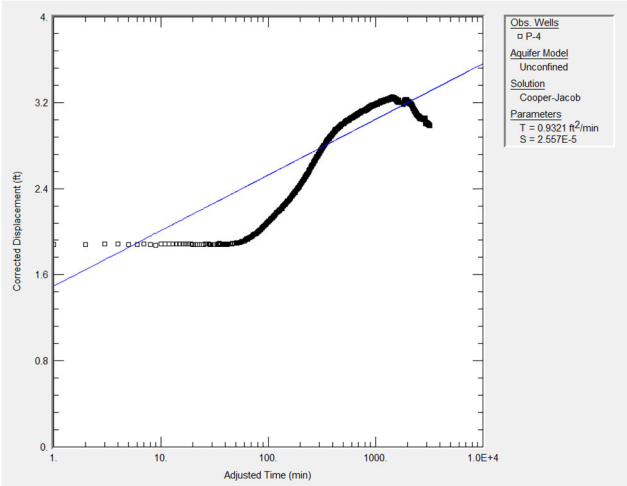
Results Distance Drawdown P-4 and P-5

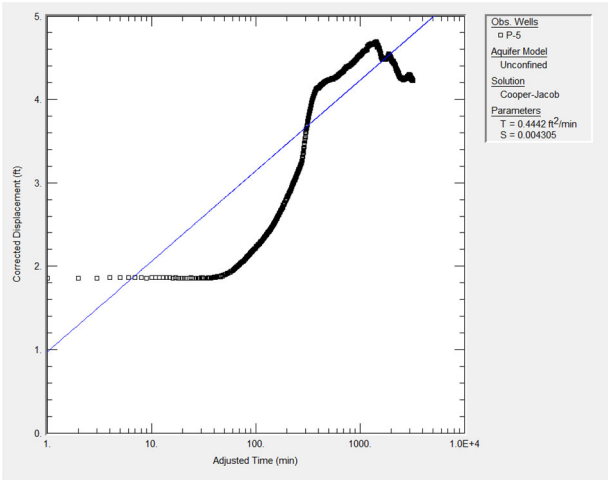
Please refer to Figure 22 for a graphical presentation of the distance drawdown observed in P-4 and P-5 on the first two days. On November 17th, the first day of testing, K was estimated to be 8.2 (ft/day) and T was estimated to be 760 feet^2/day. On November 18th, the second day of testing, K was estimated to be 7.8 feet/day and T was estimated to be 710 feet^2/day. The aquifer material was estimated to be fine sand. The slight decrease in K and T observed from day one to day two was expected per field observation of infiltration – especially in the minimally-overflowed Cell 2. Refer to Table 8 for the results of the distance-drawdown method.

Individual Well Assessments - AQTESOLV

Individual AQTESOLV files were set up for each Cell 2 well using the edited dataset as referenced in Table 9. At P-4, after approximately 40 minutes elapsed time, an increase in displacement is observed. Approximately 1,400 elapsed time, displacement had reached its peak of 3.3 feet, after which displacement began to return to baseline. The estimated T was 0.9321 feet^2/min and S was estimated to be 0.00002557, or 2.557 x 10^-5.

Like P-4, P-5 showed a response after approximately 40 minutes elapsed time, an increase in displacement is observed (graphics provided below). Approximately elapsed time = 1,400, displacement had reached its peak of 4.8 feet, after which displacement began to return to baseline. While returning to baseline, P-5 experienced a couple of localized dips and rebounds in displacement which correspond to WQ sampling taken on November 18th and/or a rainfall event on November 19th. The estimated T was 0.4442 feet^2/min and S was estimated to be 4.305 x 10^-4. For a breakdown of the estimated T and S values for Cell 2 wells, see the Tables 8 and 9.





Hydraulic Parameter Averages

For the distance-drawdown (DD) method, at Cell 1, T averaged to 1,797.5 feet^2/day and K averaged to 20.5 feet per day. At Cell 2, T averaged to 735 feet^2/day and K averaged to 7.9 feet/day.

For the AQTESOLV method, at Cell 1, T averaged to 2,425.1 feet^2/day and K averaged to 24.3 feet/ day. At Cell 2, T averaged to 990.9 feet^2/day and K averaged to 9.9 feet/ day.

Averaging both methods, at Cell 1, T averaged 2,111.3 feet^2/day and K averaged 22.4 feet per day. At Cell 2, T averaged 863.0 feet^2/day and K averaged 8.9 feet per day. Across both cells, T averages to 1487.1 feet^2/day and K averages to 15.6 feet/ day.

Conceptual Model

No computerized modeling was conducted for this evaluation. After operational data has been recovered a calibrated flow and transport model could be prepared and used as a tool for managing flows to the cell based on hydrometeorological events. Fate and transport modeling were not conducted as a part of this evaluation.

Water Balance

Three scenarios were prepared to evaluate the water balance of the SGW assuming average meteorological conditions for the lowest, highest, and average precipitation and evapotranspiration (ET) rates. The following summary is presented in Table 10. The following values are estimations based on the methodologies conducted and assuming that large volumes of water is not being lost from lateral and vertical conductivity (assumes a Ksat of 0.1 in/hr) from the SGW basin. Vertical conductivity of 0.2 in/hr have been reported in the least conductive soils at the site, while the maximum rates have been reported as high as 20 in/hr. The limiting factor of maintaining a hydrated SGW is vertical conductivity. The infiltration rates ranged from a between 9 and 16 gpm per 100 square feet. The infiltration rate through the trench was estimated to be 12 gpm per 100 square foot section for the discharge calculations.

The DD solution calculated a low-end average of ~318,000 gpd per half-gallery, or 636,000 gpd for the full gallery. Consulting the infiltration trench capacity analysis, a total of 636,000 gpd for the 3000 square foot infiltration gallery equates to about 14.7 gpm per 100 square feet. For the AQTESOLV method, the estimated discharge rate of about 544,193 gpd was calculated from Cell 1 and about 222,366 gpd for Cell

2. For the 3,000 square foot infiltration gallery these two discharge rates were averaged at about 383,280 gpd of discharge or about 9 gpm per 100 square feet.

Averaging both methods, at Cell 1, T averaged 2,111.3 feet^2/day and K averaged 22.4 feet per day, or about 501,546 gpd for the 3,000 square foot infiltration gallery. At Cell 2, T averaged 863.0 feet^2/day and K averaged 8.9 feet per day, or about 199,821 gpd for the 3,000 square foot infiltration gallery. Across both cells, T averages to 1487.1 feet^2/day and K averages to 15.6 feet/ day, or about 350,683 gpd (per cell) and about 700,000 gpd for the gallery (or about 16 gpm per 100 square feet).

Based on the hydraulic analysis, at lowest average monthly precipitation rate of 3.19 inches per month and lowest adjusted evapotranspiration (ET) values of 0.504 inches per month, this equates to a losing water balance equation for 0.75 MGD (zero off-site discharge) and 0.9 MGD (zero off-site discharge) and a gaining water balance for 1.0 MGD (~90,000 gpd or ~63 gpm offsite discharge) and 1.25 MGD (~340,000 gpd or ~236 gpm offsite discharge).

Based on the hydraulic analysis, at highest average monthly precipitation rate of 5.59 inches per month and adjusted evapotranspiration (ET) values of 5.262 inches per month, this equates to a losing water balance equation for 0.75 MGD (zero off-site discharge) and 0.9 MGD (zero off-site discharge) and, a gaining water balance for 1.0 MGD (~77,000 gpd or ~53 gpm offsite discharge), and 1.25 MGD (~327,000 gpd or ~227 gpm offsite discharge).

During average monthly conditions with a precipitation rate of 3.78 inches per month and average adjusted evapotranspiration (ET) values of 2.63 inches per month, this equates to a losing water balance equation for 0.75 MGD (zero off-site discharge) and 0.9 MGD (zero offsite discharge), and a gaining water balance for, 1.0 MGD (~81,500 gpd or ~57 gpm offsite discharge), and 1.25 MGD (~331,500 gpd or ~230 gpm offsite discharge).

A broad mounding effect is expected around the infiltration gallery. The initial mounding observed in Cell 1 gradually attenuated over time even as a constant head was maintained on the cell. This observation indicates that once the initial mounding occurs, communication with the water table aquifer attenuates mounding with time as discharge is dispersed in the aquifer. Based on the results of the testing event and the water quality sampling conducted, these effects are expected to be local to the SGW and are not expected to influence off site locations.

Recommendations

Based on the data from the basin test and the information provided in the preceding sections, it is estimated that between 750,000 and 900,000 gallons of treated effluent could be passed through the SGW daily. The soils across the site have adequate saturated hydraulic conductivity for infiltration; the main limiting factor to the operation of the SGW is the retention of water across the full length of the cell so the planting can be kept in a hydrated state. Keeping the water balanced to annual net zero discharge could be managed through several active and passive methods. Therefore, based off the calculated infiltration rates in both this and previous studies the following recommendations should be considered.

- A semi-permeable barrier of geotextile or soil mix will need to be installed to retard the vertical infiltration and facilitate movement of water through the cell to infiltrate through the infiltration gallery. The assumption for vertical discharge through the base of the SGW is 0.1 inch/hour.
- Installing a monitoring piezometer in the SGW to monitor wet conditions and direct more water (up to the maximum daily limit) or less water to the cell based on actual conditions.

- Utilize an adaptive management program in advance of predicted heavy rainfall or storm event to reduce the impact of elevated chloride effluent from entering the SGW.
    - Overfill the SGW in advance of the precipitation event.
    - Stop feeding the SGW during the event when higher chlorides are anticipated.
    - Resume feeding the SGW after chloride levels have returned to normal levels and water levels in the SGW have receded to operational levels.
- During normal precipitation events most water will be maintained on-site and infiltrated through the SGW.
- Construct a forebay for additional storage in the event of heavy precipitation events so excess "discharge" water could be stored for future processing through the SGW, limiting total offsite discharges.

SURFACE WATER REPORT

Watershed Identification

The Project lies within the Rehoboth Bay watershed in the Inland Bays/Atlantic Ocean basin. Guinea Creek's headwater is located on the east side of Cannon Road. Stormwater runoff from the Project is discharged to this creek through a grated storm sewer beneath Cannon Road. The nearest adjacent perennial stream is Phillips Branch, which lies between 3,500 and 4,000 feet north and northwest of the North Burton Field portion of the Inland Bays facility. Refer to Figure 2 for a map showing local surface waters and wetlands.

Ambient Groundwater

Groundwater at the North Burton Field has been impacted at the site due to the history of agricultural use between 1937 and 1992 and land application of effluent spray discharges since 1992 (Venables, Memorandum dated October 10, 2013). Ambient water quality is discussed above in "Groundwater Quality Testing" section.

Soil Testing

Soil chemistry has been evaluated on the site since 2005. This report adds additional shallow and deep soil analysis completed by ESSS and HCA. These data are presented in Appendix B and C and are summarized on Table 11. The major macro and micronutrients are color coded by the assigned Mehlich-3 Range. A generalized discussion is discussed above in "Soil Chemistry" section and additional discussion can be found in Appendix B.

WATER BALANCE

Please refer to the June 1, 2020, permit submittal application for detail of the overall site water balance calculations.

MONITORING PLANS

Monitoring and operational adjustments will be critical to the performance of the SGW. Communication with DNREC will be equally critical in developing the Project from a construction and testing concept to a permitted operational system.

Submerged Gravel Wetland Flux

The facility will prepare monthly operating reports which quantify the total daily inflow into and outflow from the SGW. Daily precipitation data will be presented. Additionally, any operational issues related to the wastewater treatment plant or submerged gravel wetland will be recorded and included in the operational reports.

Temporary Groundwater Utilization Monitoring

Groundwater will be used to supplement the daily flow into the SGW via two proposed temporary dewatering wellfields located along the northern and northeastern boundaries of the North Burton Field as shown of Figure 13. These new wells will be hard piped to the SGW discharge and flow measurements will be recorded via new daily totalizing flow meter. The temporary well alignments (Temporary Wellfield 1 and 2) will be expanded when necessary to meet the annual discharge requirements from these facilities. Flow measurements will be submitted in the monthly operating report.

Groundwater And Effluent Monitoring Plan

The existing groundwater monitoring network on the North Burton field consist of four wells (MW2, MW-12, MW-16, and OW-17). Four (4) additional groundwater monitoring wells (SGW-1 through 4) are proposed in conjunction with the SGW and will be installed concurrently with the construction of the SGW. Please refer to Figure 25 for a map showing the four (4) existing monitor wells and the four (4) proposed groundwater monitoring wells and the SGW. These wells will be located and installed so the groundwater quality can be periodically evaluated to ensure deleterious conditions are not projected to the local wells producing water to meet domestic or irrigation demands.

The new monitor wells will be constructed in accordance with the Delaware regulations to a depth of 12-feet below static water levels. Following construction of the new monitor wells, background water quality sampling will be conducted for full suite of microbiological, inorganic and organic quality parameters in accordance with Delaware Ground-Water Recharge Design Manual (June 2017). Monthly monitoring consists of measuring water levels and quality sampling for laboratory analysis for microbiological contaminants. Quarterly, SGW-1 and SGW-2 will be sampled for microbiological and inorganic water quality parameters. Annually, all four monitor wells will be sampled for a full suite as identified in the Groundwater Recharge Design Manual (pages SI-21 and SI-22).

Additionally, these wells will be outfitted with water level monitoring equipment to provide daily water level measurements These data, in conjunction with daily loading rates, precipitation data will provide a high-resolution understanding of the mounding effects resulting from the use of the SGW. This operational testing data will provide the information necessary to calibrate a refined numerical model which could assist with the loading schedules based on seasonal, local environmental patterns as well as month to month operations during the Project. This data will also provide the regulatory agencies the reasonable assurance that the SGW system is operating in the manner for which it was intended.

Soil Sampling Monitoring Plan

Prior to operation of the SGW, a soil sample will be collected from the vegetative layer of the soil media and analyzed to provide baseline nutrient and metal conditions. Annually, a soil analysis will be conducted to evaluate nutrient concentrations through the Project. Biennial metal concentration soil analysis will be conducted. The sampling location is identified on Figure 25. The sampling area is a zone of about 8-foot radius. Sampling will be completed via single core of the soil media.

Operations and Maintenance Program

Using an adaptive management approach modifications to the system will be driven by the resultant operation data of the SGW. For example, harvesting of the planted material will be based on water quality data recovered from the down gradient monitor wells as it is anticipated that nutrient uptake could diminish with time resulting in observed increases in nutrient loading of the groundwater. Additionally, effluent flow volumes could be adjusted to increase or decrease the contact time with the soil media prior to discharge into the infiltration gallery. As noted above in the Groundwater Monitoring Plan Section, groundwater quality and levels in the receiving aquifer will guide the County during the cycle tests to enhance and improve operations.

Bi-Annual Operating Report

Every two (2) years throughout the demonstration period the facility will submit a cycle test report that summarizes the operations of the SGW component of the facility. The report will summarize and graphically present data for the following elements:

- Operational challenges and recommended enhancements
- Monthly effluent loading rates
- Monthly discharge rates
- Groundwater levels and wellfield operational data
- Precipitation
- Water quality
    - Groundwater
    - Discharge
    - Effluent

The biennial operational reports (cycle test) will provide an evaluation of the system for improvement and scalability. The report will provide summaries correlating the relationships between the discharge, precipitation, effluent loading rates and groundwater levels and water quality within the Columbia Aquifer. Following the completion of the demonstration, the system will seek to be permitted as fully operational system if operational data support the future use of the system.

TABLES

Table 1: Wells within Area of Review

Well Type	Number of Wells (Active/Complete)	Number of Wells (pending)
Agricultural - Standard	4	
Agricultural - Within CPCN	76	1
Dewater - Standard	2	
Domestic - Standard	11	
Miscellaneous - Standard	6	
Monitor - Direct Push	1	
Monitor - Standard	4	
Monitor - Zone of Interest	1	
Observation - Standard	25	
Unknown	0	1
Total Number of Wells	**130**	**2**

Table 2: Precipitation Records

Precipitation Data										
	Amount (Inches)									
Month	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
January	4.30	2.30	3.00	3.10	5.70	2.10	3.20	3.20	4.25	3.45
February	1.95	1.70	4.35	3.10	2.80	3.50	0.80	2.75	5.70	4.00
March	4.20	2.20	3.50	2.55	4.10	1.40	3.75	4.10	4.30	4.30
April	3.00	3.55	2.65	3.60	3.45	3.00	3.45	4.35	3.60	4.45
May	1.70	2.15	1.85	2.60	0.85	5.50	5.11	8.90	6.90	4.50
June	1.00	3.50	9.30	6.90	5.70	2.50	4.10	5.20	3.50	1.70
July	7.30	1.60	12.00	7.15	3.30	2.75	5.85	2.90	3.30	2.01
August	9.20	11.20	8.50	6.70	2.30	2.80	7.70	1.13	4.60	4.85
September	2.75	4.10	0.75	4.60	3.95	15.30	3.00	9.50	2.10	4.88
October	3.10	11.45	6.20	2.05	5.50	3.60	4.55	7.35	5.70	8.25
November	3.95	1.80	2.10	3.80	3.65	0.40	2.70	6.10	2.15	5.81
December	1.6	3.6	3.3	4.1	4.4	2.85	0.5	5.9	4.41	9.6
Minimum	1.00	1.60	0.75	2.05	0.85	0.40	0.50	1.13	2.10	1.70
Maximum	9.20	11.45	12.00	7.15	5.70	15.30	7.70	9.50	6.90	9.60
Average	3.67	4.10	4.79	4.19	3.81	3.81	3.73	5.12	4.21	4.82
Total	44.05	49.15	57.50	50.25	45.70	45.70	44.71	61.38	50.51	57.80
	Peak Precip. (Inches)									
Month	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
January	1.6	0.8	0.9	0.7	1.3	1	0.6	0.95	1.6	1.9
February	0.5	0.4	1.5	1.1	1	0.8	0.45	0.7	1.6	1.4
March	1.3	1.3	1.6	1.35	0.9	0.6	3	1.1	0.9	1.1
April	1.2	2.7	1	1.5	1.7	0.8	1.1	1.6	1.2	1.1
May	0.8	0.8	0.4	1.1	0.55	1.2	1.1	3.5	1.7	2.4
June	0.4	1.6	1.8	5.5	1.6	1.1	2.4	2.3	0.8	0.9
July	2.2	1	7.8	2	1.3	1.4	3.1	1.2	1.5	1.5
August	4.4	8.1	2.9	1.4	1.35	1.2	2.7	0.4	1.6	1.25
September	0.6	1.5	0.5	1.7	1.6	6	0.8	6	0.8	1.8
October	1.2	5	1.9	0.5	3.1	3.3	2.7	4.6	2.6	2
November	1.7	1.3	0.9	1.1	2.65	0.2	1.1	1.8	0.6	3.3
December	0.8	2	1	1.5	1.7	1.1	0.2	3.1	1.3	2.7

Table 2: Precipitation Records

	Date of Peak Precip.									
Month	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
January	1/27/2011	1/12/2012	1/16/2013	1/13/2014	1/24/2015	1/19/2016	1/3 & 1/9/2017	1/29/2018	1/25/2019	2/25/2020
February	2/28/2011	2/27/2012	2/11/2013	2/12/2014	2/21/2015	2/5/2016	2/9/2017	2/12/2018	2/25/2019	2/6/2020
March	3/11/2011	3/1/2012	3/6/2013	3/30/2014	3/5/2015	3/20/2016	3/14/2017	3/21/2018	3/21/2019	3/29/2020
April	4/16/2011	4/23/2012	4/5/2013	4/16/2014	4/19/2015	4/3/2016	4/26/2017	4/16/2018	4/22/2019	4/23/2020
May	5/4/2011	5/10/2012	5/11/2013	5/16/2014	5/22/2015	5/22/2016	5/22/2017	5/19/2018	5/14/2019	5/4/2020
June	6/20/2011	6/25/2012	6/19/2013	6/13/2014	6/21/2015	6/16/2016	6/18 & 6/19/2017	6/11/2018	6/6/2019	6/12/2020
July	7/7/2011	7/9/2012	7/12/2013	7/10/2014	7/3/2015	7/28/2016	7/29 & 7/30/2017	7/23/2018	5/18/2019	7/25/2020
August	8/28/2011	8/27/2012	8/22/2013	8/1 & 8/12/2014	8/11/2015	8/1/2016	8/2/2017	8/13/2018	8/1/2019	8/6/2020
September	9/26/2011	9/4/2012	9/23/2013	9/24/2014	9/29/2015	9/28/2016	9/5 & 9/7/2017	9/10/2018	9/2/2019	9/4/2020
October	10/31/2011	10/29/2012	10/11/2013	10/13 & 10/15/2014	10/1/2015	10/9/2016	10/29/2017	10/12/2018	10/20/2019	10/30/2020
November	11/17/2011	11/9/2012	11/26/2013	11/17/2014	11/9/2015	11/15/2016	11/8/2017	11/15/2018	11/1/2019	11/12/2020
December	12/28/2011	12/27/2012	12/29/2013	12/8/2014	12/28/2015	12/7/2016	12/10/2017	12/15/2018	12/15/2019	12/16/2020

Table 3: Groundwater Monitoring Facilities

Local Well No.	DNREC Permit No.	Top of PVC Casing Elevation (FAMSL)	Well Stick Up (ft)
Monitor Wells			
MW-01	86145	26.06	2.54
MW-02	86146	24.16	2.47
MW-03	237996	26.53	1.3
MW-04	237997	25.27	1.88
MW-05	86153	26.5	3.33
MW-06	86150	34.57	2.17
MW-07	86151	24.6	1.4
MW-08	86152	25.78	2.9
MW-09	86148	26.81	1.31
MW-10	89573	26.84	0.92
MW-11	208213	43.27	1.84
MW-12	208214	25.03	1.97
MW-13	208215	23.98	2.1
MW-14	208216	23.92	2.22
MW-15	208217	26.31	1.99
MW-16	228543	21.86	1.84
MW-18	237074	22.93	2.07
MW-21	238298	20.65	2.01
MW-22	238299	24	1.85
MW-23	238967	26.6	2.07
MW-24	238968	25.35	2.25
MW-25	238969	24.83	2.37
MW-26	238970	27.2	2.25
MW-29	252815	21.01	3.06
Observation Wells			
OW-01	237998	24.03	1.97
OW-02	237999	24.26	2.04
OW-17	228544	24.33	2.3
OW-27	242932	23.32	2.66
OW-28	242933	25.79	1.72

Table 4: Groundwater Elevation Data

Well ID	DNREC ID	3/12/2018	6/18/2018	9/5/2018	12/6/2018	3/12/2019	6/18/2019	9/16/2019	12/28/2019	3/10/2020	6/6/2020	9/9/2020	12/28/2020
MW-1	86145		4.91	9.08	4.48	3.99	6.71	9.59	10.51	8.25	8.31	8.87	3.76
MW-2	86146		5.02	8.95	4.44	3.81	6.46	8.66	8.83	7.79	8.65	8.43	4.07
MW-3	237996		5.03	6.31	4.51	4.11	6.47	9.18	10.01	8.64	9.34	9.33	4.22
MW-4	237997		5.17	5.93	4.72	3.59	5.94	8.61	8.91	8.42	8.52	8.45	3.75
MW-5	86153		6.57	10.38	3.07	3.01	7.71	11.49	12.09	9.48	7.79	10.08	3.88
MW-6	86150		11.77	14.75	13.73	10.29	13.59	17.91	16.95	16.12	16.81	16.81	10.67
MW-7	86151		2.01	3.64	1.66	1.41	3.79	7.42	8.85	6.82	7.15	17.28	1.61
MW-8	86152		4.87	7.18	4.69	3.27	6.13	10.45	11.31	9.68	10.13	9.48	5.16
MW-9	86148		5.43	1.19	2.34	1.49	1.58	2.08	9.53	6.39	7.99	7.65	1.36
MW-10	89573		4.05	5.55	2.89	1.98	5.56	9.01	12.43	7.76	8.47	9.51	3.05
MW-11	208213		19.66	22.99	19.33	17.84	21.39	25.39	26.19	23.81	24.04	24.18	18.16
MW-12	208214		7.64	10.62	7.24	6.62	8.69	10.66	10.86	9.56	9.94	10.25	6.78
MW-13	208215		4.59	5.61	3.89	3.72	5.59	8.09	8.16	7.43	7.98	8.26	3.25
MW-14	208216		3.69	4.79	3.31	3.24	4.99	8.11	9.37	7.38	8.14	7.88	5.91
MW-15	208217		5.92	8.11	9.12	5.35		11.64	12.95	10.87	11.28	11.57	5.91
MW-16	228543		4.02	7.37	3.32	2.68	5.21	7.25	7.35	6.17	6.61	6.98	17.4
OW-17	228544		4.83	7.27	5.39	5.65	7.18	9.55	9.47	8.39	7.61	9.19	2.3
MW-18	237074		7.91	6.82	5.47	5.07	7.24	9.21		8.56	9.51	9.43	4.67
OW-19	237999		4.25	5.29	4.05	3.43	5.42	7.75	7.97	7.32	6.45	8.14	3.55
OW-20	237998		3.85	4.61	3.45	3.28	5.12	7.76	7.82	4.19	7.98	7.88	3.05
MW-21	238298		2.02	3.05	1.89	1.52	3.15	6.49	7.41	5.46	6.30	6.26	1.33
MW-22	238299		4.84	6.88	5.04	4.23	6.74	10.29	9.63	9.45	9.85	10.28	4.54
MW-23	238967		4.65	6.21	4.45	3.31	6.02	10.33	9.25	9.69	10.05	10.51	1.9
MW-24	238968		3.69	5.55	3.39	2.79	4.91	9.01	10.25	5.53	8.82	9.08	3.85
MW-25	238969		4.26	6.76	3.95	2.81	5.42	9.69	10.97	9.31	9.46	10.14	4.99
MW-26	238970	7.56	6.52	8.94	6.28	5.27	7.82	11.99	13.69	11.67	13.72	10.26	7.17
OW-27	242932	3.19	3.95	8.33	3.87	3.49	5.75	9.11	9.36	8.22	7.42	8.97	3.55
OW-28	242933	7.05	6.07	8.42	5.82	6.09	8.16	11.96	12.43	11.18	10.48	11.82	6.67
OW-29	252815	5.36	5.22	7.61	4.99	3.94	6.43	10.72	10.39	10.27	10.43	11.02	5.74

Table 5: Nitrogen and Phosohorus Concentrations (in mg/l)

Nitrogen Concentration												
DNREC No.	**86145**	**86146**	**237996**	**237997**	**86153**	**86150**	**86151**	**86152**	**86148**	**89573**	**208213**	**208214**
Well ID	**MW-1**	**MW-2**	**MW-3**	**MW-4**	**MW-5**	**MW-6**	**MW-7**	**MW-8**	**MW-9**	**MW-10**	**MW-11**	**MW-12**
3/12/2018	1.20	13.99	1.91	6.39	1.93	0.69	1.98	8.90	0.69	4.10	1.57	20.25
6/18/2018	1.27	8.90	2.14	19.70	2.74	0.49	3.84	9.74	1.08	3.32	1.27	22.00
9/5/2018	1.34	8.74	2.58	7.08	3.92	0.66	3.57	9.08	1.25	3.76	1.08	20.00
12/6/2018	0.895	6.88	2.62	7.18	7.94	0.25	6.15	12.31	0.25	3.00	1.15	15.67
3/12/2019	1.14	2.09	2.58	9.99	1.078	0.25	6.50	11.37	0.55	4.83	1.31	1.30
6/18/2019	1.537	2.178	2.897	6.758	1.471	0.108	2.500	12.929	0.523	4.080	1.061	9.443
9/16/2019	1.360	10.663	2.480	2.046	9.940	0.795	2.720	17.118	0.939	4.240	0.936	8.370
12/28/2019	1.370	7.200	1.905	4.630	2.991	1.390	2.600	13.800	0.652	4.220	1.240	9.290
3/10/2020	1.37	7.50	1.96	3.76	0.88	1.015	1.251	14.43	0.935	4.398	1.30	9.429
6/6/2020	2.30	29.76	1.92	4.06	1.10	0.64	7.76	6.20	1.96	4.68	1.10	7.09
9/9/2020	2.05	0.3	1.11	3.68	3.57	0.64	0.73	12	0.39	2.36	0.718	5.53
12/28/2020	1.07	2.09	1.15	4.83	1.88	0.12	1.25	58	0.29	3.55	0.62	7.18
3/1/2021	1.55	3.65	1.89	4.55	5.13	0.37	0.9	10.3	0.554	0.28	0.858	6.43
DNREC No.	**208215**	**208216**	**208217**	**228543**	**237074**	**238298**	**238299**	**238967**	**238968**	**238969**	**238970**	**252815**
Well ID	**MW-13**	**MW-14**	**MW-15**	**MW-16**	**MW-18**	**MW-21**	**MW-22**	**MW-23**	**MW-24**	**MW-25**	**MW-26**	**MW-29**
3/12/2018	5.13	10.16	21.15	13.29	10.95	14.92	10.25	10.25	16.09	8.82	9.57	9.22
6/18/2018	4.90	8.16	17.40	8.47	12.80	30.40	10.50	14.90	15.80	10.90	8.78	10.10
9/5/2018	12.31	5.23	13.56	6.87	11.92	14.51	11.04	0.82	16.61	8.04	9.45	9.05
12/6/2018	10.80	5.43	13.23	14.31	11.29	15.23	12.92	0.12	9.85	7.65	7.89	12.15
3/12/2019	12.06	4.18	12.03	5.10	7.81	3.11	10.48	0.48	8.14	4.27	7.13	12.15
6/18/2019	4.746	8.109		4.671	8.236	10.692	9.296	0.853	7.877	4.248	11.272	9.529
9/16/2019	9.860	5.810	9.850	3.210	8.680	9.670	8.210	0.619	9.075	3.920	11.400	8.740
12/28/2019	10.600	3.299	10.391	0.585		10.300	8.027	0.475	8.210	5.313	10.538	16.245
3/10/2020	6.832	2.057	7.872	2.58	4.56	11.98	7.295	0.59	6.499	6.637	13.038	14.313
6/6/2020	3.04	8.39	8.00	12.58	9.54	13.51	6.94	1.78	10.15	6.95	12.85	12.63
9/9/2020	4.86	15.12	7.74	22.18	6.33	12.07	5.75	0.52	1.43	6.31	10.95	8.82
12/28/2020	6.16	7.29	9.76	6.79	6.32	12.16	5.82	2.18	0.594	7.42	7.18	11.5
3/1/2021	8.03	11.09	10.34	3.64	7.75	10.5	8.38	1.92	8.22	8.07	17.25	8.12

Table 5: Nitrogen and Phosohorus Concentrations (in mg/l)

Phosphorus Concentration												
DNREC No.	**86145**	**86146**	**237996**	**237997**	**86153**	**86150**	**86151**	**86152**	**86148**	**89573**	**208213**	**208214**
Well ID	**MW-1**	**MW-2**	**MW-3**	**MW-4**	**MW-5**	**MW-6**	**MW-7**	**MW-8**	**MW-9**	**MW-10**	**MW-11**	**MW-12**
3/12/2018	< 0 .05	< 0.05	< 0.05	< 0.05	2.47	< .05	< .05	< .05	0.11	< 0 .05	< 0 .05	< 0 .05
6/18/2018	< 0 .05	< 0.05	< 0.05	< 0.05	2.31	< .05	< .05	< .05	0.25	0.07	< 0 .05	< 0 .05
9/5/2018	< 0 .05	< 0.05	< 0.05	< 0.05	2.26	< .05	< .05	< .05	0.41	0.06	< 0 .05	< 0 .05
12/6/2018	< 0 .05	< 0.05	< 0.05	< 0.05	1.50	< .05	0.07	< .05	0.12	< 0 .05	< 0 .05	< 0 .05
3/12/2019	< 0 .05	< 0.05	< 0.05	< 0.05	1.05	< .05	0.05	< .05	0.05	0.08	< 0 .05	< 0 .05
6/18/2019	< 0 .05	ND	< 0.05	ND	0.97	ND	ND	ND	0.24	0.07	ND	ND
9/16/2019	ND	ND	ND	ND	0.586	ND	0.113	ND	ND	ND	ND	ND
12/28/2019	ND	ND	ND	ND	0.46	ND	0.081	ND	0.08	0.07	ND	ND
3/10/2020	ND	ND	ND	ND	0.66	ND	ND	ND	0.08	0.09	ND	ND
6/6/2020	ND	ND	ND	ND	2.50	ND	ND	ND	1.48	0.06	ND	ND
9/9/2020	ND	ND	ND	ND	1.26	ND	ND	ND	0.16	0.11	0.06	ND
12/28/2020	ND	ND	ND	ND	2.01	ND	0.18	ND	0.06	0.06	ND	ND
3/1/2021	ND	ND	ND	ND	4.03	ND	0.08	ND	ND	0.05	ND	0.06
DNREC No.	**208215**	**208216**	**208217**	**228543**	**237074**	**238298**	**238299**	**238967**	**238968**	**238969**	**238970**	**252815**
Well ID	**MW-13**	**MW-14**	**MW-15**	**MW-16**	**MW-18**	**MW-21**	**MW-22**	**MW-23**	**MW-24**	**MW-25**	**MW-26**	**MW-29**
3/12/2018	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05
6/18/2018	0.62	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05
9/5/2018	0.40	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05
12/6/2018	0.35	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05
3/12/2019	< 0 .05	0.48	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05	< 0 .05
6/18/2019	0.82	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND
9/16/2019	0.26	0.07	0.12	< 0 .05	ND	ND	0.052	ND	ND	ND	ND	ND
12/28/2019	0.11	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND
3/10/2020	0.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6/2020	0.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/9/2020	0.11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/28/2020	0.08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/1/2021	0.28	0.17	0.11	ND	ND	ND	ND	ND	0.1	ND	0.09	0.16

Table 6: Groundwater Quality Testing Results

Analyte/ Well ID (Phase)	Unit	W-1 (B)	Effluent (T)	W-1 (T)	W-2 (T)	P-3 (T)	P-4 (T)	W-2 (R)
Sample Date		11/10/2021	11/18/2021	11/18/2021	11/18/2021	11/18/2021	11/18/2021	11/22/2021
Arsenic	ug/l	ND	1.1	1.1	1.8	2.9	1.6	3.9
Cadmium	mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	mg/l	44	89	179	219	174	20	349
Chromium	mg/l	0.0036	0.0031	0.002	0.0025	0.0026	0.0018	0.0027
Copper	mg/l	0.0126	0.0419	0.0221	0.0237	0.0154	0.0125	0.0075
Hardness	mg/l	13.6	142	78	76	99	40	74
Lead	ppb	5.3	ND	2	1.6	ND	2.8	ND
Manganese	mg/l	0.1366	0.0356	0.0877	1.2336	0.0226	0.0102	0.6477
Mercury	mg/l	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/l	0.0048	0.0031	0.0052	0.0158	0.0025	0.0034	0.0102
Selenium	mg/l	ND	0.0031	0.0051	0.006	0.0034	0.0032	0.0043
Sodium	mg/l	24	170	177	183	174	106	167
Zinc	mg/l	0.0315	0.1216	0.0638	0.0502	0.0608	0.0239	0.0321
Total Dissolved Solids	mg/l	156	1003	965	1045	1022	550	905
TSS	mg/l	820	16	20	2	5	1816	ND
Iron	mg/l	2.2	ND	0.2	2.4	0.1	1.8	0.2
Sulfate	mg/l	42	63	72	60	61	60	66
Total Nitrogen, Calculation	mg/l	3.3	13.1	7.8	6	11.1	27.8	6.6
Nitrate+Nitrite as N	mg/l	3.3	7.7	7.1	6	7.4	27.8	6.6
Nitrite-N	mg/l	0.09	1.01	1.09	1	1.12	0.18	1.26
Ammonia-N	mg/l	ND	2.2	ND	ND	2.1	ND	ND
TKN	mg/l	ND	5.4	0.7	ND	3.7	ND	ND
Phosphorus, Total	mg/l	0.9	7.1	ND	ND	7	0.72	ND
Fecal coliform	MPN	ND	204.6	ND	ND	30.9	ND	ND
E. Coli	MPN	ND	DNS	DNS	DNS	DNS	DNS	DNS
Total coliform	MPN	18.9	1413.6	1	ND	260.3	66.3	8.6
Final Field Parameters								
pH	SU	4.94	7.72	4.6	4.93	7.68	7.32	4.76
Temperature	C	18	16.1	14.9	14.2	15.7	16.9	15.1
Conductivity	umhos/cm	232.1	1487	1376	1364	1519	831	1500
Dissolved Oxygen	mg/l	7.13	10.93	11.43	8.54	10.03	10.26	10.09

ND = Non Detect
DNS = Did Not Sample
MPN = Most Probable Number

SU = Standard Unit
C = Degrees Centigrade

Table 7: Site Hydraulic Conductivity

Hydraulic Conductivity					
Well ID	DNREC No.	Screened Interval (ft bls)	Basin Depth (in ft bls)	Hydraulic Conductivity (feet/day)	Data Source
MW-11	208213	24-34		4	Whitman, Requardt and Associates
MW-12	208214	6-16		29	Whitman, Requardt and Associates
MW-13	208215	6-16		42	Whitman, Requardt and Associates
MW-14	208216	4-14		2	Whitman, Requardt and Associates
MW-15	208217	8-18		38	Whitman, Requardt and Associates
79008		42-47		332	Delaware Geological Survey
79009		73-78		491	Delaware Geological Survey
76371		31-36		50	Delaware Geological Survey
76529		83-88		297	Delaware Geological Survey
Basin Cell 1			0-12	24	RK&K
Basin Cell 2			0-7	10	RK&K

Table 8: Distance Drawdown Results and Method Averages

Results - Distance Drawdown				
		C ell 1		Cell 2
		W-1 and W-2	P-1 and P-2	P-4 and P-5
Day 1	K (ft/day)	26	8.8	8.2
	K (ft/min)	0.0181	0.0061	0.0057
	T (ft2/day)	2300	790	760
	T (ft2/min)	1.597	0.549	0.528
Day 2	K (ft/day)	35	12	7.6
	K (ft/min)	0.0243	0.0083	0.0053
	T (ft2/day)	3100	1000	710
	T (ft2/min)	2.153	0.694	0.493

Distance Drawdown - Average				
	Cell 1	Cell 2	Cell Avg.	St. Dev
T_{avg} (ft2/day)	1797.5	735.0	1266.3	751.3
T_{avg} (ft2/min)	1.25	0.51	0.88	0.52
Tstd	0.7607	0.0246	0.3926	0.5206
K_{avg} (ft/day)	20.5	7.9	14.2	8.9
K_{avg} (ft/min)	0.0142	0.0055	0.0098	0.0062
Kstd	0.00850	0.00029	0.0044	0.0058
Gallery K_{avg} (gpm)	318.7	123.1	220.9	138.3
Gallery K_{avg} (gpd)	458,898	177,276	318,087	199,137

AQTESOLV - Average				
	Cell 1	Cell 2	Cell Avg.	St. Dev
T_{avg} (ft2/day)	2425.1	990.9	1708.0	1014.1
T_{avg} (ft2/min)	1.68	0.69	1.19	0.70
S_{avg}	0.0029	0.0022	0.0025	0.0005
K_{est} (ft/day)	24.3	9.9	17.1	10.1
K_{est} (ft/min)	0.0168	0.0069	0.0119	0.0070
Gallery K_{avg} (gpm)	377.9	154.4	266.2	158.0
Gallery K_{avg} (gpd)	544,193	222,366	383,280	227,566

Method Average				
	Cell 1	Cell 2	Cell Avg.	St. Dev
T_{avg} (ft2/day)	2111.3	863.0	1487.1	882.7
T_{avg} (ft2/min)	1.47	0.60	1.03	0.61
K_{avg} (ft/day)	22.4	8.9	15.6	9.5
K_{avg} (ft/min)	0.0155	0.0062	0.0109	0.0066
Gallery K_{avg} (gpm)	348.3	138.8	243.5	148.2
Gallery K_{avg} (gpd)	501,546	199,821	350,683	213,352

Table 9: AQTSOLV Data Input and Results

AQTESOLV Coordinates										
Cell 1								Cell 2		
W-1	W-2	W-3	W-4	W-5	P-1	P-2	P-3	P-4	P-5	P-6
(0, 6.6)	(10.2, 0)	N/A	(-9.9, 0)	(1, 0)	(0, 4.4)	(6.3, 0)	(0, 0)	(10.4, 0)	(5.45, 0)	(0, 0)

AQTESOLV Erroneous Values										
Cell 1								Cell 2		
W-1	W-2	W-3	W-4	W-5	P-1	P-2	P-3	P-4	P-5	P-6
1612 to 1623	1631 to 1646 7417 to 7432	N/A	N/A	7413	7410 to 7428	N/A	7413 to 7419	1662 to 1831 7392 to 7400	7394 to 7397	N/A

In Elapsed Time from Testing Start

AQTESOLV								
Cell 1						Cell 2		
Aquifer Type	Leaky Confined Aquifer					Unconfined Aquifer		
Solution Type	Hantush-Jacob (1955) / Hantush (1964) Solution for a Pumping Test in a Leaky Aquifer					Cooper-Jacob (1946) Solution for a Pumping Test in an Unconfined Aquifer		
	W-1	W-2	W-5	P-1	P-2		P-4	P-5
T (ft^2/min)	0.8775	2.346	2.221	1.976	1	T (ft^2/min)	0.9321	0.4442
S	3.12E-03	2.28E-03	7.24E-03	6.14E-04	1.00E-03	S	2.557E-05	4.31E-03
r/B	0.1	0.1	0.1	0.1	0.1			
Kz/Kr	1	1	1	1	1			
b (ft)	100	100	100	100	100			
T = transmissivity, S = storativity, r/B = leakage parameter,								

AQTESOLV - Average				
	Cell 1	Cell 2	Cell Avg.	St. Dev
T_{avg} (ft2/day)	2425.1	990.9	1708.0	1014.1
T_{avg} (ft2/min)	1.68	0.69	1.19	0.70
Tstd	0.6947	0.3450	0.5198	0.2472
S_{avg}	0.0029	0.0022	0.0025	0.0005
K_{est} (ft/day)	24.3	9.9	17.1	10.1
Sstd	0.0027	0.0030	0.0028	0.0003
K_{est} (ft/min)	0.0168	0.0069	0.0119	0.0070
Gallery K_{avg} (gpm)	377.9	154.4	266.2	158.0
Gallery K_{avg} (gpd)	544,193	222,366	383,280	227,566

Table 10: Water Balance Estimates

SGW Area (ac): 6.24						Water Balance - Low Precipitation/ET - January/February					
Influent (gal/day)	Precipitation (in/month)	(gal/day)	Ksatv (in/hr)	Infiltration (gal/day)	Adjusted ET (in/month)	(gal/day)	Infiltration (gal/min) per 10x10 cell	Infiltration (gal/min) per width of SGW (300 ft)	(gal/day)	Excess Water (gal/day)	Excess Water (gpm)
750,000	3.19	18,016	0.1	406,634	0.504	2,846	12	360	518,400	-159,865	0
900,000	3.19	18,016	0.1	406,634	0.504	2,846	12	360	518,400	-9,865	-7
1,000,000	3.19	18,016	0.1	406,634	0.504	2,846	12	360	518,400	90,135	63
1,250,000	3.19	18,016	0.1	406,634	0.504	2,846	12	360	518,400	340,135	236
Water Balance - High Precipitation/ET - July/August											
Influent (gal/day)	Precipitation (in/month)	(gal/day)	Ksatv (in/hr)	Infiltration (gal/day)	Adjusted ET (in/month)	(gal/day)	Infilitration (gal/min) per 10x10 cell	Infilitration (gal/min) per width of SGW (300 ft)	(gal/day)	Excess Water (gal/day)	Excess Water (gpm)
750,000	5.59	31,571	0.1	406,634	5.262	29,718	12	360	518,400	-173,182	0
900,000	5.59	31,571	0.1	406,634	5.262	29,718	12	360	518,400	-23,182	-16
1,000,000	5.59	31,571	0.1	406,634	5.262	29,718	12	360	518,400	76,818	53
1,250,000	5.59	31,571	0.1	406,634	5.262	29,718	12	360	518,400	326,818	227
Water Balance - Average Precipitation/ET											
Influent (gal/day)	Precipitation (in/month)	(gal/day)	Ksatv (in/hr)	Infiltration (gal/day)	Adjusted ET (in/month)	(gal/day)	Infiltration (gal/min) per 10x10 cell	Infiltration (gal/min) per width of SGW (300 ft)	(gal/day)	Excess Water (gal/day)	Excess Water (gpm)
750,000	3.78	21,320	0.1	406,634	2.63	14,853	12	360	518,400	-168,568	0
900,000	3.78	21,320	0.1	406,634	2.63	14,853	12	360	518,400	-18,568	-13
1,000,000	3.78	21,320	0.1	406,634	2.63	14,853	12	360	518,400	81,432	57
1,250,000	3.78	21,320	0.1	406,634	2.63	14,853	12	360	518,400	331,432	230

Table 11: Soil Chemical Analysis

Soil Chemical Analysis													
Sample ID	Sample Time	Sample Date	Nitrite (mg/kg)	Nitrate (mg/kg)	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Potassium (mg/kg)	Zinc (mg/kg)	pH (S.U.)	Total Nitrogen (mg/kg)	Phosphorus (mg/kg P2O5)
S-1	9:35	8/19/2021	ND	1.3	ND	10	9.70	14.0	2,300	49	5.1	290	99.1
S-2	10:15	8/19/2021	ND	1.6	ND	11	8.70	19.0	2,400	50	5.1	190	124.0
S-3	10:45	8/19/2021	ND	1.2	ND	4	4.00	7.3	890	31	6.8	120	239.0
1A	Various Between 4/8/21 to 5/1/21		<1.0	31	<0.1	ND	5.45	1.8	ND	ND	ND	214.0	ND
1B			<1.0	1	<0.1	ND	3.39	2.4	ND	ND	ND	1.1	ND
2A			<1.0	13	<0.1	ND	3.85	1.4	ND	ND	ND	13.1	ND
2B			<1.0	1	<0.1	ND	1.85	1.6	ND	ND	ND	1.1	ND
3A			<1.0	13	<0.1	ND	5.56	2.2	ND	ND	ND	203.0	ND
3B			<1.0	<1.0	<0.1	ND	3.41	3.0	ND	ND	ND	<1.0	ND

Sample ID	Organic Matter (%)	W/V Soil Class	ENR (lb/A)	Phosphorus (ppm)	Potassium (ppm)	Magnesium (ppm)	Calcium (ppm)	Sodium (ppm)	pH		Acidity (H meq/100g)	C.E.C. (meq/100g)
									Soil pH	Buffer Index		
S-1	0.9	ND	61	8	101	93	329	83	5	6.72	2.1	5.1
S-2	0.9	ND	61	8	99	100	364	78	5.2	6.76	1.7	4.9
S-3	0.8	ND	58	16	91	137	415	76	5.2	6.73	2	5.8
1A	1.1	ND	66	142	44	69	712	11	5.8	6.83	1	5.3
1B	0.5	ND	53	101	39	43	209	15	6.7	ND	0.1	1.7
2A	0.7	ND	58	120	36	70	291	9	6.8	ND	0.1	2.3
2B	0.2	ND	45	65	46	66	441	14	6.9	ND	0	2.9
3A	1.3	ND	70	299	61	92	484	19	6.4	ND	0.3	3.7
3B	0.5	ND	43	125	56	65	265	21	6.9	ND	0	2.1

Sample ID	Precent Base Saturation					Nitrate (ppm)	Sulfur (ppm)	Zinc (ppm)	Manganese (ppm)	Iron (ppm)	Copper (ppm)	Boron (ppm)	Soluble Salts (ms/cm)	Sodium Absorption Ratio (ppm)	TKN (ppm)
	K %	Mg %	Ca %	Na %	H %										
S-1	5.1	15.2	32.3	7.1	41.2	ND	51	0.6	3	55	0.7	0.2	ND	1.04	290
S-2	5.2	17.0	37.1	6.9	34.7	ND	29	0.4	1	42	0.4	0.2	ND	0.93	190
S-3	4.0	19.7	35.8	5.7	34.5	ND	37	0.5	8	44	0.2	0.1	ND	0.83	120
1A	2.1	10.8	67.2	0.9	18.9	ND	14	4	16	104	1.2	0.2	ND	0.26	183
1B	5.9	21.1	61.5	3.8	5.9	ND	4	1.2	10	79	0.5	0.1	ND	2.07	<50
2A	4.0	25.4	63.3	1.7	4.3	ND	3	4.3	8	78	0.7	0.1	ND	0.32	<50
2B	4.1	19.0	76.0	2.1	0.0	ND	5	1.5	23	61	0.5	0.1	ND	1.09	<50
3A	4.2	20.7	65.4	2.2	8.0	ND	7	7.4	16	143	1.2	0.3	ND	1.05	190
3B	6.8	25.8	63.1	4.3	0.0	ND	5	2.3	9	73	0.6	0.1	ND	3.57	<50

Laboratory Reported Mehlich-3 Range color code: Very Low | Low | Medium | High | Very High

ND = No Data

FIGURES

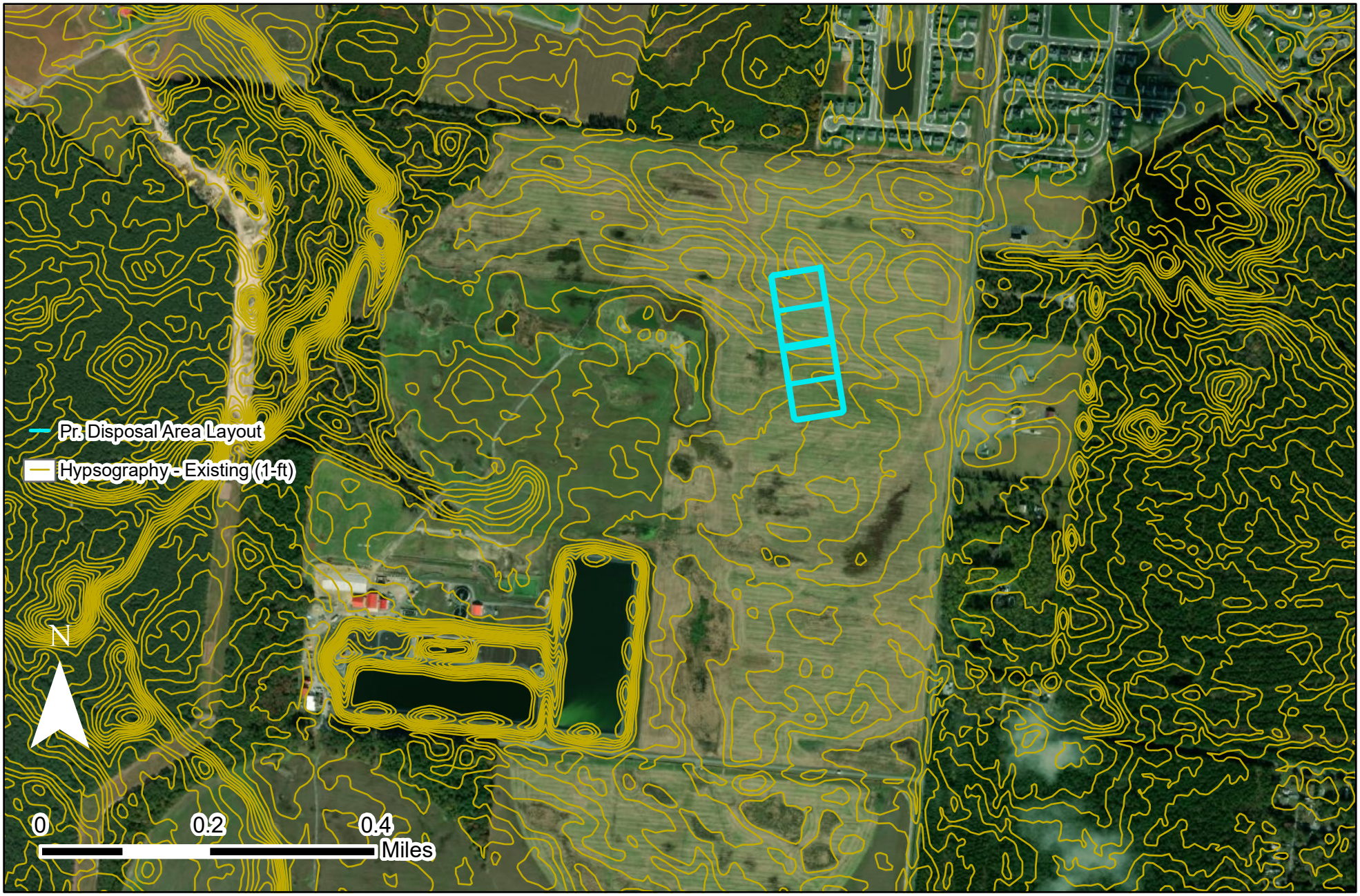
RK&K	General Project Location Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Drawn By: RMH Date: 05/03/2021 **Figure 1**

RK&K

Surface Water and Test Borings
Inland Bays Wastewater Treatment Facility

Project #: 18208.000	
Drawn By: RMH	Date: 04/30/2021

Figure 2

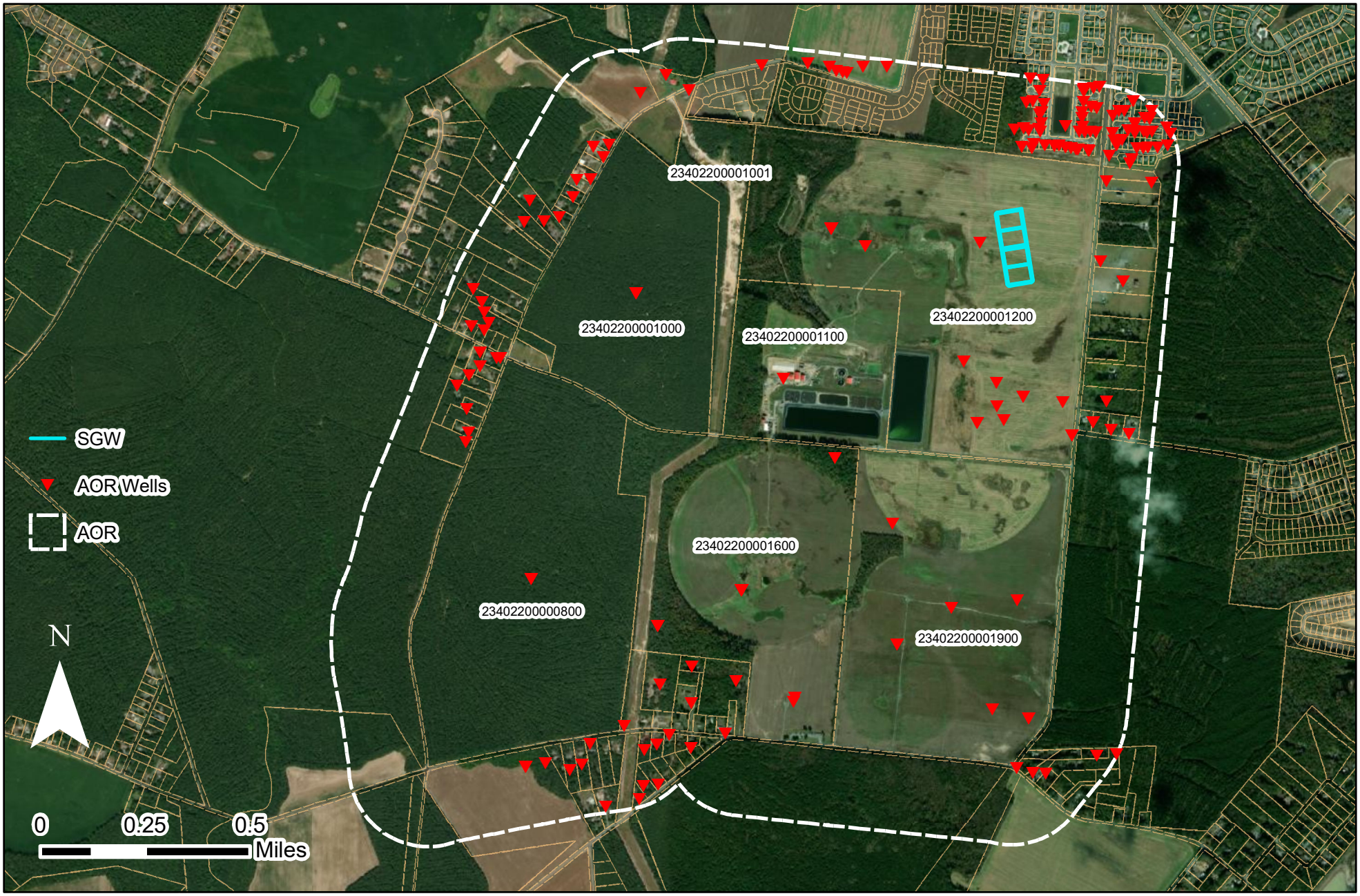


RK&K

Pre-Development Hypsography
Inland Bays Wastewater Treatment Facility

Project #: 18208.000	
Drawn By: RMH	Date: 04/30/2021

Figure 3



RK&K	Area of Review - Wells within 1,000 Ft of Project Area Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Drawn By: RMH Date: 04/30/2021 **Figure 4**

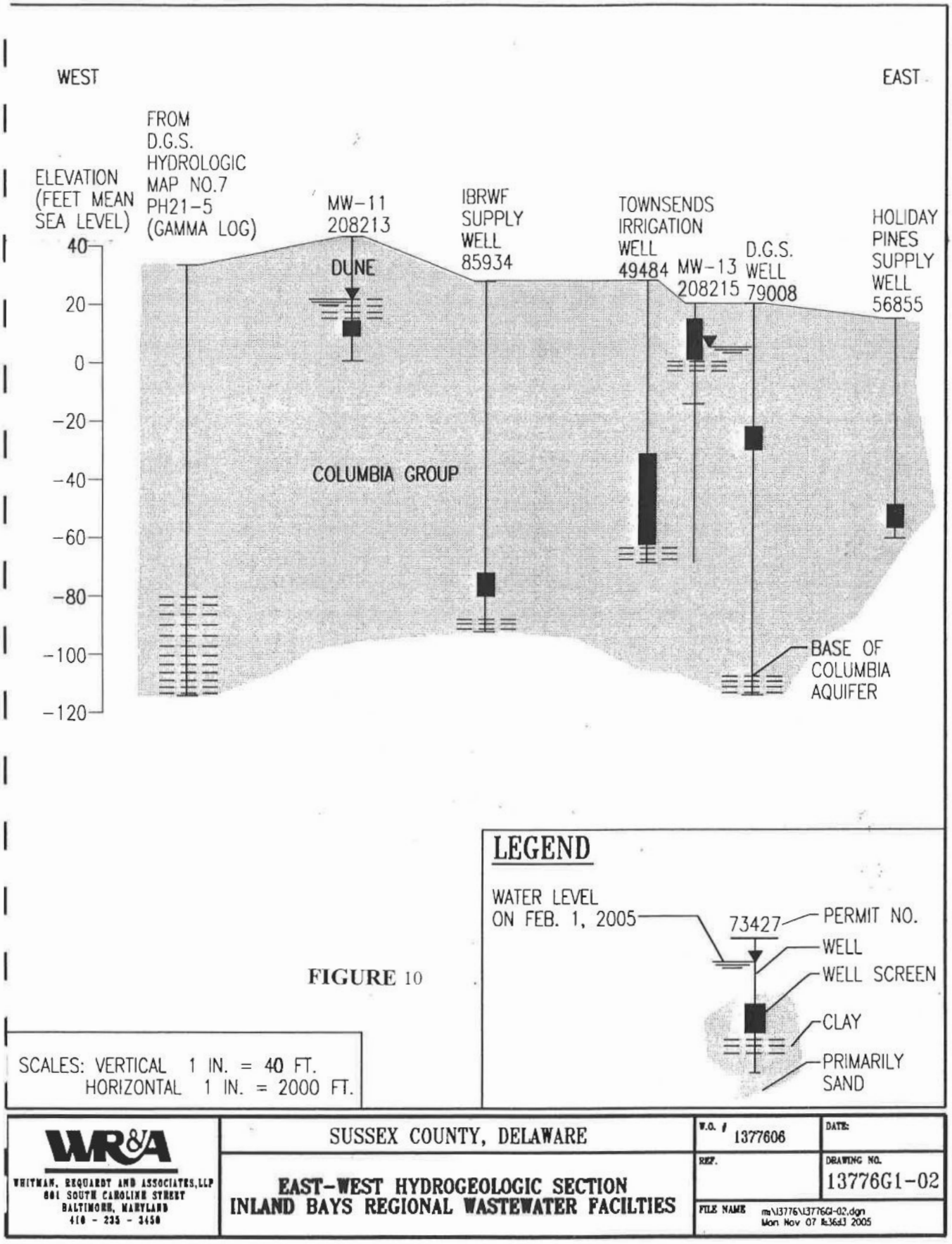
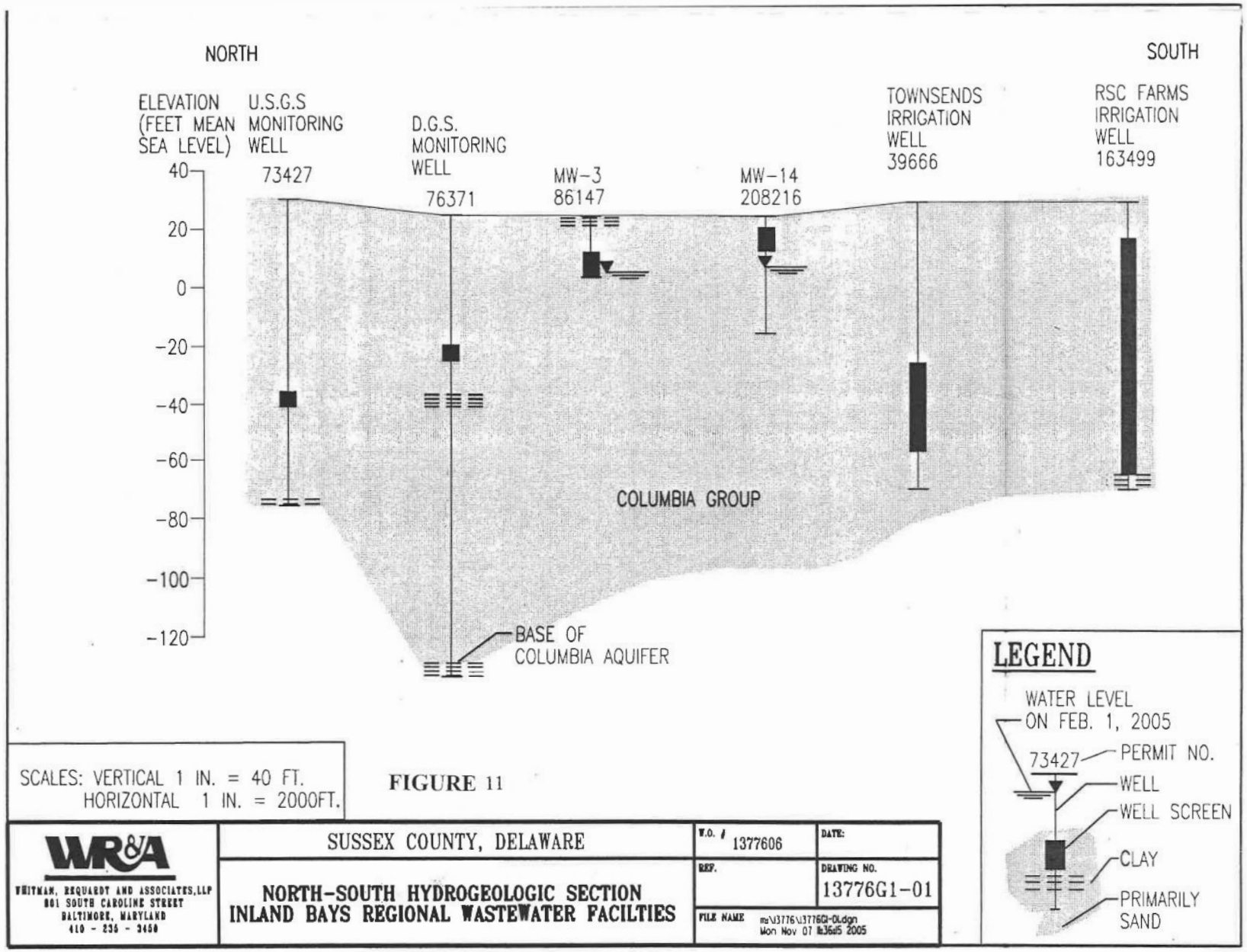


FIGURE 10

RK&K Engineers | Construction Managers | Planners | Scientists	West to East Cross-Section (modified from WRA) Inland Bays Wastewater Treatment Facility	Project #: 18208.000
		Date: 2021-12-22
		Figure 5



RK&K
Engineers | Construction Managers | Planners | Scientists

North to South Cross-Section (modified from WRA)
Inland Bays Wastewater Treatment Facility

Project #: 18208.000

Date: 2021-12-22

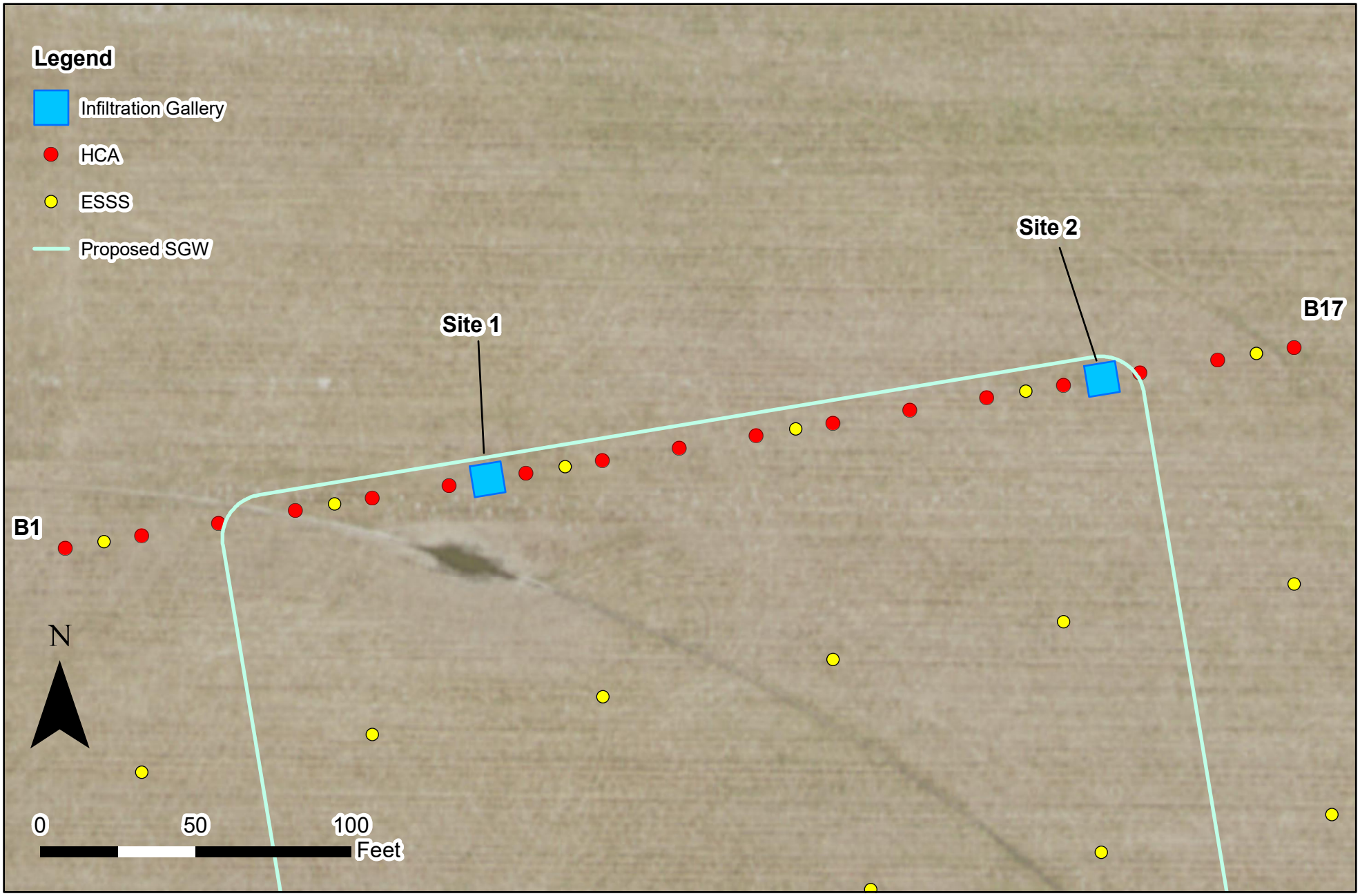
Figure 6

RK&K

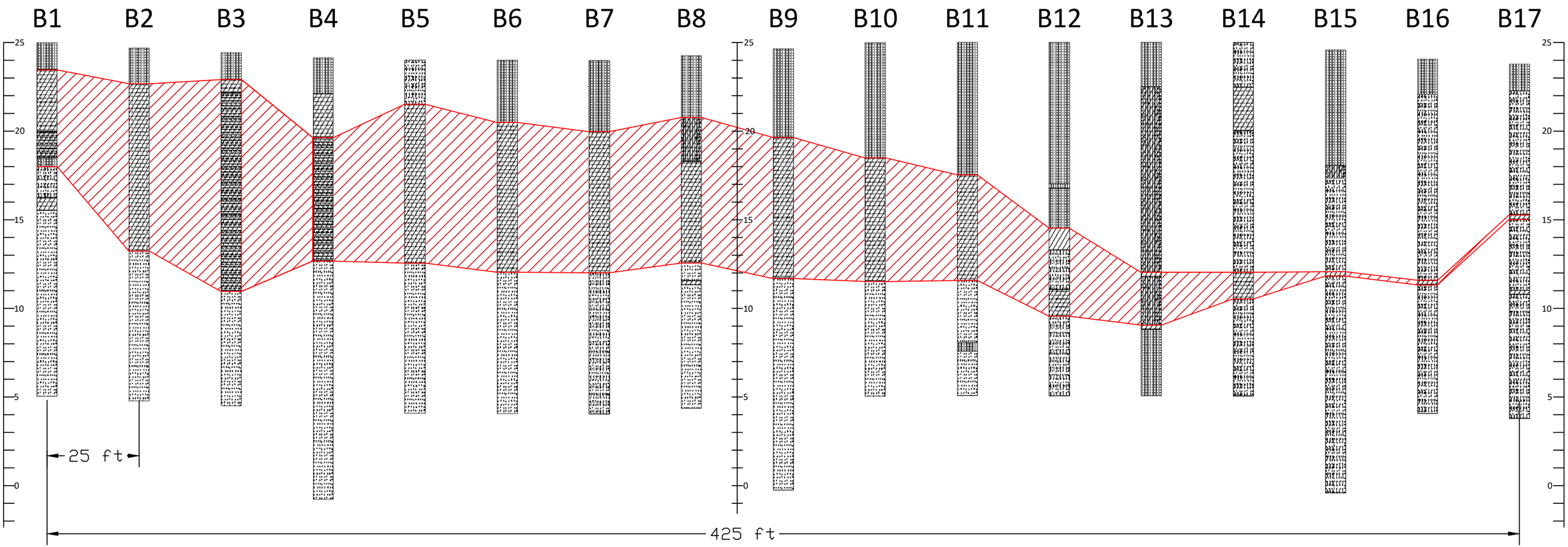
Surficial Geology - DGS Map No. 16 Excerpt
Inland Bays WWTP Submerged Gravel Wetland

Project #: 18208.000	
Drawn By: JAM	Date: 2021-12-22

Figure 7



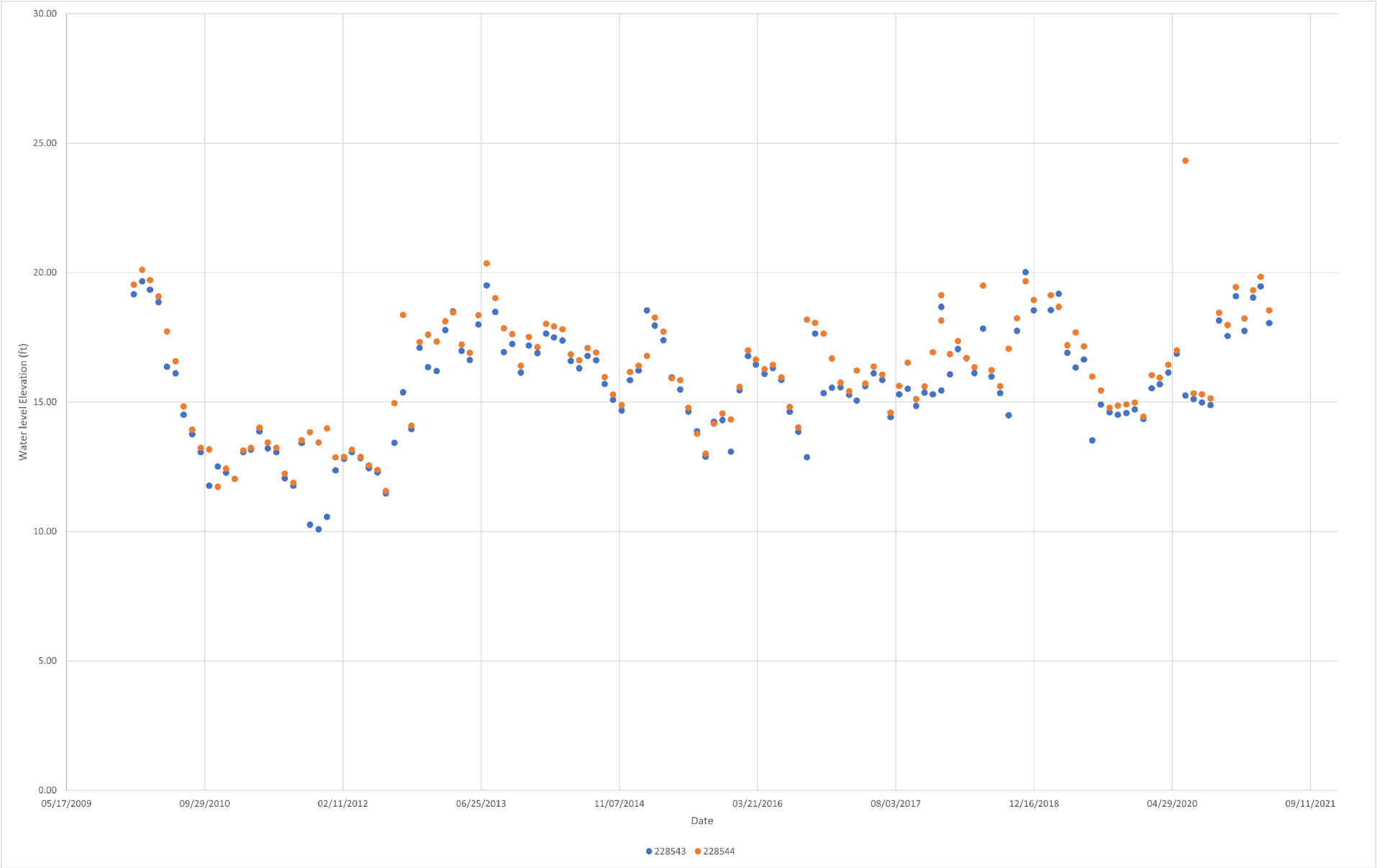
RK&K	Transect 1 and Basin Test Location Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Drawn By: RMH Date: 09/07/2021 **Figure 8**



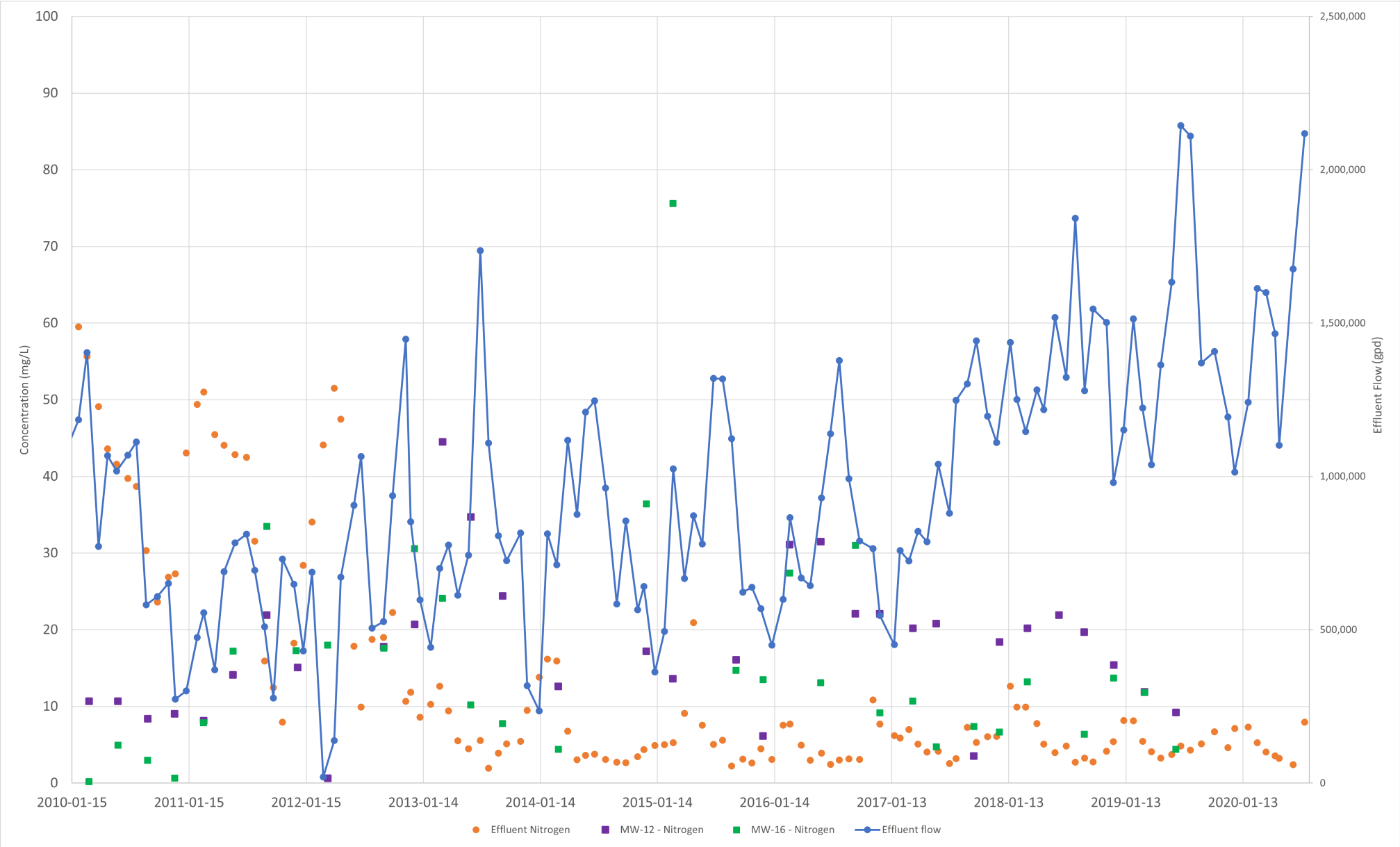
Restrictive Layer

*Sidebar scales represent Elevation

RK&K	Transect 1 Cross-Section Inland Bays Wastewater Treatment Plant	Project #: 18208.002 Date: 09/07/2021 **Figure 9**



RK&K	**Hydrograph for MW16 (228543) & OW17 (228544)**	Project #: 18208.000 Drawn By: RMH Date: 05/27/2021 **Figure 10**



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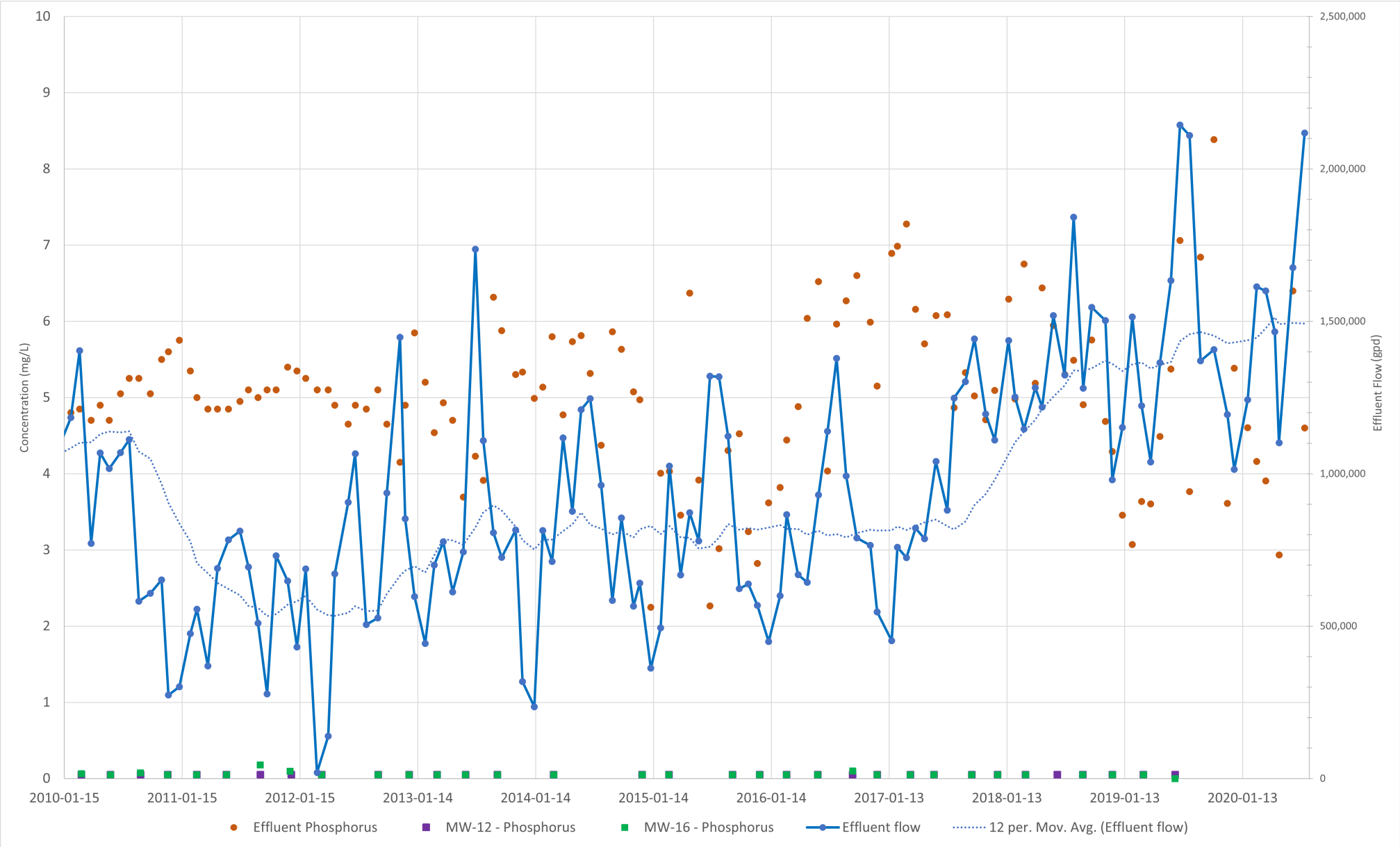
Time Series Water Quality Graphs showing
Effluent Nitrogen Concentrations
Inland Bays Wastewater Treatment Facility

Project #: 18208.000

Date: 2021-12-16

Figure 11



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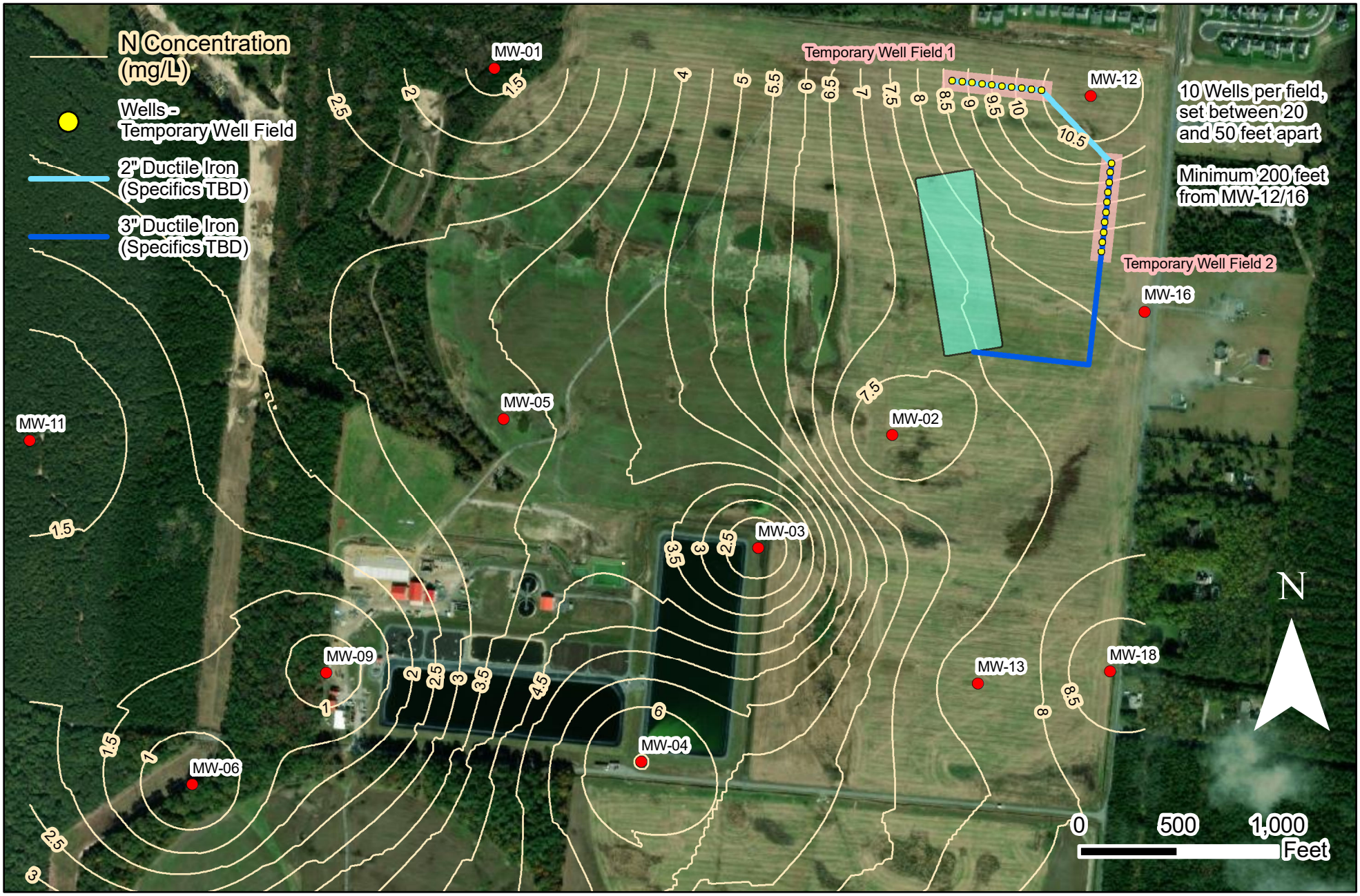
Time Series Water Quality Graphs showing
Effluent Phosphorus Concentrations
Inland Bays Wastewater Treatment Facility

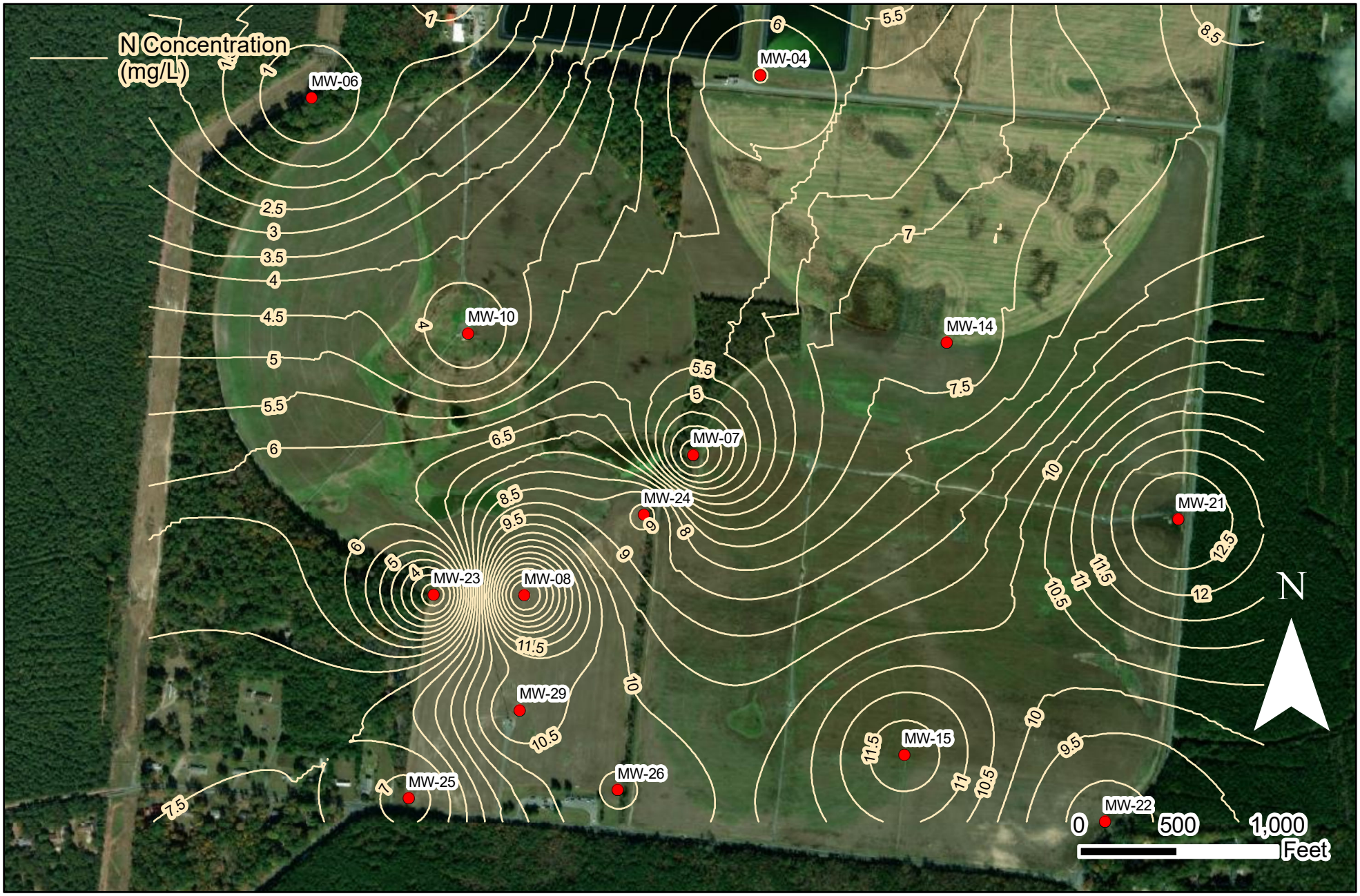
Project #: 18208.000

Date: 2021-12-22

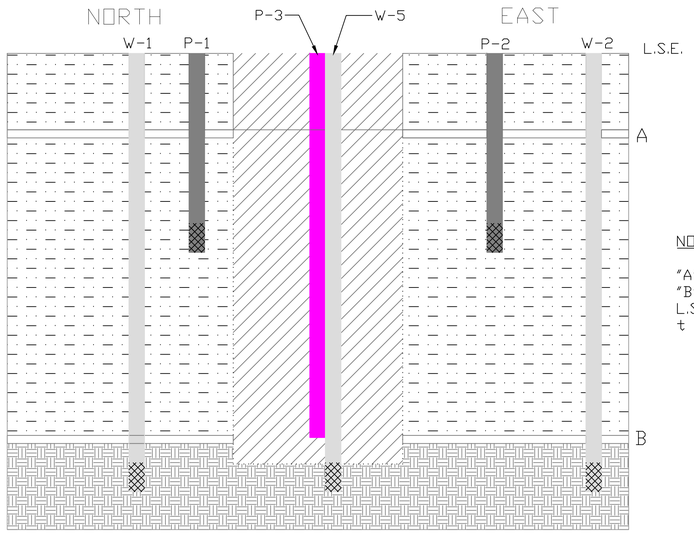
Figure 12



RK&K	Average Nitrogen Concentration of Groundwater Samples for the North Spray Fields Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Drawn By: RMH Date: 2022-01-27 **Figure 13**



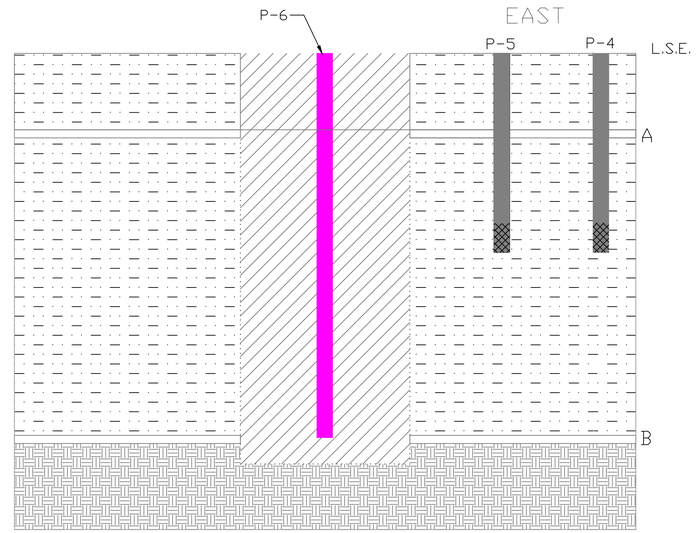
RK&K	Average Nitrogen Concentration of Groundwater Samples for the South Spray Fields Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Drawn By: RMH Date: 06/18/2021 **Figure 14**



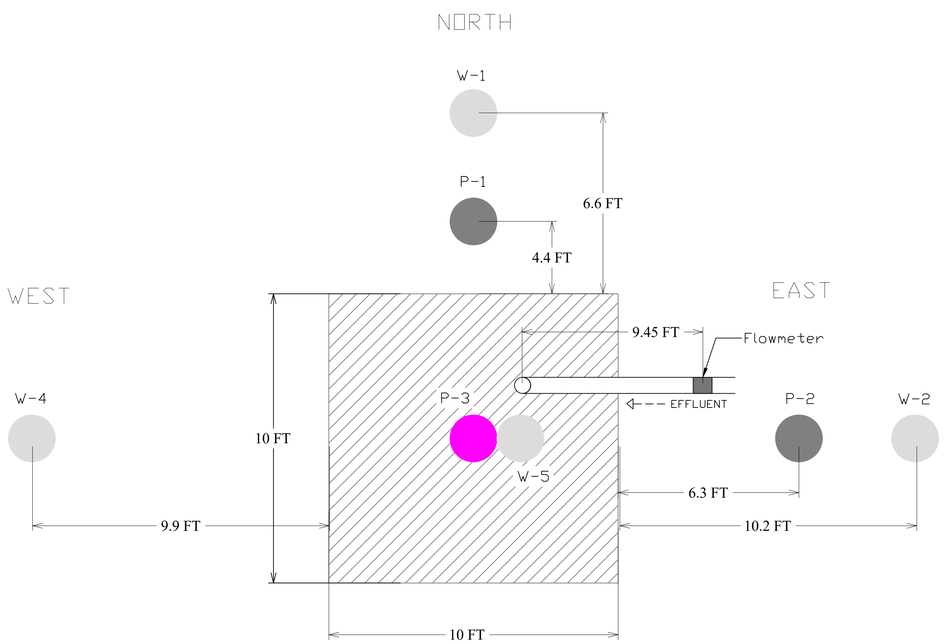
NOTES

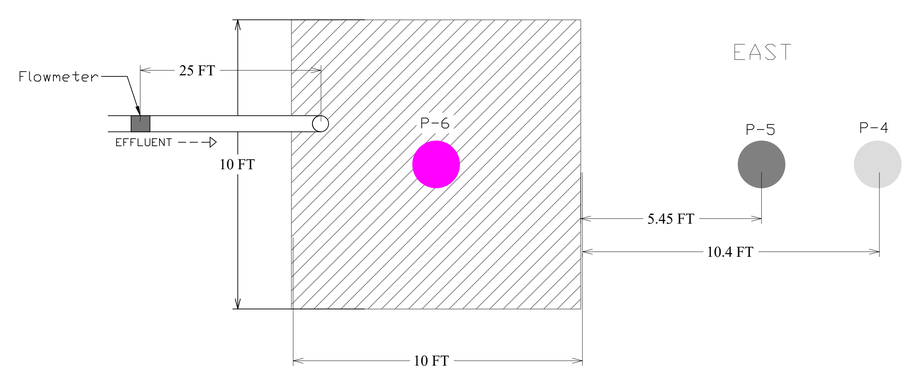
"A" = TOP OF RESTRICTIVE LAYER
"B" = BASE OF RESTRICTIVE LAYER
L.S.E. = LAND SURFACE ELEVATION
t = THICKNESS, UNKNOWN DEPTH

INFILTRATION CELL 1 CROSS-SECTION



INFILTRATION CELL 2 CROSS-SECTION





2" DIAMETER WELL

SHALLOW PIEZOMETER

PIT PIEZOMETER

INFILTRATION CELL 1 - PLAN VIEW

INFILTRATION CELL 2 - PLAN VIEW

REVISIONS

CLIENT INFORMATION

SUSSEX COUNTY, DE
ENGINEERING
DEPARTMENT

INLAND BAYS RWF
SUBMERGED GRAVEL
WETLAND
CONTRACT 18208.002

KEY - PLAN

GRAPHIC SCALES

SIGNATURE

RK&K
One Riverwalk Center
110 South Poplar Street, Suite 102 | Wilmington, DE 19801

SUBMERGED GRAVEL WETLAND - BASIN TEST GRAPHICS

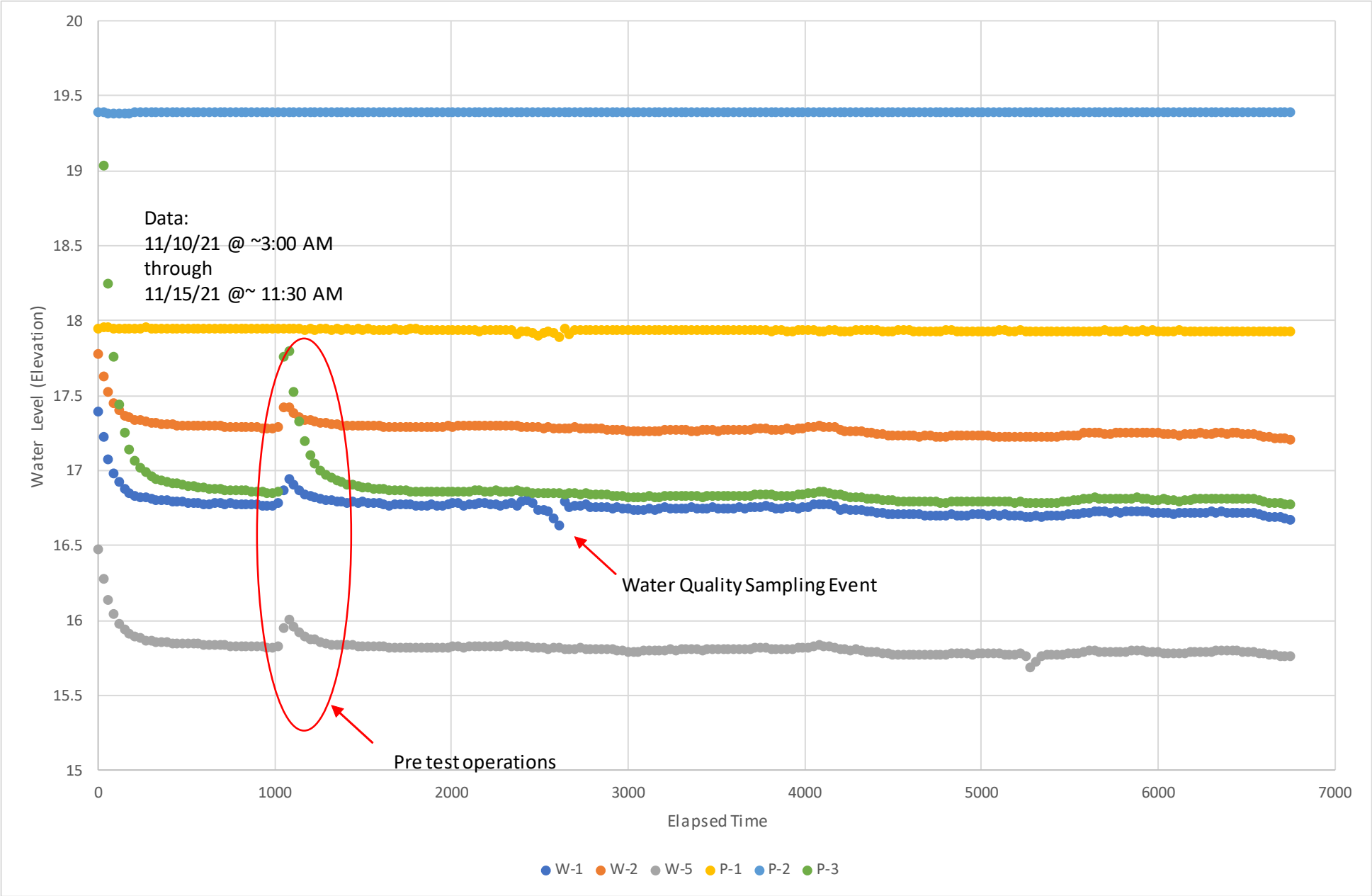
DRAWING NO.

Figure 15

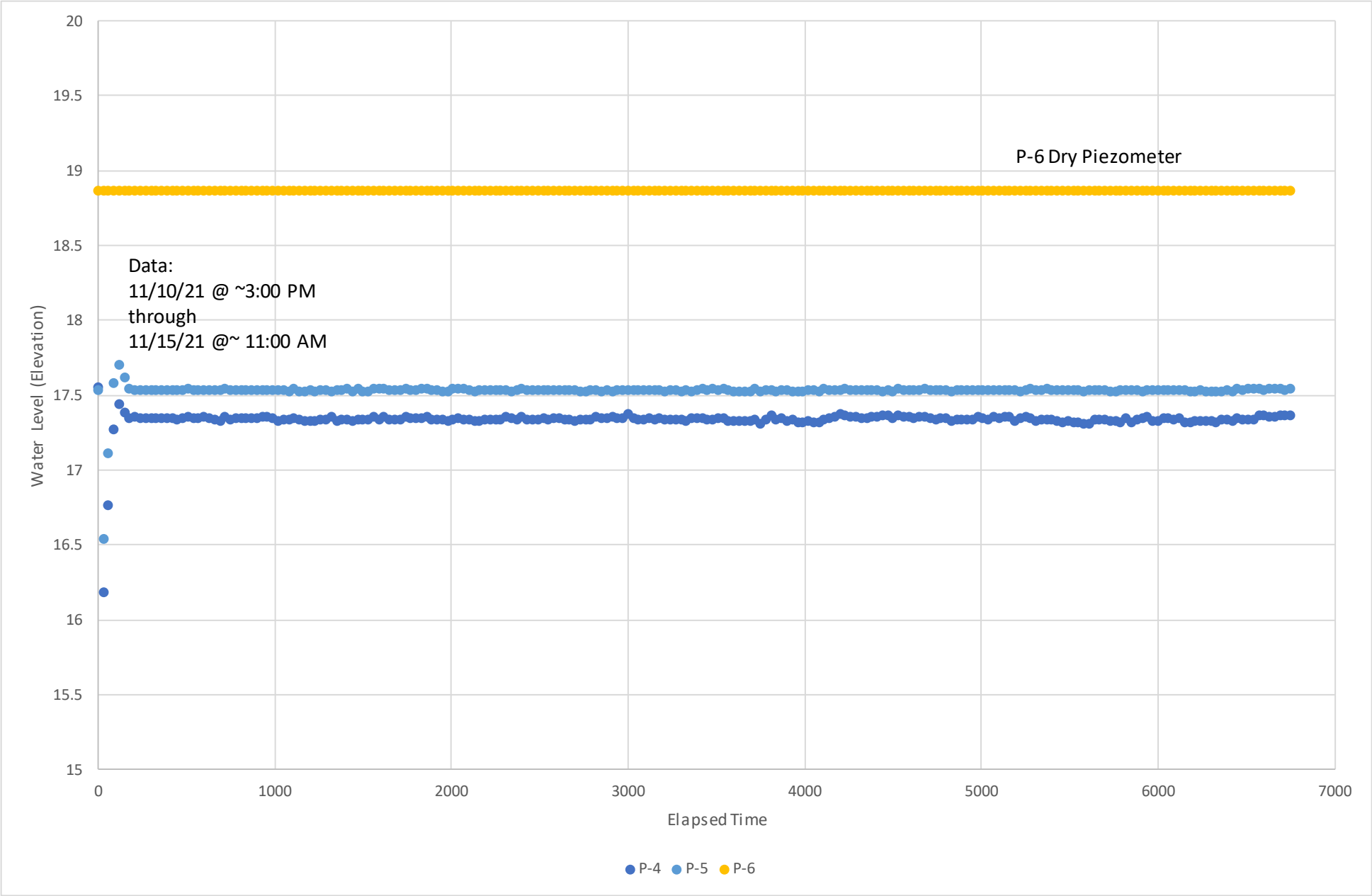
SCALE: AS NOTED		
DATE: DEC. 2021	SHEET 1	
DES: JKM	DRAWN: JKM	CHECK: JM

BY: rhiggins

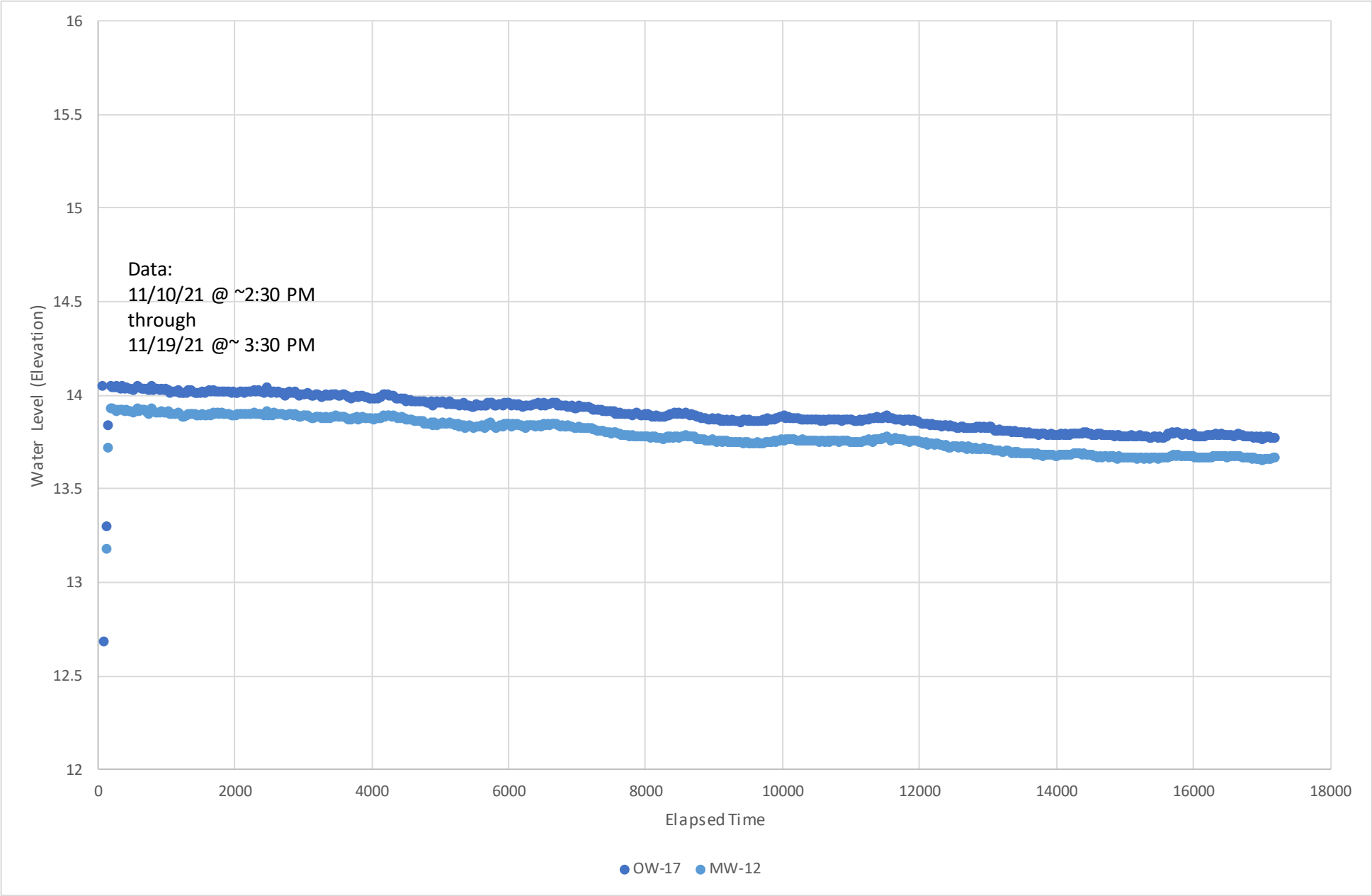
FILE PATH: \\ad.rkk.com\fs\Cloud\Projects\2018\18208_SusBanking\Inland Bays WWTP\CADD\Working\RMH\SGW Graphics - RMH.dwg
PLOTTED: Monday, December 20, 2021 3:55:24 PM



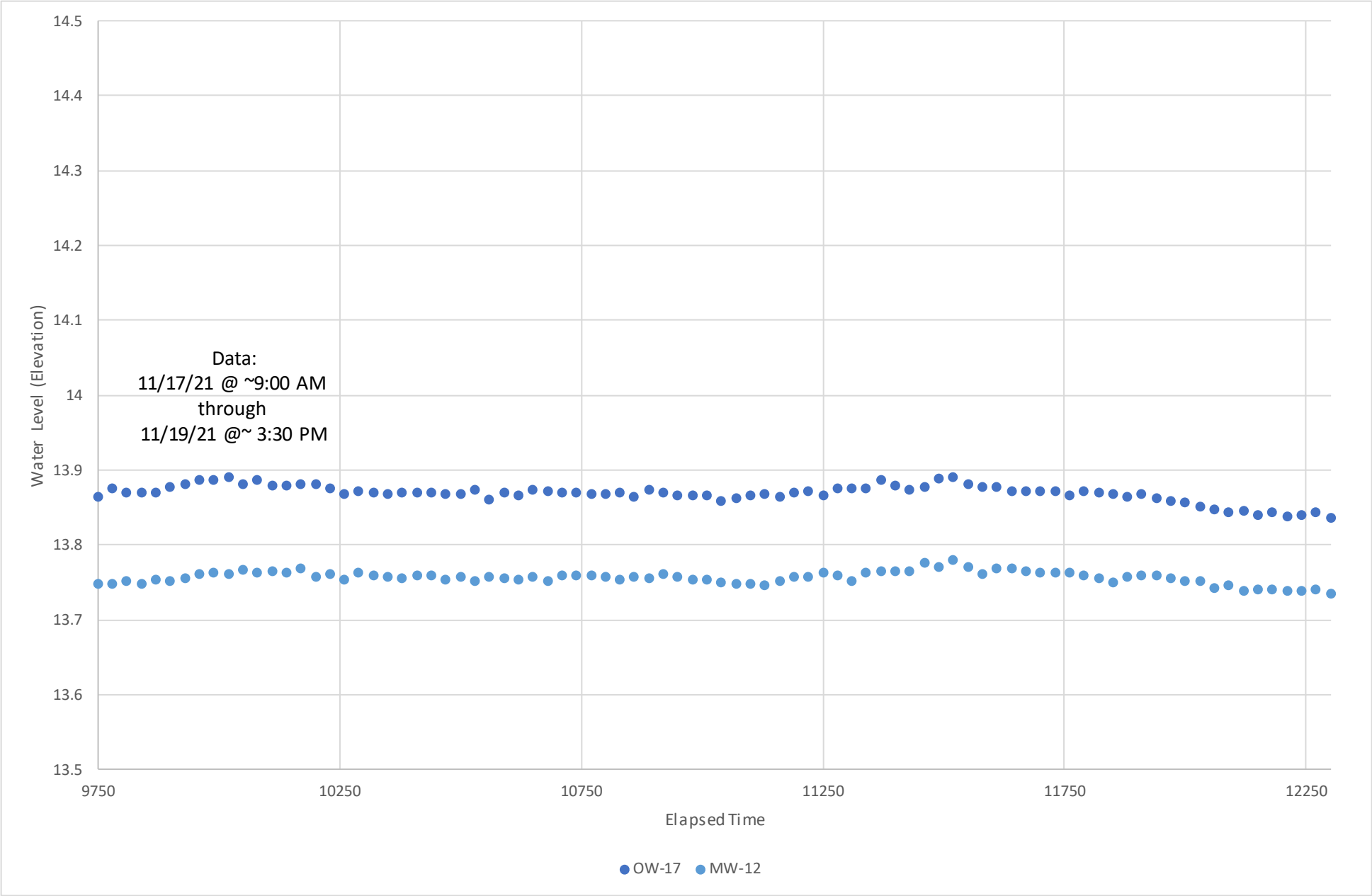
RK&K	Cell 1 - Background Water Levels Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Date: 2021-12-16 **Figure 16**



RK&K	Cell 2 - Background Water Levels Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Date: 2021-12-16 **Figure 17**



RK&K	Far Field Water Levels Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Date: 2021-12-16 **Figure 18**



RK&K	Far Field Testing Event Water Levels Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Date: 2021-12-16 **Figure 19**

PUMPING WELL ID: P-3

INPUT

Construction:	
Casing dia. (d_c)	2 Inch
Annulus dia. (d_w)	2 Inch
Screen Length (L)	12 Feet
Depths to:	
Initial Depth to Water	29.6 Feet
Top of Aquifer	20 Feet
Base of Aquifer	120 Feet
Annular Fill:	
across screen -- Coarse Sand	
above screen -- Backfill	
Aquifer Material -- Medium Sand	
FLOW RATE	16.7 GPM

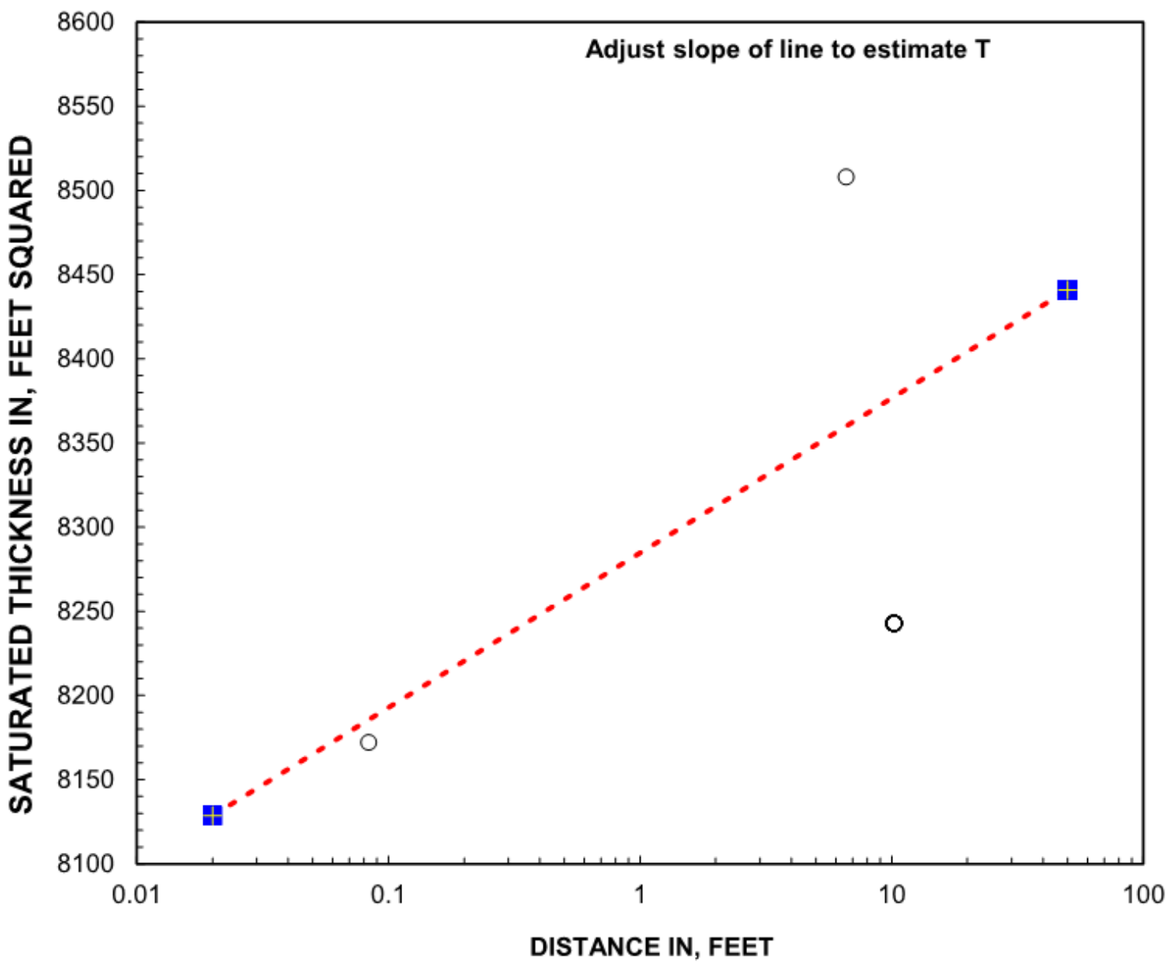
Date: 2021-12-15
Time: 14:20

COMPUTED

Aquifer thickness = 90 Feet
Aquifer is: **UNCONFINED**
Slope = 91.88797 Feet²/log10

Input is consistent.

K = 26 Feet/Day
T = 2300 Feet²/Day



REMARKS: Drawdown-Distance analysis of multi-well aquifer test

Infiltration Cell Testing Event
Inland Bays Regional Wastewater Treatment Facility, Millsboro, DE
Data from End of Day 1 of Testing Event, Cell 1: W-1 and W-2
11/17/2021, 5:15 PM, Elapsed Time from Test Start = 490 minutes

PUMPING WELL ID: P-3

INPUT

Construction:	
Casing dia. (d_c)	2 Inch
Annulus dia. (d_w)	2 Inch
Screen Length (L)	12 Feet
Depths to:	
Initial Depth to Water	29.6 Feet
Top of Aquifer	20 Feet
Base of Aquifer	120 Feet
Annular Fill:	
across screen -- Coarse Sand	
above screen -- Backfill	
Aquifer Material -- Medium Sand	
FLOW RATE	16.7 GPM

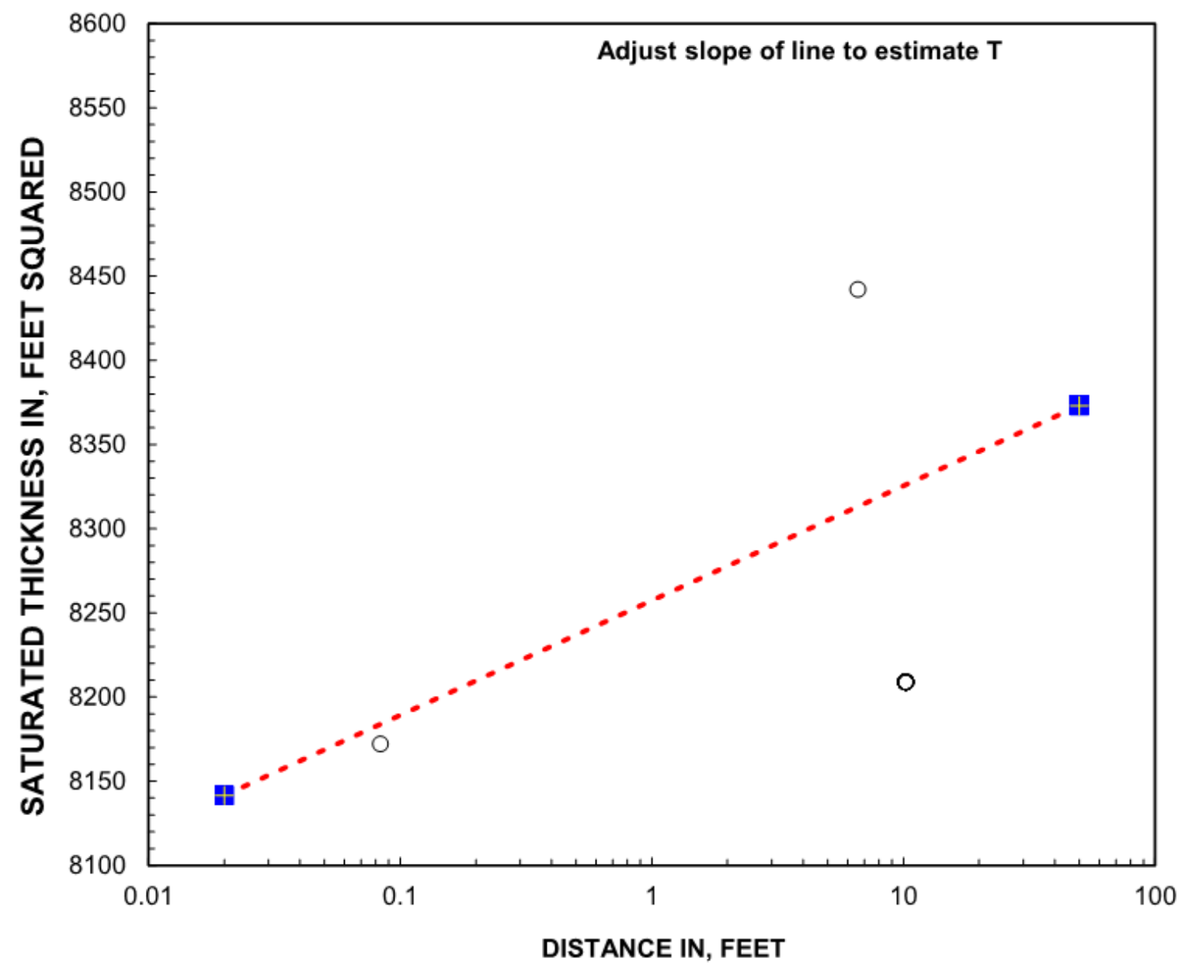
Date: 4:23 PM
Time: 16:23

COMPUTED

Aquifer thickness = 90 Feet
Aquifer is: **UNCONFINED**
Slope = 68.14153 Feet²/log10

Input is consistent.

K = 35 Feet/Day
T = 3100 Feet²/Day



REMARKS: Drawdown-Distance analysis of multi-well aquifer test

Infiltration Cell Testing Event
Inland Bays Regional Wastewater Treatment Facility, Millsboro, DE
Data from End of Day 2 of Testing Event, Cell 1: W-1 and W-2
11/18/2021, 4:30 PM, Elapsed Time from Test Start = 1,885 minutes

RK&K
Engineers | Construction Managers | Planners | Scientists

Distance Drawdown for Cell 1 - W-1 and W-2 - Day 1 and Day 2
Inland Bays Wastewater Treatment Facility

Project #: 18208.000
Date: 2021-12-22

Figure 20

PUMPING WELL ID: P-3

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	12	Feet
Depths to:		
Initial Depth to Water	29.6	Feet
Top of Aquifer	20	Feet
Base of Aquifer	120	Feet
Annular Fill:		
across screen -- Coarse Sand		
above screen -- Backfill		
Aquifer Material -- Fine Sand		
FLOW RATE	16.7	GPM

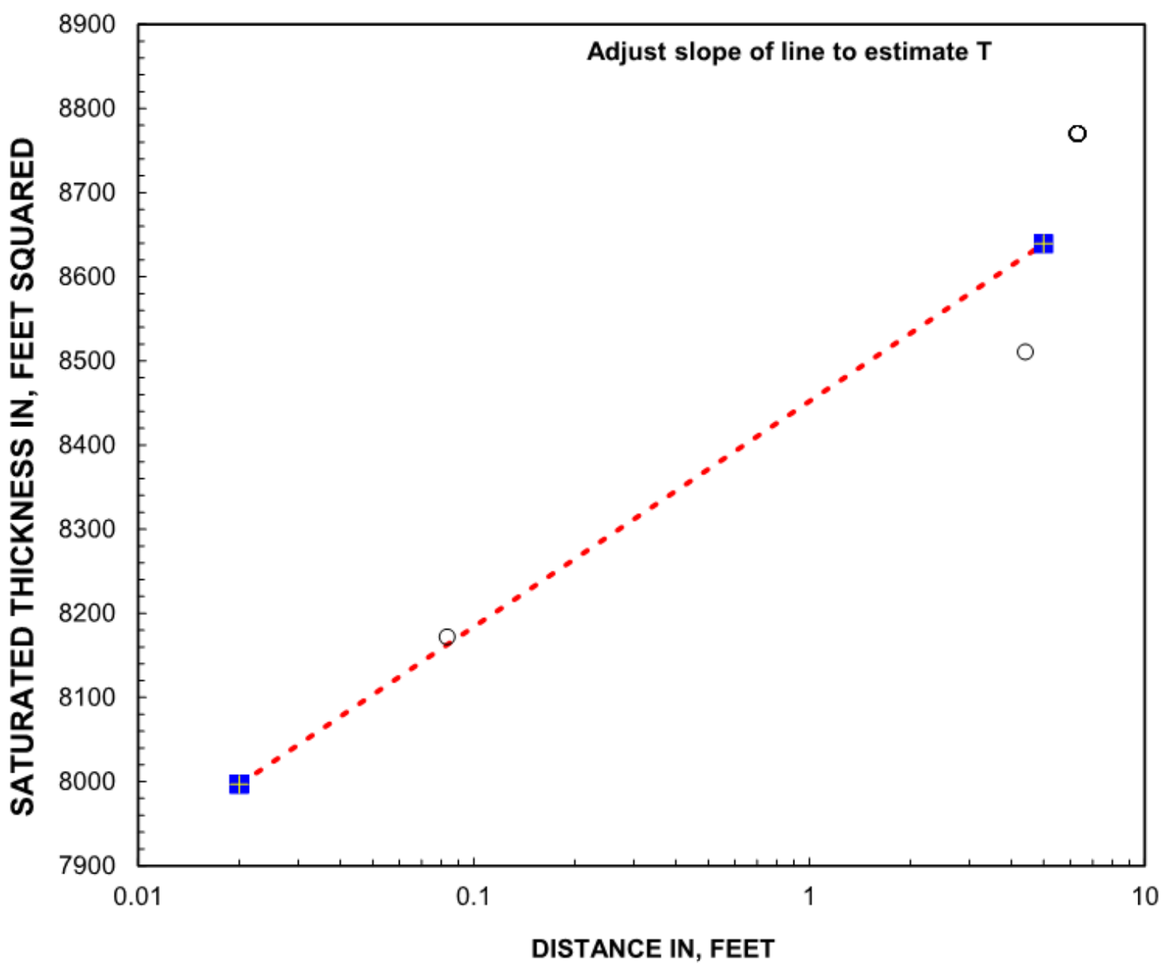
Date: 2021-12-15
Time: 14:20

COMPUTED

Aquifer thickness = 90 Feet
Aquifer is: **UNCONFINED**
Slope = 267.9973 Feet²/log10

Input is consistent.

K = 8.8 Feet/Day
T = 790 Feet²/Day



REMARKS: Drawdown-Distance analysis of multi-well aquifer test

Infiltration Cells Testing Event
Inland Bays Regional Wastewater Treatment Facility, Millsboro, DE
Data from End of Day 1 of Testing Event, Cell 1: P-1 and P-2
11/17/2021, 5:15 PM, Elapsed Time from Test Start = 490 minutes

PUMPING WELL ID: P-3

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	12	Feet
Depths to:		
Initial Depth to Water	29.6	Feet
Top of Aquifer	20	Feet
Base of Aquifer	120	Feet
Annular Fill:		
across screen -- Coarse Sand		
above screen -- Backfill		
Aquifer Material -- Fine Sand		
FLOW RATE	16.7	GPM

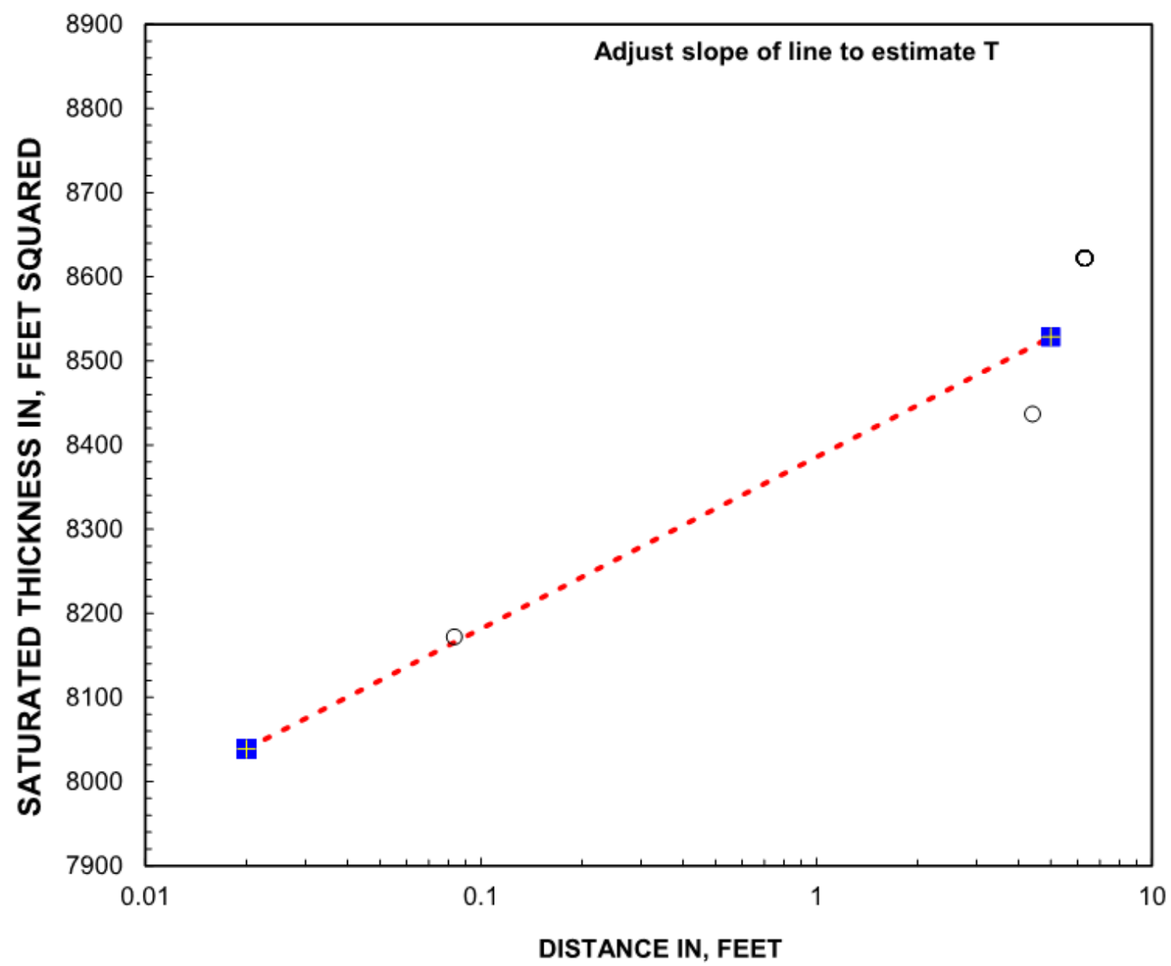
Date: 2021-12-15
Time: 14:20

COMPUTED

Aquifer thickness = 90 Feet
Aquifer is: **UNCONFINED**
Slope = 204.0831 Feet²/log10

Input is consistent.

K = 12 Feet/Day
T = 1000 Feet²/Day



REMARKS: Drawdown-Distance analysis of multi-well aquifer test

Infiltration Cells Testing Event
Inland Bays Regional Wastewater Treatment Facility, Millsboro, DE
Data from End of Day 2 of Testing Event, Cell 1: P-1 and P-2
11/18/2021, 4:30 PM, Elapsed Time from Test Start = 1,885 minutes

RK&K
Engineers | Construction Managers | Planners | Scientists

Distance Drawdown for Cell 1 - P-1 and P-2 - Day 1 and Day 2
Inland Bays Wastewater Treatment Facility

Project #: 18208.000
Date: 2021-12-22

Figure 21

PUMPING WELL ID: P-6

INPUT

Construction:	
Casing dia. (d_c)	2 Inch
Annulus dia. (d_w)	2 Inch
Screen Length (L)	8 Feet
Depths to:	
Initial Depth to Water	27 Feet
Top of Aquifer	20 Feet
Base of Aquifer	120 Feet
Annular Fill:	
across screen --	Coarse Sand
above screen --	Backfill
Aquifer Material --	Fine Sand
FLOW RATE	19.7 GPM

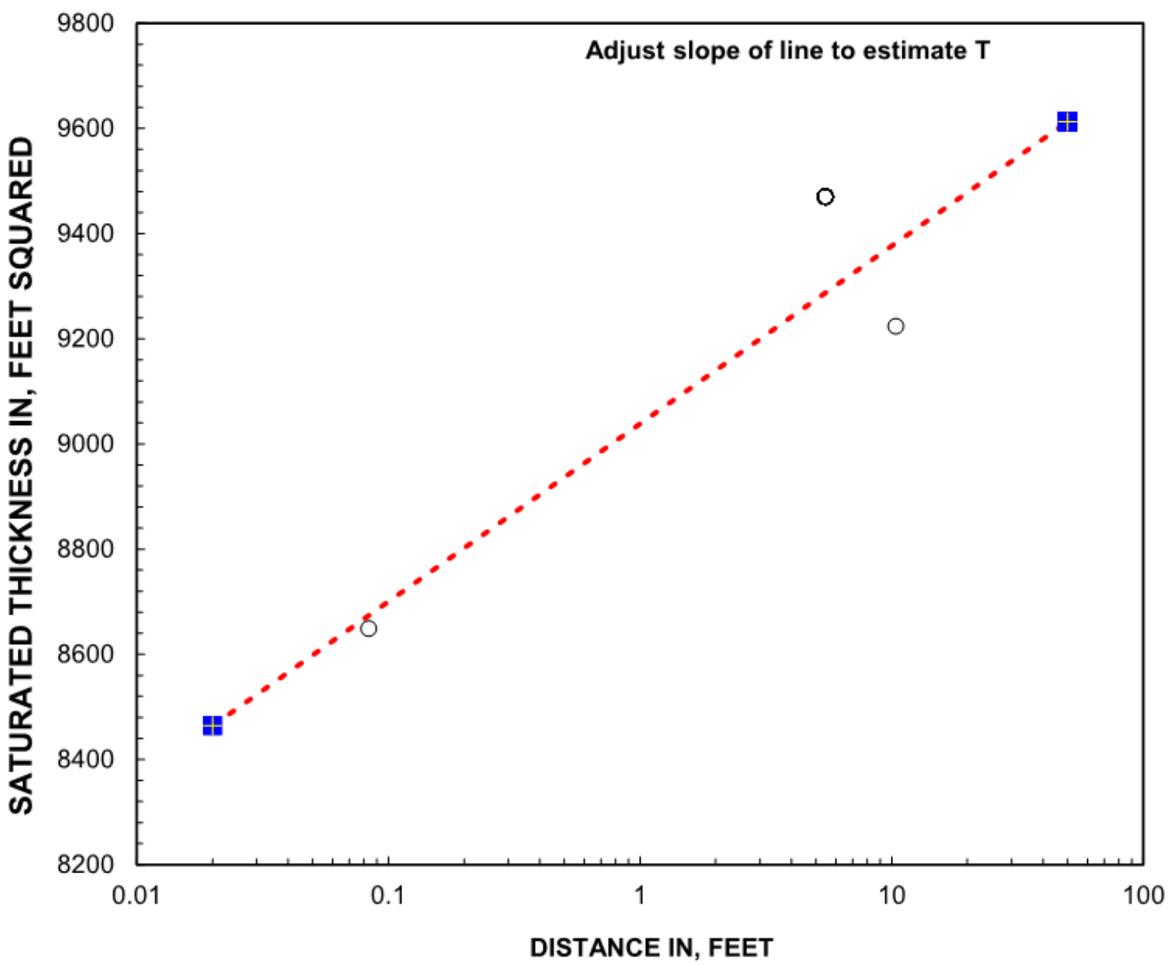
Date: 2021-12-15
Time: 14:20

COMPUTED

Aquifer thickness = 93 Feet
Aquifer is: **UNCONFINED**
Slope = 338.1251 Feet²/log10

Input is consistent.

K = 8.2 Feet/Day
T = 760 Feet²/Day



REMARKS: Drawdown-Distance analysis of multi-well aquifer test

Infiltration Cells Testing Event
Inland Bays Regional Wastewater Treatment Facility, Millsboro, DE
Data from End of Day 1 of Testing Event, Cell 2: P-4 and P-5
11/17/2021, 5:15 PM, Elapsed Time from Test Start = 490 minutes

PUMPING WELL ID: P-6

INPUT

Construction:	
Casing dia. (d_c)	2 Inch
Annulus dia. (d_w)	2 Inch
Screen Length (L)	8 Feet
Depths to:	
Initial Depth to Water	27 Feet
Top of Aquifer	20 Feet
Base of Aquifer	120 Feet
Annular Fill:	
across screen --	Coarse Sand
above screen --	Backfill
Aquifer Material --	Fine Sand
FLOW RATE	19.7 GPM

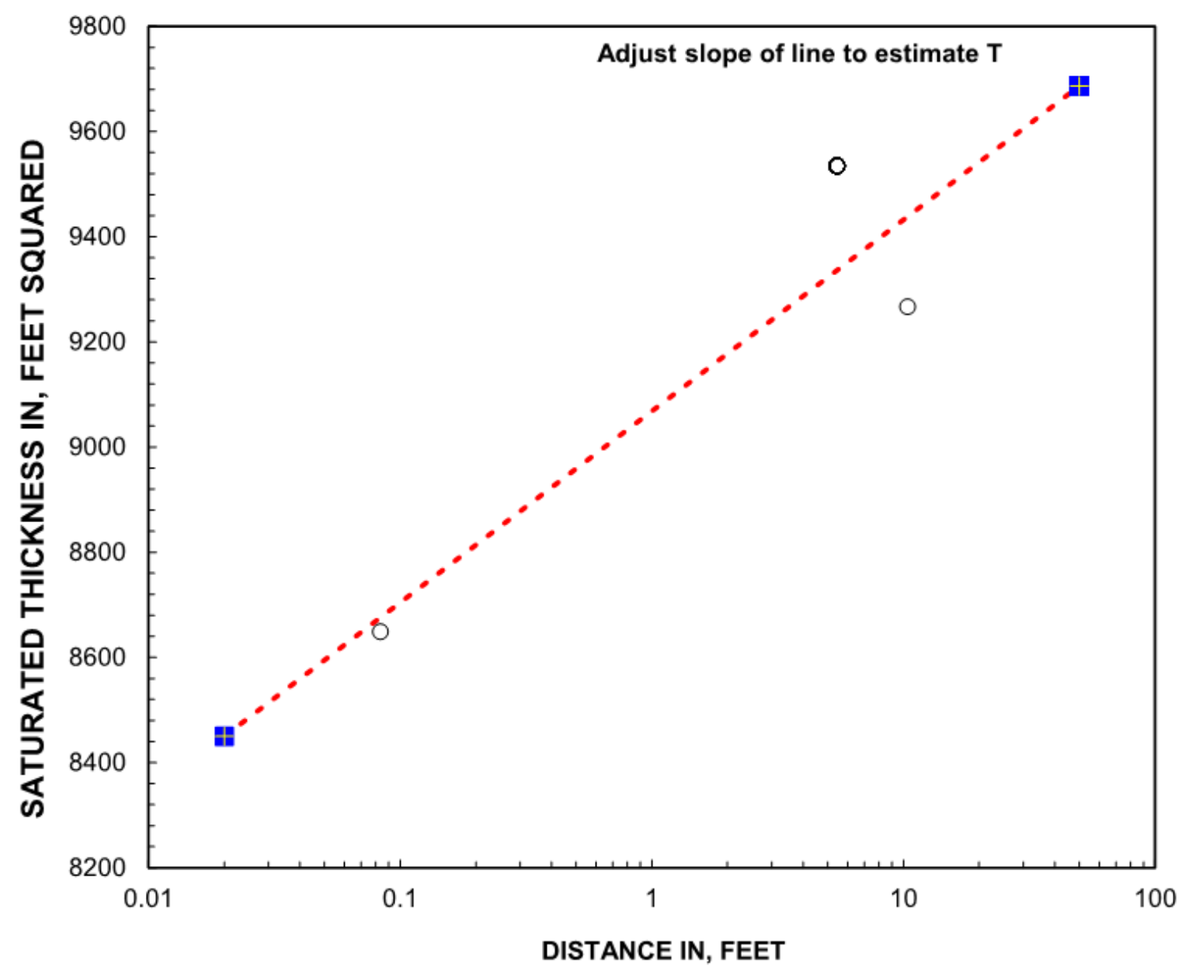
Date: 2021-12-15
Time: 14:20

COMPUTED

Aquifer thickness = 93 Feet
Aquifer is: **UNCONFINED**
Slope = 363.9635 Feet²/log10

Input is consistent.

K = 7.6 Feet/Day
T = 710 Feet²/Day



REMARKS: Drawdown-Distance analysis of multi-well aquifer test

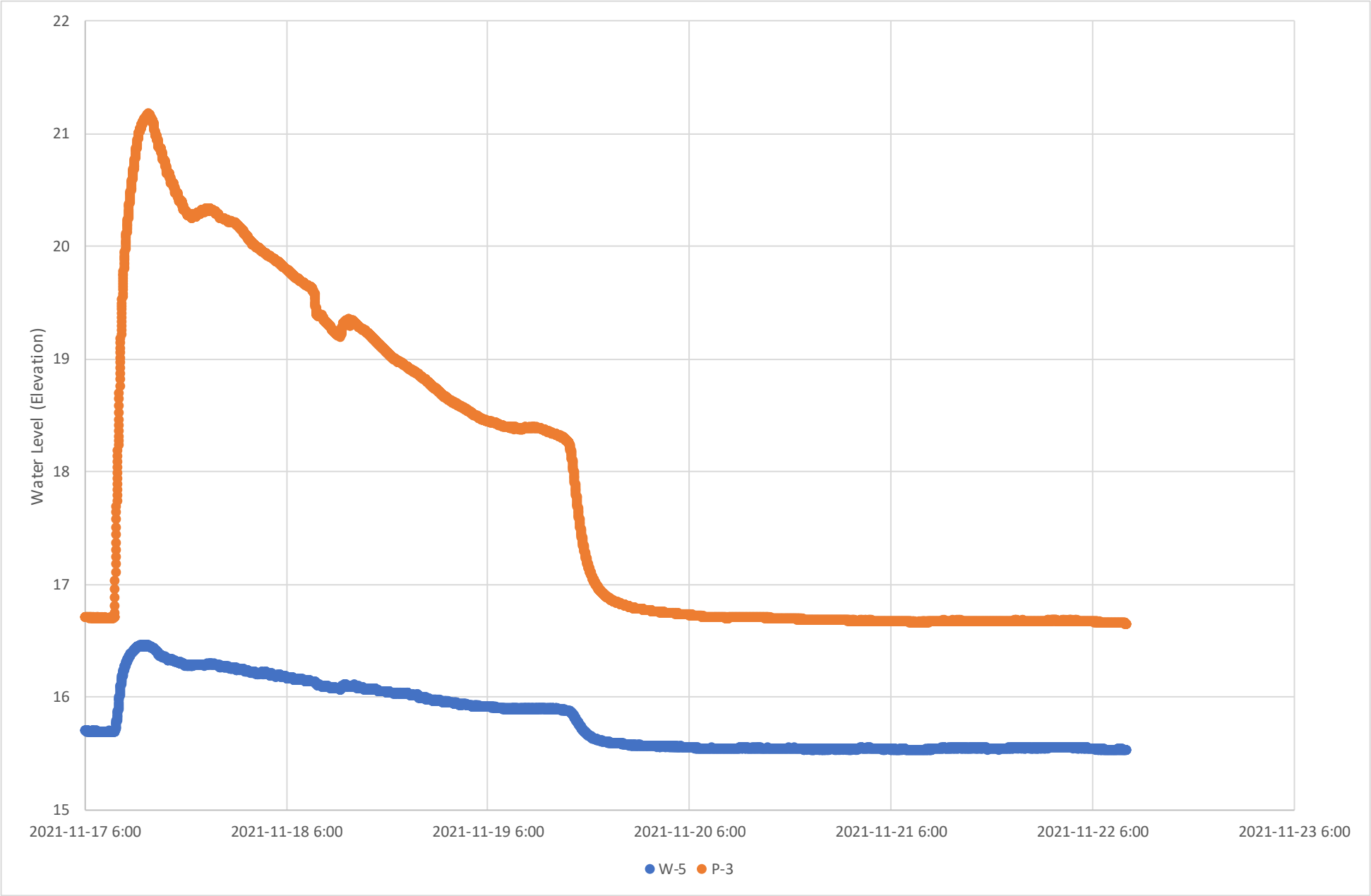
Infiltration Cells Testing Event
Inland Bays Regional Wastewater Treatment Facility, Millsboro, DE
Data from End of Day 2 of Testing Event, Cell 2: P-4 and P-5
11/18/2021, 4:30 PM, Elapsed Time from Test Start = 1,885 minutes

RK&K
Engineers | Construction Managers | Planners | Scientists

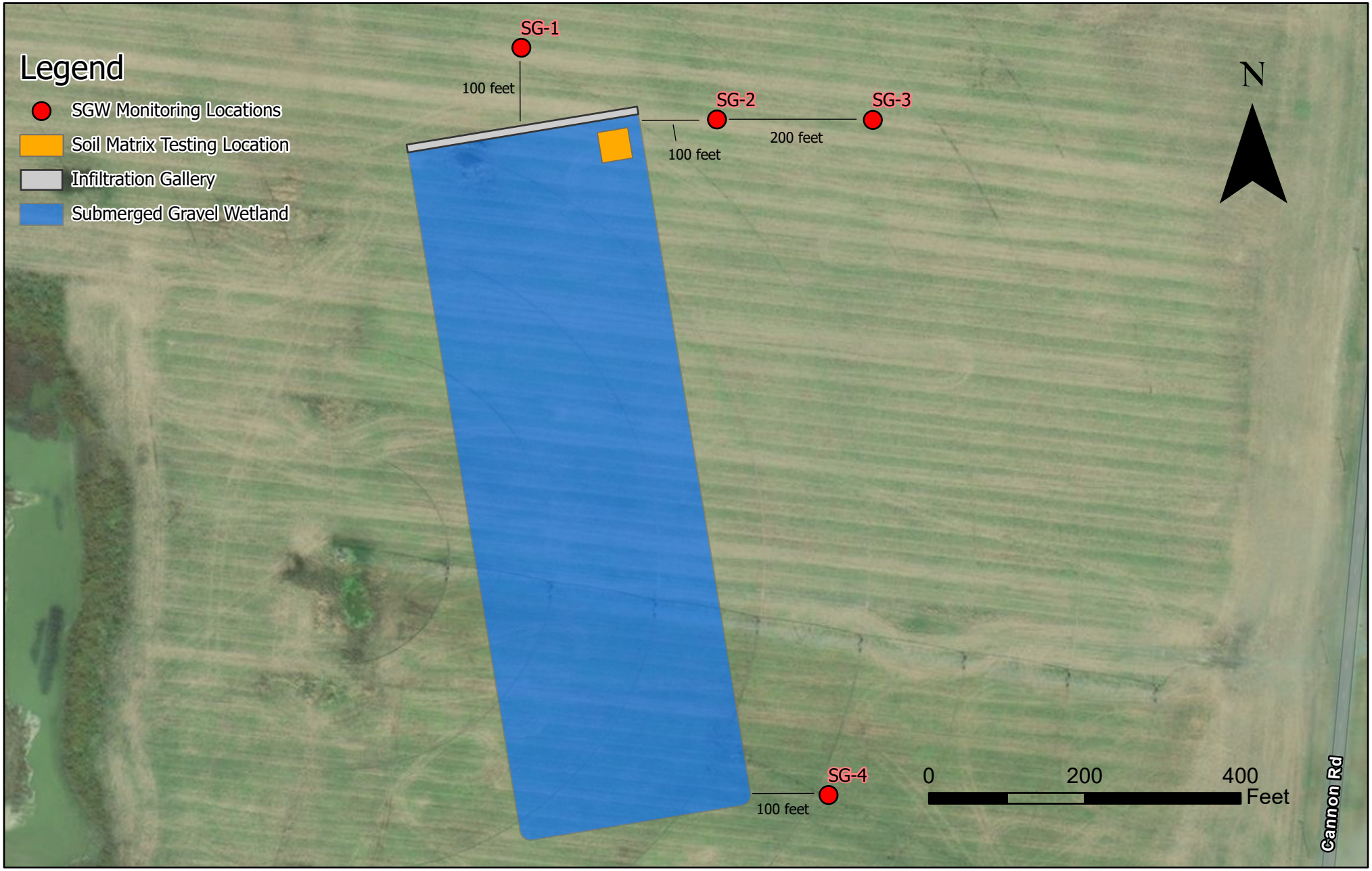
Distance Drawdown for Cell 2 - P-4 and P-5 - Day 1 and Day 2
Inland Bays Wastewater Treatment Facility

Project #: 18208.000
Date: 2021-12-22

Figure 22



RK&K	Mounding and Recovery for P-3 and W-5 Inland Bays Wastewater Treatment Facility	Project #: 18208.000 Date: 2021-12-17 **Figure 23**



RK&K
Engineers | Construction Managers | Planners | Scientists

SGW Monitoring Locations
Inland Bays Wastewater Treatment Facility

Project #: 18208.000

Date: 2021-12-22

Figure 24