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Savannah River Site

**Treatability Study Data Report for Groundwater Injection and Discharge
Canal Neutralization at the D-Area Groundwater (OU) (U)**

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LIST OF ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CaCO ₃	calcium carbonate
CPRB	Coal Pile Runoff Basin
DAG	D-Area Groundwater
DCSA	D-Area Coal Storage Area
ft	feet
gpm	gallons per minute
m	meters
MCL	maximum contaminant level
OU	operable unit
RSER/EE/CA	Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis
SCDHEC	South Carolina Department of Health and Environmental Control
SRNS	Savannah River Nuclear Solutions LLC
SRS	Savannah River Site
USEPA	U.S. Environmental Protection Agency
UTRA	Upper Three Runs aquifer

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1.0 INTRODUCTION

SRS has begun implementation of a groundwater treatability study in D-Area to reduce the acidic conditions in groundwater (SRNS 2019a). The acidic conditions were caused by the storage of coal in the former 484-17D D-Area Coal Storage Area (DCSA), and subsequent runoff into the 489-D Coal Pile Runoff Basin (CPRB). The groundwater beneath and downgradient of these areas has been acidified and will continue to be so even though the coal was removed in 2012-2013. This data report summarizes all actions and data that have been taken to date as presented in the *Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (DAG) Operable Unit (OU)* (SRNS 2019a).

The coal-fired 484-D Powerhouse provided electricity and steam for the D-Area facilities and other areas at SRS. The power plant was put into operation in 1952. The major ancillary facilities associated with the powerhouse are the former DCSA, the 489-D CPRB, and four ash basins (Figure 1). For over 60 years, the DCSA was a staging area for coal prior to its use in the powerhouse. Exposure of the coal to rainwater has allowed the degradation of iron sulfide (pyrite; a mineral commonly found in coal) to sulfuric acid. As a result, the soils underneath the DCSA, associated storm water runoff, and groundwater underlying the area have been acidified. The leaching of metals from both the coal and the natural minerals in the underlying soils in the vadose zone and aquifer due to the acidic conditions has resulted in a sulfate and metals groundwater plume in the Upper Three Runs Aquifer (UTRA) (Figure 2). Currently, acidic groundwater outcrops into the D-Area Effluent Discharge Canal at pH levels generally below 4.

Maintenance actions conducted in 2012 and 2013 removed the majority of coal present at the DCSA; however, the vadose zone soils beneath the DCSA remain acidified. A Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) was submitted in 2019 to describe a non-time critical removal action for neutralization of the soils to a 4 ft depth at the DCSA (SRNS 2018). This removal action was completed in 2020. This treatability study is designed to address the acidic pH conditions in the groundwater beneath the DCSA and 489-D CPRB and discharge to surface water in the D-Area Effluent Discharge Canal.

2.0 PROJECT DESCRIPTION

The vadose zone and groundwater beneath the DCSA and the 489-D CPRB are impacted by low pH conditions (< pH of 4) that was expected to last for decades under natural groundwater conditions. The low-pH groundwater is currently outcropping into the D-Area Effluent Discharge Canal which later converges with Beaver Dam Creek and flows through the Savannah River floodplain to the Savannah River. If the pH of the aquifer can be raised to more normal, less acidic conditions, the groundwater and surface water conditions in the D-Area Effluent Discharge Canal would improve.

This study is testing the viability of an approach to remediation that contains two relatively simple elements:

- Higher pH, potable groundwater sourced from production wells in D Area will be added into the aquifer upgradient of the low-pH, metals, and sulfate plumes using injection wells. The injected production well water is naturally buffered which will aid in the neutralization of acidic conditions currently present in the water table aquifer. The injected production well water will also create a hydraulic head that will displace the low-pH groundwater within in the aquifer.
- Treat the low-pH surface water that outcrops into the D-Area Effluent Discharge Canal by adjusting the pH with calcium carbonate (CaCO_3) reactive structure(s).

Injection of Production Well Water

Two potable water production wells (PW 3D and PW 136D) are in D-Area northwest of the 484-D Powerhouse. Both production wells were used for operations and are screened approximately 204 - 229 meters (m) (670 - 750 feet [ft]) below ground surface (bgs) within the McQueen Branch Aquifer. These production wells produce groundwater with a pH of approximately 6.0 to 6.5 containing low, but measurable, levels of carbonate alkalinity. This water will be injected into the upper water table aquifer upgradient of the low-pH, metals, and sulfate plumes to create a hydraulic head and increase groundwater flow velocity horizontally to displace the low-pH groundwater currently present in the aquifer. The alkalinity will buffer the system and partially neutralize

acidity in the aquifer. Both production wells are artesian and produce over 60 gallons per minute (gpm) each without the assistance of pumps. The well head pressure of the wells is approximately 5 to 10 pounds per square inch and is expected to support enough flow and pressure to deliver large volumes of water to the proposed injection field. Artesian flow testing was conducted in 2019 on both production wells (Section 4.1).

The production well water will be piped to the DCSA and 489-D CPRB and injected into the upper water table aquifer with a series of injection wells (Figure 3). A portion of the injection well field has been installed and is described in section 4.2. Creating a water mound approximately 1.5 m (5 ft) above current conditions is expected to increase the volume of groundwater out cropping into the D-Area Effluent Discharge Canal. It is expected that the production wells can supply enough water to fill the pore space volume (the space between the sediment grains in the vadose zone) to create the 1.5 m (5 ft) water mound in approximately 100 days. The pore space volume was calculated by multiplying the surface area of the DCSA and the 489-D CPRB by the proposed rise in water elevation (1.5 m [5 ft]) by the porosity (30%) and converting to gallons. A total of approximately 19 million gallons is estimated to be needed to raise the water table 1.5 m (5 ft). Based on aqueous chemical equilibrium modeling software, a total of 10 pore space volumes of injected potable groundwater could significantly displace and raise the pH levels in the upper water table within a three-year study period. The production wells are expected to support the groundwater injection study in addition to future remedial activities if needed (SRNS 2016a).

Although the water table is expected to rise approximately 1.5 m (5 ft) into the vadose zone, the groundwater injection is not intended to be the only treatment for the vadose zone and is not expected to remove all of the acidity from the vadose zone. However, the production well water to be injected within the upper water table aquifer is anticipated to provide an important buffering interaction to mitigate the low-pH groundwater. The DCSA RSER/EE/CA action that added neutralization amendments to the vadose zone soils (SRNS 2018) is intended to reduce acidity in the vadose zone source that has contributed to groundwater contamination. Although acidity is expected to be released from the lower vadose zone soils into the groundwater, the lower vadose zone is not expected to be neutralized or have much change in pH as a result of the groundwater injection treatability study. The lower vadose zone will eventually see the buffering effects of the

upper vadose zone amendments through infiltration over time. The combined (or synergistic) effects of the two actions will be apparent from the measurement of the parameters described in the Treatability Study Work Plan and the DCSA RSER/EE/CA (SRNS 2018), and the regular DAG OU groundwater and surface water monitoring.

Reactive Structures in D-Area Effluent Discharge Canal

An increase in the amount of acidic water outcropping into the D-Area Effluent Discharge Canal is expected to occur as groundwater elevations rise and low-pH groundwater is displaced. Titration test results using surface water from the D-Area Effluent Discharge Canal indicate that contact of surface water with a high purity CaCO_3 reactive structure will raise the pH of the surface water to over 6.0 (SRNS 2016b). Figure 4 shows the carbonate consumption rates associated with the neutralization of the sulfuric acid and illustrates a titration curve of the test. Although the installation of one reactive structure should be sufficient in raising the pH of the surface water, installation of two reactive structures has been completed to further ensure pH adjustment is sufficient over time. CaCO_3 marble chips, placed within the stream in two sections downgradient of the acidic groundwater discharge point within the D-Area Effluent Discharge Canal, are expected to allow enough contact time with the surface water for pH adjustment to natural conditions (Figure 3 and Figure 5). The use of high purity CaCO_3 (typically greater than 90% CaCO_3) limits the introduction of undesirable materials into the surface water (silt, clay, reactive minerals, etc.). The description of installation and the data collected to date associated with the CaCO_3 reactive structures is summarized in section 4.3.

3.0 TEST OBJECTIVES

The objective of this treatability study is to determine the ability of injected higher-pH potable groundwater to:

- Displace the acidic groundwater out of the upper water table aquifer of the UTRA in the vicinity of and downgradient of the DCSA and 489-D CPRB to improve the aquifer conditions (increase the pH) and reduce or eliminate the dissolved metal groundwater plumes.

- Increase the pH level of the D-Area Discharge Canal surface water with CaCO₃ reactive structures prior to discharge into Beaver Dam Creek and the Savannah River floodplain and river.

The results of the treatability study will be used to support the development of the DAG OU Feasibility Study, currently scheduled to be submitted by March 10, 2026.

Monitoring of water table elevations and pH measurements in surrounding monitoring wells and streams, as well as metal analyses of groundwater and surface water, will be used to determine the impact of the production well water injections. Stream flow measurements will document the increase in flow in the D-Area Discharge Canal from the groundwater injections.

4.0 TREATABILITY STUDY PROGRESS AND DATA

Due to the discovery of unfavorable injection sediments within the UTRA, potential interferences with deactivation & decommissioning (D&D) activities in D Area, and delays in field personnel availability due to Covid-19 management practices, a stepped approach has been taken with implementation of the DAG OU treatability study. Five injection wells (DGI007, DGI010, DGI014, DGI016, and DGI019) spread across the northeastern line were installed between December 2019 and February 2020 to provide a profile of the sediments that will be encountered and to allow for slug testing of the injection wells. Additionally, the two CaCO₃ reactive structures have been installed within the D-Area Effluent Discharge Canal. Initial sampling of the production wells, groundwater, and surface water have been completed as was proposed in the treatability study (Table 1). Ongoing monthly monitoring of pH and metal analyses within the D-Area Effluent Discharge Canal is performed upgradient, between, and downgradient of the CaCO₃ reactive structures to determine the efficacy of both the CaCO₃ material and structure design. Details on each portion of the treatability study project are provided below.

4.1 Production Well Sampling and Artesian Flow Testing

Production wells PW3D and PW 136D provide potable, higher-pH groundwater and are under artesian conditions. Sampling of the water at production wells PW 3D and PW 136D was

conducted in December 2018 to determine the pH, alkalinity, and metals concentrations. Table 2 provides the results of the sampling event. As expected, metal concentrations are low as concentrations were either non-detect or at levels below Maximum Contaminant Levels, which will provide water injections that will not introduce any additional contaminant burden on the UTRA aquifer. The pH levels of the groundwater from the production wells are approximately 6 – 6.5. Alkalinity results indicate low levels of dissolved carbonate material that will help to further buffer the acidic conditions within the UTRA in the injection area.

The natural artesian flow from PW 3D and PW 136D was tested from June through September 2019 to determine if the wells can sustain a water supply of a combined 120 gallons per minute [gpm] for the treatability study under natural artesian conditions and to aid in the engineering design of the injection piping system. Flow meters, pressure gauges, and throttle valves were installed at each production well (Figure 6). The aquifer response and drawdown were measured at the production wells, along with another regional deep well cluster near the TNX area (i.e., P 26 cluster located approximately 1,860 m [6,100 ft] northwest of the production wells) (Figures 7 and 8).

Initially, short duration single well tests were performed to determine maximum flow capacities at each production well. This included a 7-day flow test at PW 3D and a 3-day flow test at PW-136D. Results were promising, with an initial flow rate at PW 3D of 327 gpm and a final flow rate of 308 gpm. Since half of the decline in flow occurred within the first 24 hours, PW 136D was only tested for approximately three days. PW 136D results were similar with an initial flow rate of 319 gpm and a final flow rate of 303 gpm.

After the initial testing, both production wells were operated at full throttle continuously for a 30-day test since the final treatability study design is expected to utilize both production wells simultaneously. For both wells, about half of the flow decrease occurred during the first 24 hours, then flow rates stabilized and more slowly declined. Flow rates were slightly lower than the initial individual tests, but still performed at acceptable flow rates: PW 3D displayed initial flow rates of 315 gpm and final flow rate of 287 gpm and PW-136D had an initial flow rate of 312 gpm and final flow rate of 277 gpm. The flow rates exceed the 60 gpm per production well needed for each

well (total of 120 gpm with both production wells). It is expected that the artesian flow will slowly decrease over time; however, the initial prolonged testing indicates that the flow rate will be sufficient for the length of the treatability study.

Aquifer response during the combined production well flow testing was also measured in the regional well cluster P26 near TNX which includes wells screened within the same aquifer (McQueen Branch) as the production wells (Figure 8). The P26 cluster wells water levels were monitored with data logging pressure transducers to determine the groundwater transmissivity and hydraulic conductivity of the McQueen Branch Aquifer. Aquifer response was measured with an approximately 0.76 to 0.91 m (2.5 to 3 ft) drop in water elevation at the P26 cluster wells over the 30-day testing period. Based on the monitoring results, the hydraulic conductivity of the McQueen Branch aquifer was determined to be 97 ft/day and indicates that the production wells will be able to sustain an adequate water supply for the duration of the treatability study.

4.2 Injection Well Installation

Five injection wells (DGI007, DGI010, DGI014, DGI016, and DGI019) spread across the northeastern line have been installed to date to provide a profile of the sediments that will be encountered and allow slug testing of the actual injection wells (Figure 9). An additional five injection wells (DGI011, DGI012, DGI013, DGI015, and DGI017) will be installed in 2021.

The injection wells were originally planned to be screened within the upper water table aquifer at approximately 12-32 ft bgs. However, due to the abundance of clays, sandy clays, and silty sands, especially near the DCSA, the wells were installed deeper within the mid to lower zone of the UTRA (Table 3). Geologic core logs are provided in Appendix A. A cross-sectional view of the sediments can be seen in Figures 10 and 11.

Following the installation of the five injection wells, slug tests were performed on each well to determine if groundwater injection is feasible before constructing the remaining injection wells and piping system from the production wells. An average of approximately 5 gpm injection rate is required per injection well to be able to raise the water table and provide 10 pore volumes of water within a 3-year timeframe. The slug tests were performed by injecting 2,500 gallons of

potable water by gravity feed (no pumps) into each well while the flow rate and total time were recorded (Table 4) (Figure 12). As expected based on the lithology observed, the flow rates in the injection wells near the DCSA (DGI007 and DGI010) were much less than the injection wells towards the 489-D CPRB (DGI014, DGI016, and DGI019) and were also less than the targeted 5 gpm injection rate. To improve the injection rates in DGI007 and DGI010, the wells were robustly redeveloped by pumping, swabbing, and surging. The subsequent 2,500-gallon slug test indicated much improvement in the injection rates (Table 4).

Water levels in nearby wells, when available, were also measured during the slug tests. Even though the injection wells were installed deeper than originally designed, both lower aquifer zone and upper aquifer zone wells showed an increase in water elevations indicating that there is sufficient communication within the UTRA.

The five injection wells to be installed in 2021 are located towards the south end of the DCSA and 489-D CPRB where the lithology indicates more favorable conditions for injection. SRS plans to start groundwater injections into the 10 installed injection wells (Figure 9) and existing well DCB 2A in 2021 with water from one or both of the production wells. Since approximately half of the injection wells will be utilized initially, simultaneous operation of both production wells may not be needed. Based on the results of the initial groundwater injections, a phased approach to install additional injection wells will be used.

4.3 CaCO₃ Reactive Structures

Due to the ongoing and further expected acidic conditions within the D-Area Discharge Canal, two CaCO₃ reactive structures were installed during 2020 (Figure 13). To perform initial testing of the design and function of the structures, one reactive structure was installed in February 2020. A surface water pH increase was observed with the first structure, and the second reactive structure was installed immediately downgradient of the first structure in October 2020.

Due to the final placement of the reactive structures, a change in the surface water stations initially proposed to monitor pH/metals was required. Surface water station DSWM-8 now monitors upgradient of the first structure (originally DSWM-7), DSWM-8A monitors between the first and

second structure (originally DSWM-8), and station DSWM-9 monitors downgradient of the structures (no change) (Figure 14). Figure 15 displays the field pH measurements collected monthly upgradient, between, and downgradient of the two CaCO₃ reactive structures. As is depicted in the graph, surface water pH increases are occurring as water flows through the reactive structures with the pH increasing after each structure. However, during periods of prolonged or heavy rains, stream flow increases and tops over the reactive structures. This is part of the design to not restrict flooding events; however, this reduces the contact time of the surface water with the reactive structures. The impact of heavy rains to the pH adjustments can be seen in Figure 15 during the first three months of monitoring and during the most recent measurement in January 2021. During baseflow and lower flow periods, each reactive structure increases the pH of surface water between 1 and 2 pH values (1 and 2 orders of magnitude change) to achieve the minimum pH 5 threshold. If the pH of the surface water downgradient of the two reactive structures at surface water station DSWM-9 is not raised to or above a pH of 5.0 (during times when surface water is not topping over the reactive structures), then remixing, replacement, and/or reconfiguration of the calcium carbonate material will be evaluated.

Additionally, metal sample results indicate some decreasing concentrations as surface water passes through the reactive structures and the pH is increased. This is more noticeable during baseflow and low flow conditions similar to the pH results. Appendix B contains the surface water data analytical and field results. Further sampling will support trending data analysis.

5.0 SAMPLING AND ANALYSIS

Measurements of water table elevations, stream flow, pH, and sample collection for metal analyses are conducted following the SRS *3Q1 Manual: Environmental Requirements and Program Documents, Procedure 9015: Sampling Groundwater Monitoring Wells, Tanks/Vessels (Sample Ports or Spigots) and Surface Water* (SRNS 2019b).

One round of sampling occurred in 2Q2020 as a baseline before production well water injections begin in 2021. Table 1 and Figure 15 includes the locations that were monitored, and analytical and field data are provided in Appendix B. Surface water station DSWM-8A, which is now being used to monitor surface water between the two reactive structures, was also included. Well

DCB 6 did not include metal analyses during 2Q2020, but these will be included in the 2Q2021 sampling event. Water table elevations were and will be measured at the injection wells prior to being connected to the injection piping system, and wells surrounding the DCSA and the 489-D CPRB will be monitored to adjust the injection well flow and monitor the effects of the groundwater injections.

A potentiometric surface map of the UTRA during 2Q2020 is provided in Figure 16. Water elevations will be measured on a monthly basis for the first eight months after groundwater injections begin, then quarterly afterwards. A map of the acidic groundwater with pH data is provided in Figure 2.

Stream flow measurements will be collected at all surface water station locations within the D-Area Effluent Discharge Canal and the tributary to the east where safely accessible. Groundwater and surface water samples will be monitored for the metals included in DAG OU monitoring program. Monitoring will also include field pH measurements and other routine field measurements (i.e., oxidation/reduction potential, dissolved oxygen, specific conductance, total alkalinity [as CaCO₃], turbidity, water temperature, and water elevation [at wells]).

A total of 32 wells and 10 surface water stations outside of the injection field will be monitored. Twenty monitoring wells and all 10 surface water stations will include metals, pH, and other routine field analyses.

SRS is proposing to modify the analytical sampling to allow time for the groundwater injections to increase the water table elevation and displace water within the aquifer. Once production well water injections begin, water elevations at groundwater wells will still be conducted monthly for 8 months and quarterly afterwards. However, once injections begin, metals analyses at groundwater wells and seven surface water stations (DSWM-4 through DSWM-7) will be changed from monthly sampling to quarterly. In addition, surface water station DSWM-7 will not monitor pH on a monthly basis as DSWM-8 now monitors surface water upgradient of the reactive structures, as discussed in section 4.3. Monthly metal analyses and field parameters will continue for the three surface water stations monitoring upgradient, between, and downgradient of the

CaCO₃ reactive structures (DSWM-8, DSWM-8A, and DSWM-9) for the first eight months (Dec 2020 through July 2021). Afterwards, monthly monitoring of pH will be conducted with metal analytical samples collected quarterly. Table 5 captures these proposed changes.

Adjustments to the monitoring may be made based on field conditions or monitoring results. Any changes to the monitoring of wells, surface water stations, or parameters will be discussed with the United States Department of Energy, United States Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC) and approved prior to implementation. The second quarter (2Q) and fourth quarter (4Q) DAG OU monitoring will not be impacted by the treatability study and will continue as normally scheduled.

As field conditions warrant, adjustments such as varying injection flows or other traditional methods such as re-development of the wells could also be employed. Any permanent discontinuation of an injection well will be communicated with EPA and SCDHEC.

6.0 DATA COLLECTION AND REPORTING

Once groundwater injections begin, data (field measurements, sample results, flow rates, etc.) will be collected and presented in a combination of tabular form, graphs, and time-series plots. Maps depicting the water table will also be created. All these items and an interpretation will be supplied in data reports. Future data reports will be no later than every 12 months following this initial report, unless an alternative proposal is made to and accepted by USEPA and SCDHEC.

7.0 SUMMARY

The anticipated length of the treatability study is currently estimated at three years of groundwater injection. Analysis of the production well flow rates, injection operation, aquifer acceptance, field data, sample data, and performance of the CaCO₃ reactive structures will indicate the actual length of the treatability study. Construction of the CaCO₃ reactive structures in the D-Area Effluent Discharge Canal is complete and is sufficiently raising the pH of groundwater outcropping into the surface water to a pH above 5. A portion (five) of the proposed 20 injection wells have been installed. A stepped approach has been taken with the DAG OU treatability study and installation of the remaining injection wells. Slug testing of the five injection wells has been completed and

with the redevelopment of two of the wells, groundwater injection rates seem adequate to move forward with the treatability study. Five additional injection wells will be installed in 2021 and the piping system from the production well(s) will be installed to begin groundwater injection into the 10 injection wells and existing DCB 2A well during 2021/2022. Additional injection wells will be installed following performance review of the initial groundwater injections.

Baseline sampling was conducted for the treatability study monitoring network (Table 1) in 2Q2020. Ongoing monthly monitoring of pH and metals is occurring upgradient, between, and downgradient of the CaCO₃ reactive structures through July 2021. Afterwards pH will be monitored monthly with metal analyses occurring on a quarterly basis.

Based on the lithology encountered in the upper portion of the injection field adjacent to the DCSA, it is unknown if groundwater injection is feasible in this area. Depending on how the flow rates of production well water injections proceed in the existing injection wells (minimum of 5 gpm or equivalent average for a particular area), injection may or may not be a suitable means of introducing clean, higher-pH water into the shallow aquifer.

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Table 1. Originally Proposed D-Area Treatability Study Monitoring Network and Sampling Schedule

Monitoring Well Information				Sampling			
Station	Station Type	Total Depth (ft bgs)	Screened Interval (ft msl)	Before Injection	After Injections start		
					Monthly - First 8 months	Monthly	Quarterly
PW 3D	Production Well	736	-541.25 - -551.25, -651.25 - -601.25	M	WL		WL
PW 136D	Production Well	765	-507.5 - -537.5, -577.5 - -617.5	M	WL		WL
DCB 3A	Monitoring Well	36.8	126.2 - 96.2	WL	WL		WL
DCB 4A	Monitoring Well	37	122.5 - 92.5	M	M		M
DCB 5A	Monitoring Well	37	115.9 - 85.9	WL	WL		WL
DCB 6	Monitoring Well	23.7	129.5 - 109.5	M	M		M
DCB 7	Monitoring Well	23.9	128.9 - 108.9	WL	WL		WL
DCB 8	Monitoring Well	26.5	130.3 - 110.3	M	M		M
DCB 9	Monitoring Well	25	117.3 - 97.3	WL	WL		WL
DCB 10	Monitoring Well	24.1	119.8 - 99.8	M	M		M
DCB 21A	Monitoring Well	20	120.1 - 110.1	M	M		M
DCB 21B	Monitoring Well	27	104.7 - 102.2	M	M		M
DCB 21C	Monitoring Well	44	90.8 - 88.3	M	M		M
DCB 22A	Monitoring Well	18.5	119.8 - 109.8	M	M		M
DCB 23A	Monitoring Well	16	115.7 - 105.7	WL	WL		WL
DCB 23B	Monitoring Well	27.5	96.6 - 94.1	M	M		M
DCB 23C	Monitoring Well	35	89.1 - 86.6	M	M		M
DCB 26AR	Monitoring Well	26	111.7 - 97.4	WL	WL		WL
DCB 33B	Monitoring Well	37	114 - 104	WL	WL		WL
DCB 34A	Monitoring Well	26	112 - 102	M	M		M
DCB 34C	Monitoring Well	59.3	80.8 - 70.8	M	M		M
DCB 35A	Monitoring Well	25	103.4 - 93.4	M	M		M
DCB 35C	Monitoring Well	44	84.2 - 74.2	M	M		M
DCB 36A	Monitoring Well	20	114.1 - 104.1	M	M		M
DCB 36C	Monitoring Well	37	97.3 - 87.3	M	M		M
DCB 37A	Monitoring Well	25.9	110.8 - 100.8	M	M		M
DCB 41A	Monitoring Well	33	108.28 - 98.28	WL	WL		WL
DCB 44A	Monitoring Well	26.5	123.3 - 108.3	WL	WL		WL
DCB 45A	Monitoring Well	25.2	125.2 - 110.2	WL	WL		WL
DCB 49	Monitoring Well	16.5	118.65 - 106.15	WL	WL		WL
DCB 53	Monitoring Well	41	87.58 - 77.48	WL	WL		WL
DCB 70A	Monitoring Well	12.5	114.69 - 104.69	M	M		M
DCB077	Monitoring Well	31.7	118 - 98	M	M		M
DCB078	Monitoring Well	41.7	107 - 87	M	M		M
DSWM-4	Surface Water Station	--	--	M	M		M
DSWM-4A	Surface Water Station	--	--	M	M		M
DSWM-4B	Surface Water Station	--	--	M	M		M
DSWM-4C	Surface Water Station	--	--	M	M		M
DSWM-5	Surface Water Station	--	--	M	M		M
DSWM-6	Surface Water Station	--	--	M	M		M
DSWM-7	Surface Water Station	--	--	M	M	pH	M
DSWM-8	Surface Water Station	--	--	M	M	pH	M
DSWM-9	Surface Water Station	--	--	M	M	pH	M

M = Metals and field parameters including pH

WL = Water table elevation measurement only

pH = pH reading of surface water only for performance monitoring of the reactive structures

Table 2. D-Area Production Wells Sample Results - December 6, 2018

STATION ID	ANALYTE NAME	RESULT	RESULT UNITS	QUALIFIER
PW 3D	ALUMINUM	50	µg/L	U
PW 136D	ALUMINUM	50	µg/L	U
PW 3D	ANTIMONY	3	µg/L	U
PW 136D	ANTIMONY	3	µg/L	U
PW 3D	ARSENIC	5	µg/L	U
PW 136D	ARSENIC	2.01	µg/L	U
PW 3D	BARIUM	59.4	µg/L	
PW 136D	BARIUM	46.4	µg/L	
PW 3D	BERYLLIUM	0.211	µg/L	J
PW 136D	BERYLLIUM	0.314	µg/L	J
PW 3D	CADMIUM	1	µg/L	U
PW 136D	CADMIUM	1	µg/L	U
PW 3D	CALCIUM	1100	µg/L	
PW 136D	CALCIUM	1260	µg/L	
PW 3D	CHLOROETHENE (VINYL CHLORIDE)	1	µg/L	U
PW 136D	CHLOROETHENE (VINYL CHLORIDE)	1	µg/L	U
PW 3D	CHROMIUM	10	µg/L	U
PW 136D	CHROMIUM	10	µg/L	U
PW 3D	CIS-1,2-DICHLOROETHYLENE	1	µg/L	U
PW 136D	CIS-1,2-DICHLOROETHYLENE	1	µg/L	U
PW 3D	COBALT	1	µg/L	U
PW 136D	COBALT	1	µg/L	U
PW 3D	COPPER	0.601	µg/L	J
PW 136D	COPPER	0.324	µg/L	J
PW 3D	IRON	3120	µg/L	
PW 136D	IRON	536	µg/L	
PW 3D	LEAD	2	µg/L	U
PW 136D	LEAD	2	µg/L	U
PW 3D	MAGNESIUM	345	µg/L	
PW 136D	MAGNESIUM	387	µg/L	
PW 3D	MANGANESE	113	µg/L	
PW 136D	MANGANESE	17.4	µg/L	
PW 3D	MERCURY	0.2	µg/L	U
PW 136D	MERCURY	0.2	µg/L	U
PW 3D	NICKEL	2	µg/L	U
PW 136D	NICKEL	2	µg/L	U
PW 3D	POTASSIUM	3900	µg/L	
PW 136D	POTASSIUM	3990	µg/L	
PW 3D	SELENIUM	5	µg/L	U
PW 136D	SELENIUM	5	µg/L	U
PW 3D	SILVER	1	µg/L	U
PW 136D	SILVER	1	µg/L	U
PW 3D	SODIUM	6780	µg/L	J
PW 136D	SODIUM	6870	µg/L	J
PW 3D	SULFATE	5.89	mg/L	
PW 136D	SULFATE	12.5	mg/L	
PW 3D	TETRACHLOROETHYLENE (PCE)	1	µg/L	U
PW 136D	TETRACHLOROETHYLENE (PCE)	1	µg/L	U

ug/L = micrograms per liter; mg/L = milligram per liter; U = non-detect (result listed is the sample quantitation limit);
J = estimated value;

Table 2. D-Area Production Wells Sample Results - December 6, 2018 (continued, end)

STATION ID	ANALYTE NAME	RESULT	RESULT UNITS	QUALIFIER
PW 3D	THALLIUM	2	µg/L	U
PW 136D	THALLIUM	2	µg/L	U
PW 3D	TRANS-1,2-DICHLOROETHYLENE	1	µg/L	U
PW 136D	TRANS-1,2-DICHLOROETHYLENE	1	µg/L	U
PW 3D	TRICHLOROETHYLENE (TCE)	1	µg/L	U
PW 136D	TRICHLOROETHYLENE (TCE)	1	µg/L	U
PW 3D	TRITIUM	-0.0374	pCi/mL	U
PW 136D	TRITIUM	-0.106	pCi/mL	U
PW 3D	URANIUM	0.2	µg/L	U
PW 136D	URANIUM	0.2	µg/L	U
PW 3D	VANADIUM	10	µg/L	U
PW 136D	VANADIUM	4.33	µg/L	J
PW 3D	ZINC	10	µg/L	U
PW 136D	ZINC	10	µg/L	U
PW 3D	AIR TEMPERATURE	4.7	degC	
PW 136D	AIR TEMPERATURE	7.6	degC	
PW 3D	OXIDATION/REDUCTION POTENTIAL	44	mV	
PW 136D	OXIDATION/REDUCTION POTENTIAL	41	mV	
PW 3D	OXYGEN	3.09	mg/L	
PW 136D	OXYGEN	3.44	mg/L	
PW 3D	PH	6.7	pH	
PW 136D	PH	5.8	pH	
PW 3D	SPECIFIC CONDUCTANCE	64	µS/cm	
PW 136D	SPECIFIC CONDUCTANCE	59	µS/cm	
PW 3D	TOTAL ALKALINITY (AS CaCO ₃)	28	mg/L	
PW 136D	TOTAL ALKALINITY (AS CaCO ₃)	8	mg/L	
PW 3D	TURBIDITY	0.3	NTU	
PW 136D	TURBIDITY	0.5	NTU	
PW 3D	WATER TEMPERATURE	18.9	degC	
PW 136D	WATER TEMPERATURE	19.8	degC	

ug/L = micrograms per liter; mg/L = milligram per liter; pCi/mL = picocuries per milliliter; degC = degrees Celsius; mV = millivolts; uS/cm = microsiemens per centimeter; NTU = Nephelometric Turbidity Unit; U = non-detect (result listed is the sample quantitation limit); J = estimated value;

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Table 3. D-Area Injection Well Screen Zone Depths

Injection Well	Screen Zone (ft bgs)
DGI007	21.49 - 42.41
DGI010	30.51 - 51.43
DGI014	34.58 - 55.5
DGI016	34.37 - 55.29
DGI019	23.72 - 44.64

Table 4. D-Area Injection Well Slug Test Results

Injection Well	Slug Test Flow Rates (gal/min)		Flow Rate after Redevelopment (gal/min)	
	Initial	Final	Initial	Final
DGI007	3	0.5	11	10
DGI010	4	1	12	7
DGI014	13	8	--	--
DGI016	18	13	--	--
DGI019	20	16	--	--

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Table 5. Revised D-Area Treatability Study Monitoring Network and Sampling Schedule

Monitoring Well Information				Sampling			
Station	Station Type	Total Depth (ft bgs)	Screened Interval (ft msl)	Before Injection	After Injections start		
					Monthly - First 8 months	Monthly	Quarterly
PW 3D	Production Well	736	-541.25 - -551.25, 651.25 - -601.25	M	WL		WL
PW 136D	Production Well	765	-507.5 - -537.5, -577.5 - -617.5	M	WL		WL
DCB 3A	Monitoring Well	36.8	126.2 - 96.2	WL	WL		WL
DCB 4A	Monitoring Well	37	122.5 - 92.5	M	WL		M
DCB 5A	Monitoring Well	37	115.9 - 85.9	WL	WL		WL
DCB 6	Monitoring Well	23.7	129.5 - 109.5	M	WL		M
DCB 7	Monitoring Well	23.9	128.9 - 108.9	WL	WL		WL
DCB 8	Monitoring Well	26.5	130.3 - 110.3	M	WL		M
DCB 9	Monitoring Well	25	117.3 - 97.3	WL	WL		WL
DCB 10	Monitoring Well	24.1	119.8 - 99.8	M	WL		M
DCB 21A	Monitoring Well	20	120.1 - 110.1	M	WL		M
DCB 21B	Monitoring Well	27	104.7 - 102.2	M	WL		M
DCB 21C	Monitoring Well	44	90.8 - 88.3	M	WL		M
DCB 22A	Monitoring Well	18.5	119.8 - 109.8	M	WL		M
DCB 23A	Monitoring Well	16	115.7 - 105.7	WL	WL		WL
DCB 23B	Monitoring Well	27.5	96.6 - 94.1	M	WL		M
DCB 23C	Monitoring Well	35	89.1 - 86.6	M	WL		M
DCB 26AR	Monitoring Well	26	111.7 - 97.4	WL	WL		WL
DCB 33B	Monitoring Well	37	114 - 104	WL	WL		WL
DCB 34A	Monitoring Well	26	112 - 102	M	WL		M
DCB 34C	Monitoring Well	59.3	80.8 - 70.8	M	WL		M
DCB 35A	Monitoring Well	25	103.4 - 93.4	M	WL		M
DCB 35C	Monitoring Well	44	84.2 - 74.2	M	WL		M
DCB 36A	Monitoring Well	20	114.1 - 104.1	M	WL		M
DCB 36C	Monitoring Well	37	97.3 - 87.3	M	WL		M
DCB 37A	Monitoring Well	25.9	110.8 - 100.8	M	WL		M
DCB 41A	Monitoring Well	33	108.28 - 98.28	WL	WL		WL
DCB 44A	Monitoring Well	26.5	123.3 - 108.3	WL	WL		WL
DCB 45A	Monitoring Well	25.2	125.2 - 110.2	WL	WL		WL
DCB 49	Monitoring Well	16.5	118.65 - 106.15	WL	WL		WL
DCB 53	Monitoring Well	41	87.58 - 77.48	WL	WL		WL
DCB 70A	Monitoring Well	12.5	114.69 - 104.69	M	WL		M
DCB077	Monitoring Well	31.7	118 - 98	M	WL		M
DCB078	Monitoring Well	41.7	107 - 87	M	WL		M
DSWM-4	Surface Water Station	--	--	M			M
DSWM-4A	Surface Water Station	--	--	M			M
DSWM-4B	Surface Water Station	--	--	M			M
DSWM-4C	Surface Water Station	--	--	M			M
DSWM-5	Surface Water Station	--	--	M			M
DSWM-6	Surface Water Station	--	--	M			M
DSWM-7	Surface Water Station	--	--	M			M
DSWM-8	Surface Water Station	--	--	M	M	pH	M
DSWM-8A	Surface Water Station	--	--	M	M	pH	M
DSWM-9	Surface Water Station	--	--	M	M	pH	M

M = Metals and field parameters including pH

WL = Water elevation measurement only

pH = pH reading of surface water only for performance monitoring of the reactive structures

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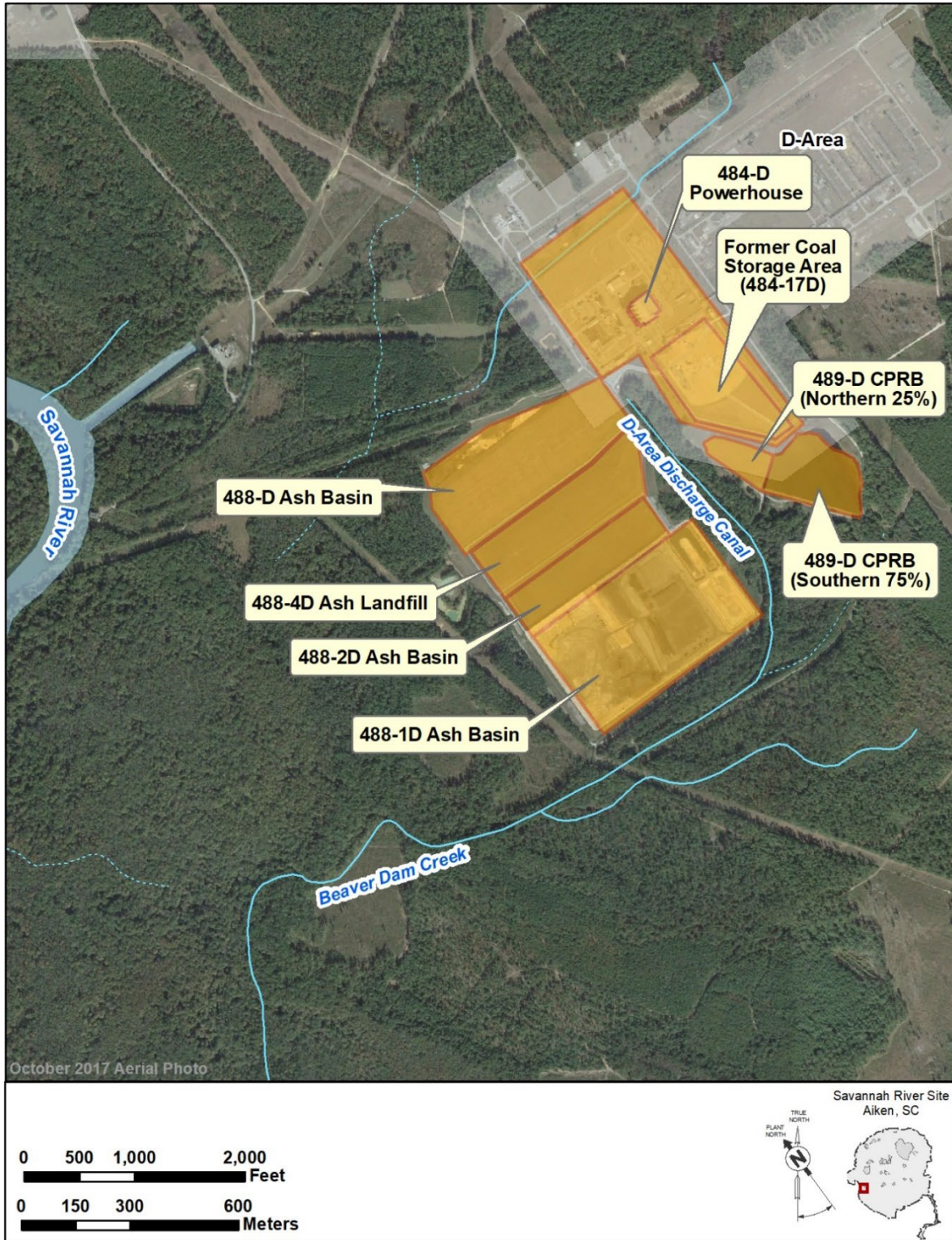


Figure 1. D-Area Powerhouse Associated Facilities

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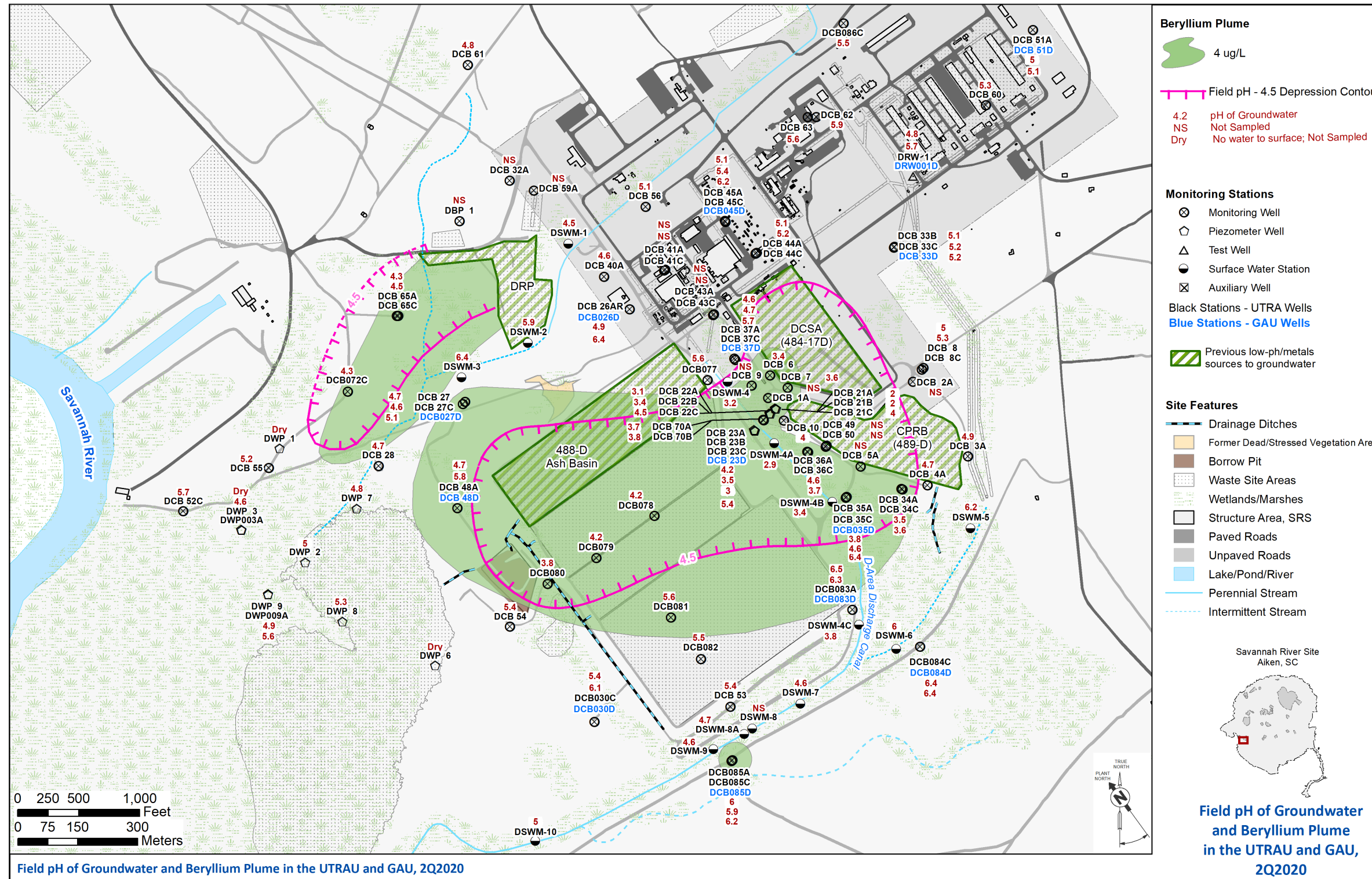


Figure 2. D-Area Groundwater 2Q2020 pH and Beryllium Plume

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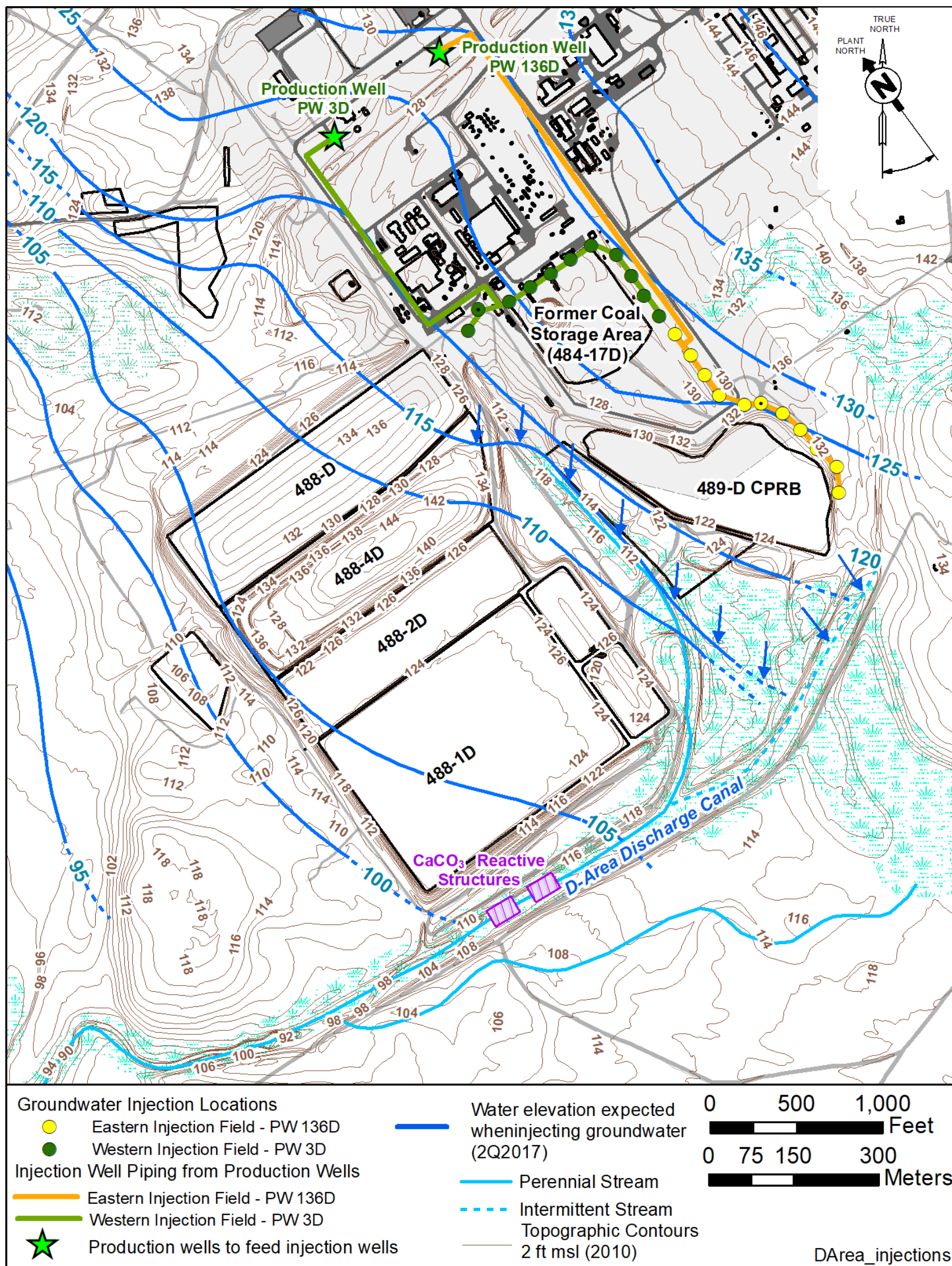


Figure 3. D-Area Treatability Study Injection Wells, Reactive Structure, and Projected Water Table Elevation

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Water Volume, ml	CaCO ₃ Mass, g	Initial pH	Final pH	Mass CaCO ₃ per Water Volume, mg/l
Initial		3		0
200	0.018	3.08	3.99	90
200	0.05	3.05	5.75	250
200	0.1	3.02	6.15	500
50	0.1	2.98	6.64	2,000
50	0.25	2.93	6.50	5,000
50	0.5	2.90	6.60	10,000

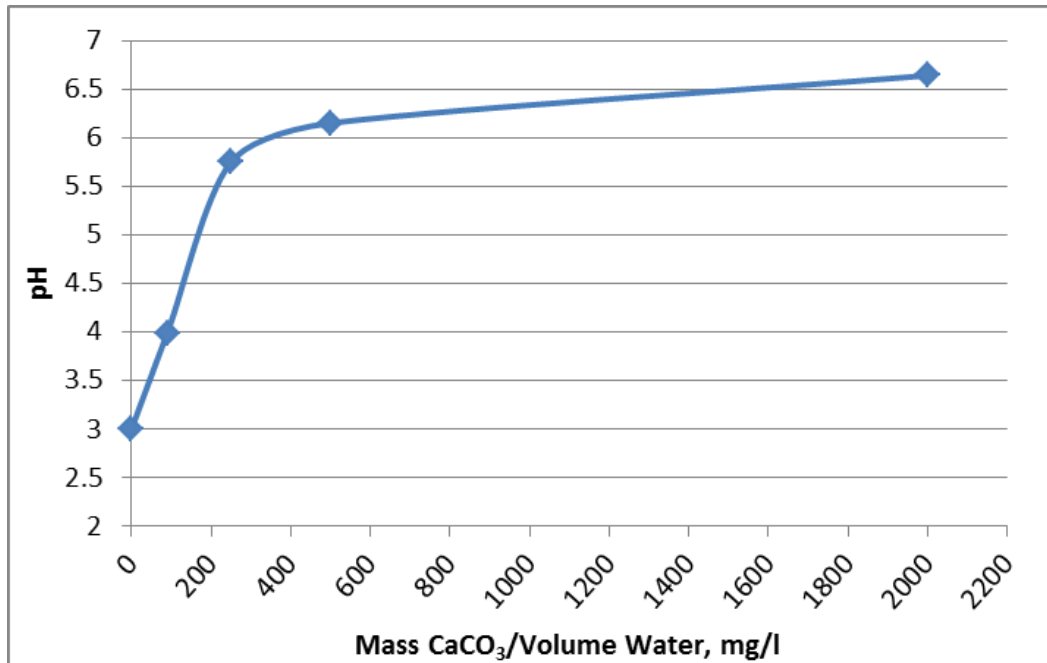


Figure 4. Titration Test Chart and Graph of D-Area Discharge Canal Acidic Surface Water with Calcium Carbonate Additions

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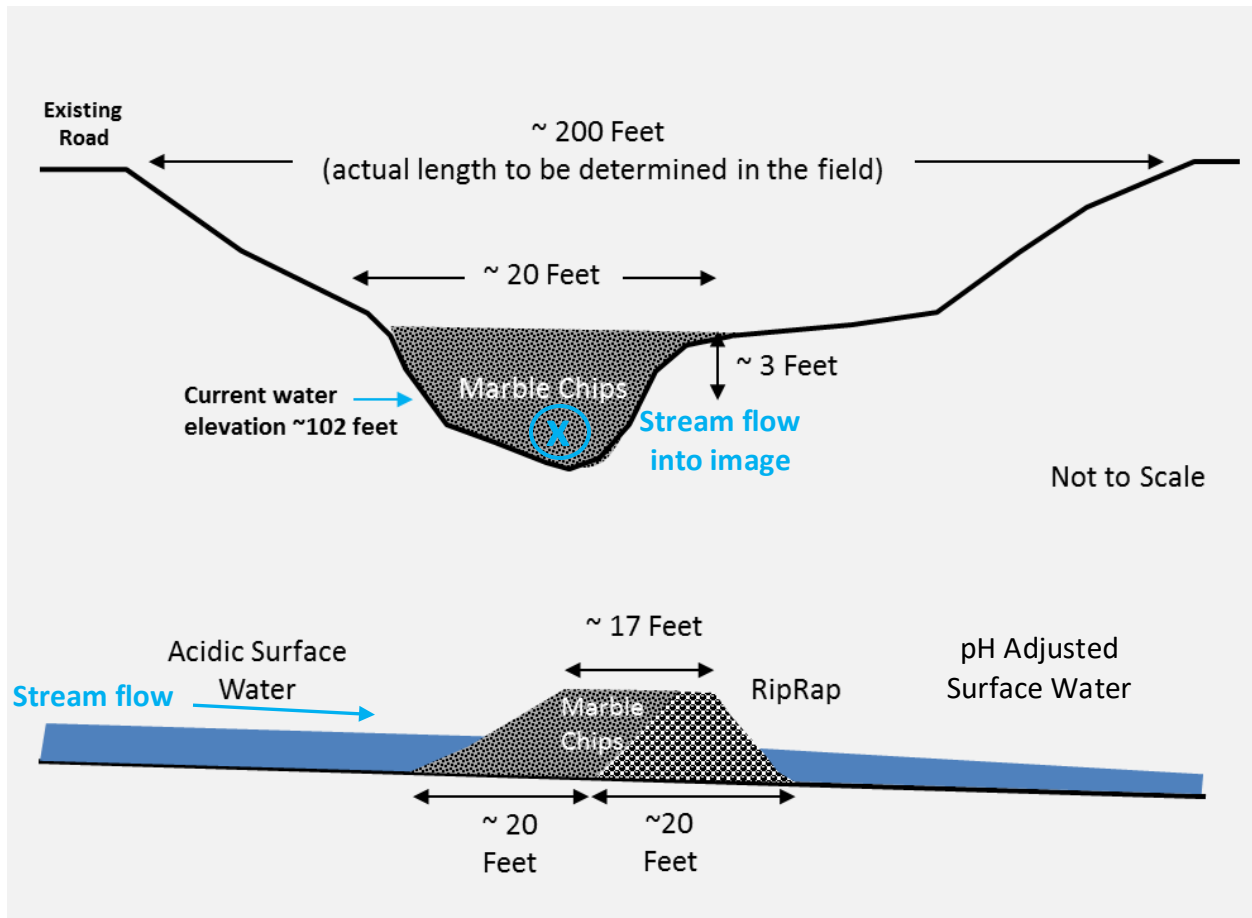


Figure 5. Diagram of CaCO_3 Reactive Structures in the D-Area Discharge Canal

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Figure 6. Production Well Flow Testing Setup

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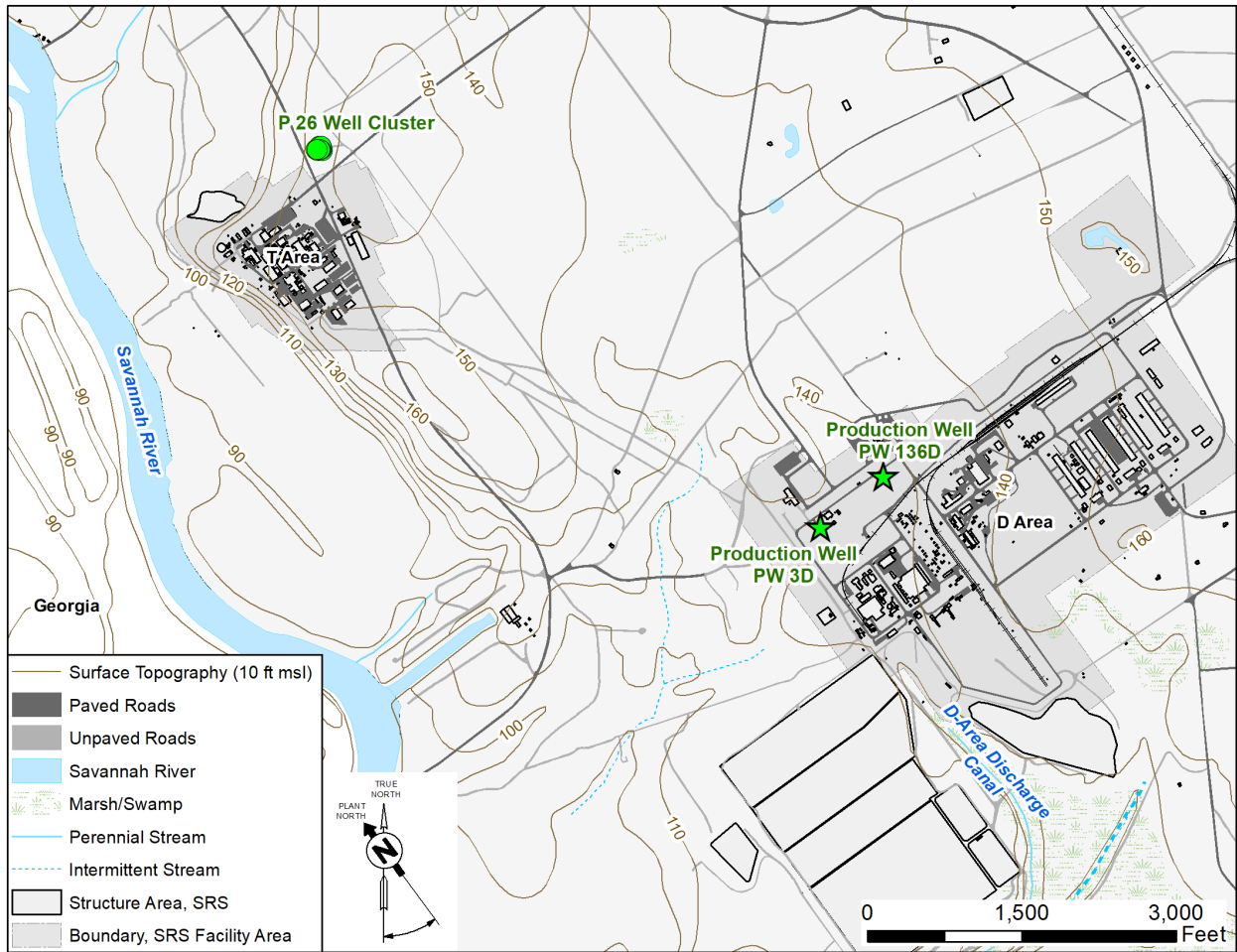
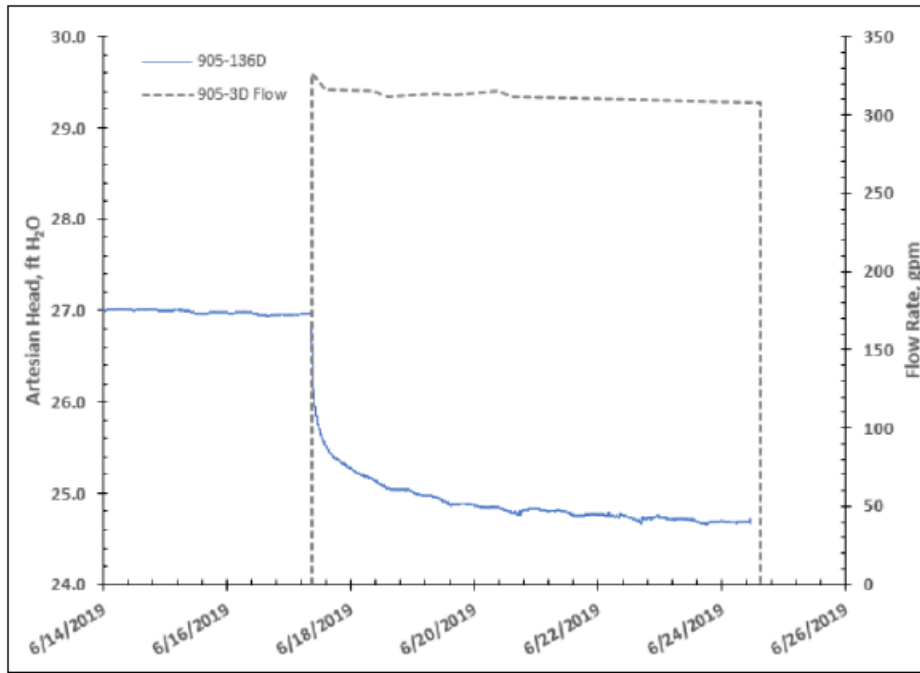
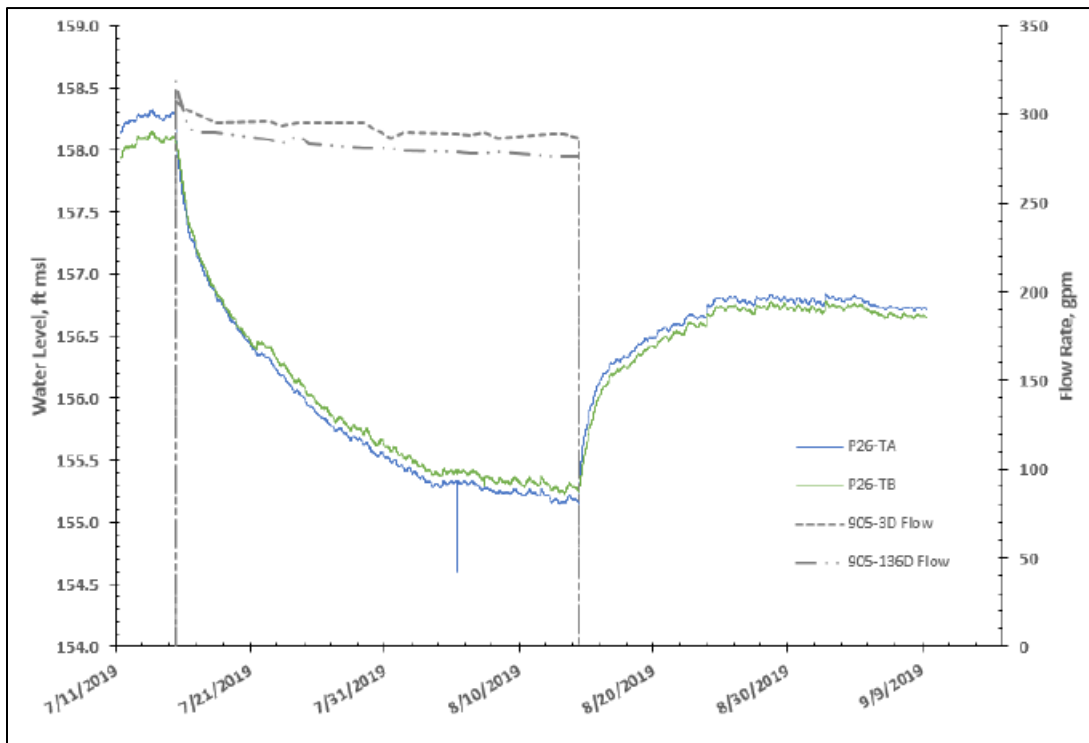


Figure 7. Location of the P 26 Well Cluster

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Aquifer Response at PW 136D Due to Withdrawal at PW 3D



Aquifer Response at P 26-TA and P 26TB Due to Withdrawal at PW 3D and PW 136D

Figure 8. Flow Test Aquifer Response Graphs

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Figure 9. D-Area Injection Wells Installed and to be Installed in 2021

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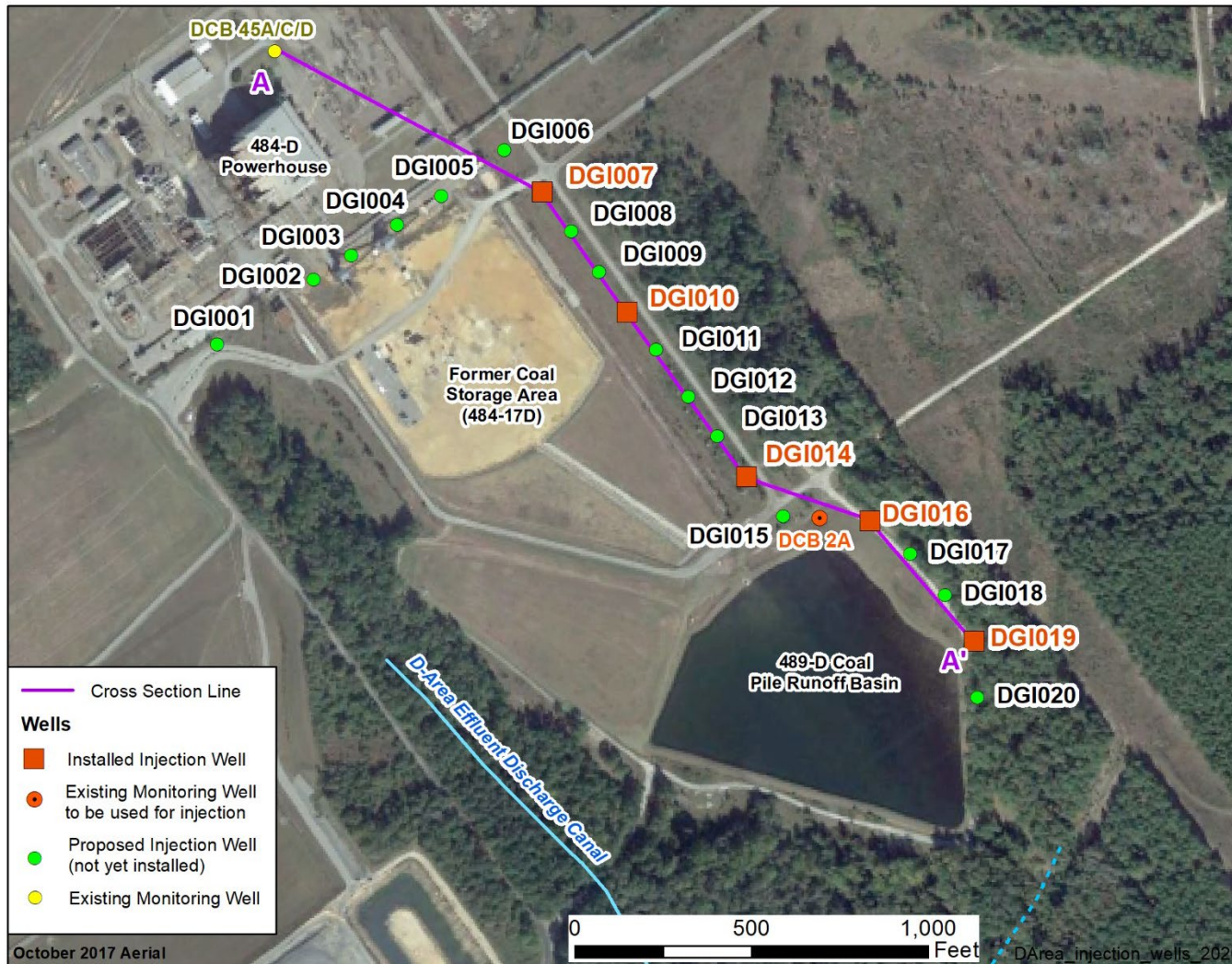


Figure 10. Installed Injection Wells and Cross Section Line A – A'

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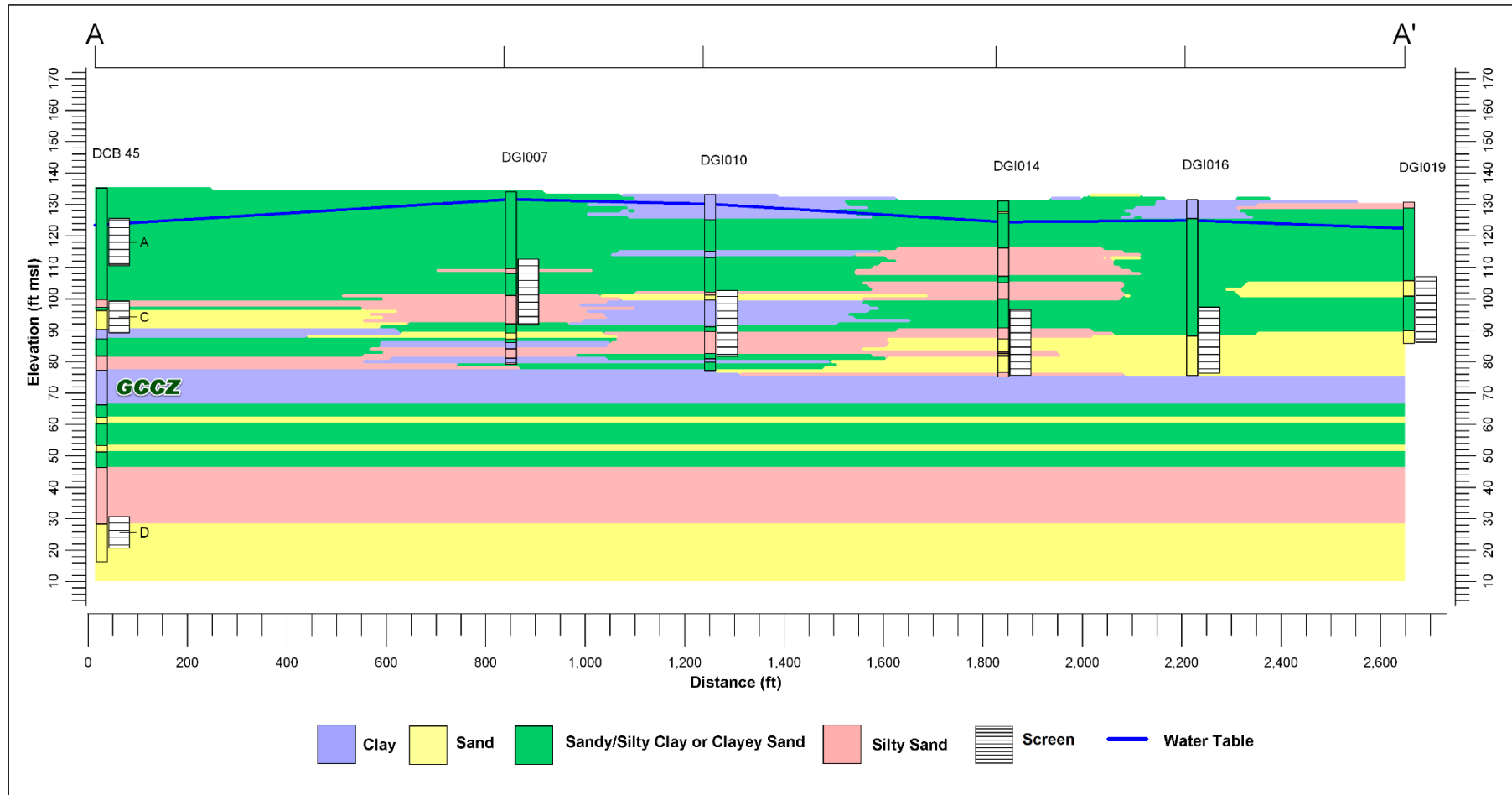


Figure 11. D-Area Injection Well Lithological Cross-Section A- A'

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Figure 12. Slug Testing at Injection Well DGI007

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Figure 13. D-Area Effluent Discharge Canal CaCO_3 Reactive Structures

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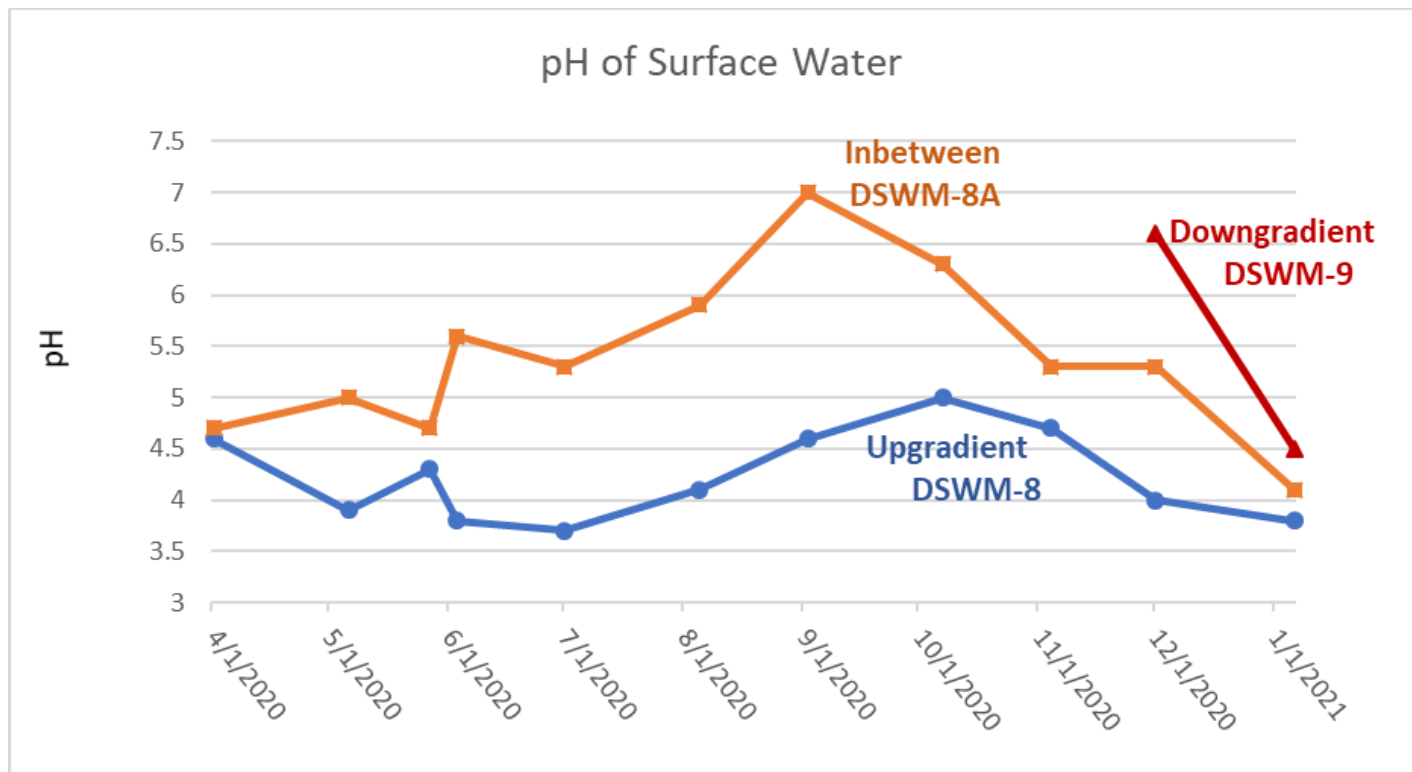


Figure 15. CaCO₃ Reactive Structure Surface Water pH Results

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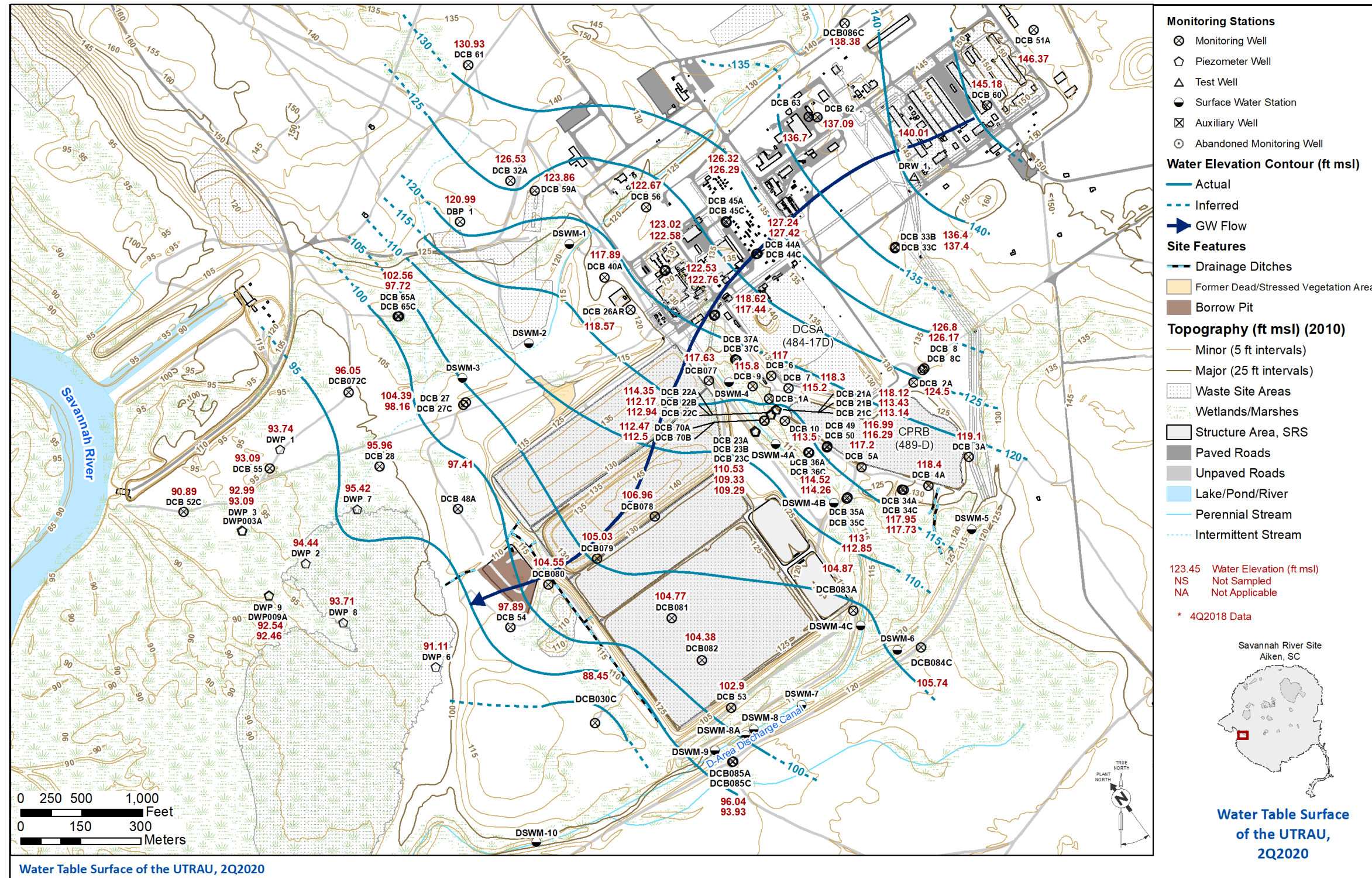


Figure 16. D-Area Groundwater OU UTRA Potentiometric Surface (2Q2020)

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APPENDIX A

GEOLOGIC LOGS OF INJECTION WELLS

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Field Geologic Log

Project		Start Date		Sheet	
Well Number		Location		Drilling Subcontractor	
Logs Prepared By		Driller		Drilling Method	
Company		Run		Depth Below Ground Surface (Feet)	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
D- Area Injection & Monitoring Well Installation		12-17-19		1 of 3	
DGI-007		S3 W7		Cascade	
Matt Malin		Donald Myles		Roto-Sonic	
North Wind					
1	0			2.5YR 3/3 - organic layer = roots w/ (CL) silty clay - damp	1105 start drilling PID = 0.0
	1				
	2		20	Too wet to catch using bottom catcher	
	3				
	4				
2	5				Hard layer @ bottom felt by driller
	6				
	7			2.5YR 3/3 stiff/organic material (CL) from above, silty CLAY	
	8		80		
	9			2.5Y 5/2 v. stiff sandy CLAY. f.g. to river gravel, poorly sorted (CL) dense 8.5-14.0 subang. subord sand & gravel	Driller notes stiff PID = 0.0
3	10				
	11				
	12				
	13			2.5Y 6/2 med stiff. f.g. sandy (CL) CLAY, poorly sorted, subang. subord sand	↓
	14				
3	15				
	16				
	17			2.5Y 6/2 f-med gr. sandy CLAY (CL) med-stiff to soft wet, mushy in places poorly sorted subang. subord. 17-20.5	PID = 0.0 ↓
	18		80		
	19				
	20				

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection & Monitoring Well Installation		12-17-19		2 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-007		SSWJ		Cascade	
Logs Prepared By				Driller	
Matt Malin				Donald Myles	
Company				Drilling Method	
North Wind				Roto-Sonic	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
3	2.0		80	2.5 yd 6/2 f-m gr clayey SAND, poorly sorted, subang-subrad. damp 20.5-21.5	PID=0.0 ↓
	1			10 yd 6/8 f. gr. silty clayey SAND; (SM) poorly sorted. subang-subrad. 21.5-22.5	
	2			10 yd 6/8 clayey SILT soft-d/h (ML) roll v. well 22.5-24.5	
4	3		90	10 yd 6/8 v. silty SAND - coarse gr. to pea gravel, poorly sorted, subang-subrad. 24.5-25.0	PID=0.0 ↓
	4			10 yd 6/8 f.-m-c gr. sandy CLAY/CLAY. damp/sat. in places w/ coarse sand. poorly sorted. subang-subrad. 26.0-29.0	
	5			10 yd 6/8 f. gr. silty clayey SAND poorly sorted, subang-subrad damp. 29.0-33	
5	6		25	10 yd 6/8 sf. gr. sandy SILT, poorly sorted. 33.0-35.0	↓ 1235
	7			10 yd 6/8 f. gr. silty SAND. saturated poorly sorted subang-subrad. LOST out bottom. Went back in w/ catcher box for core & grain size from bottom.	
	8			LOST out bottom. Went back in w/ catcher box for core & grain size from bottom.	
	4.0				

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injections Monitoring Well Installation		12-17-19		3 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-007		S3W7		Cascade	
Logs Prepared By				Driller	
Matt Malin				Donald Myles	
Company				Drilling Method	
North Wind				Roto-Sonic	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
5	0			104R 6/8 - saturated f. gr. silty SAND 40.0-42.0	1230. run back in w/ leather. logged for description. NOT in situ (assumed)
	1				
	2			GLE 1 4/5 GY - f. gr. silty clayey SAND. damp poorly sorted subang. - sub rnd.	
	3			42.0-45	
	4				
6	5			GLE 1 4/5 GY - f. gr. silty SAND, wet/ saturated poorly sorted, subang. - sub rnd. 45.0-47.0	1235 Ashley small says to drill another 10'
	6			GLE 1 4/5 GY f. gr. sandy CLAY. damp, soft. 47.0-48.0	
	7			104R 6/8 7/1 - dense, stiff CLAY 48.0-50.0	
	8		100	104R 6/8 7/2 f. gr. silty SAND, poorly sorted, subang. - sub rnd. damp. 50.0-53.0	
	9			104R 7/2 dense, stiff CLAY 53.0-54.5.	
	0			104R 7/4 f. gr. silty SAND, poorly sorted, subang. - sub rnd.	
	1			TD 55.0'	
	2				
	3			Screen 22-42' backfill w/ sand 42-55	
	4				
5				TD 55.0' 1300 Ashley says stop drilling	

Field Geologic Log

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
Project: D-Area Injection -> Monitoring Well Installation Start Date: 12-18-19 Sheet 1 of 3 Well Number: DGI-010 Location: S3 W7 Drilling Subcontractor: Cascade Logs Prepared By: Matt Martin Driller: Donald Myles Company: North Wind Drilling Method: Roto-Sonic					
1	0		33	5 y 3/1 gray, dense CLAY w/red (CL) mottling 4.0-6.0	PID = 0.0 ↓ PID = 0.0
	1				
2	2		100	5 y 6 1/2-7 1/2 gray/lt. olive gray dense, (CL) v. stiff CLAY 6.0-8.0, dry 5 y 6 1/4-7 1/4 dense gray/lt. gray, dense (CL) v. stiff t. gr. sandy CLAY w/some, mottling 11-14.0, 8.0-14.5	1245 ↓ 1257 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
3	12		75	2.5 y 6 1/2-6 3/4 (lt. gray/lt. yell. gray) dense stiff sand f. gr. sandy CLAY w/ rounded/subround pebbles, dry 14.5-16.0	PID = 0.0 ↓
	13				
	14				
	15				
20	18.5-20.0	5 y 5/2 reddish gray stiff, dense CLAY dry. 18.5-20.0			

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection & Monitoring Well Installation		12-18-19		2 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-010		S3 W7		Cascade	
Logs Prepared By				Driller	
Matt Malin				Donald Myles	
Company				Drilling Method	
North Wind				Roto-Sonic	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
3	2 0		75	2.5y 7/2 lt. gray f. gr. sandy CLAY wet w/depth. max end, less clay, poorly sorted, subang-sub rnd. 20.0-21.5	PID = 0.0 ↓
	1				
	2				
	3				
	4				
	5				
4	2 6		85	GLEY 1 5/1 5G-1/1 greenish gray f. gr. clayey silty SAND/sandy CLAY damp, poorly sorted, subang-sub rnd. 21.5-26.0	PID = 0.0 ↓
	7				
	8				
	9				
	3 0				
	1				
5	3 0		75	GLEY 1 5/1 5G-1/1 greenish gray silty SAND, f. gr. poorly sorted (31.0-32.0)	1412 ↓
	1				
	2				
	3				
	4				
	5				
5	3 6		75	10YR 5/8 fm gr. silty SAND, poorly sorted, subang-sub rnd 32.0-33.5 damp	1430 ↓
	7				
	8				
	9				
	4 0				
	4 0				
5	3 6		75	10YR 6/6 dense med chff-stiff CLAY 36.0-37.0	1430 ↓
	7				
	8				
	9				
	4 0				
	4 0				
5	3 6		75	GLEY 1 6/10y greenish green dense, stiff CLAY 37.0-38.0-40.5 w/ occ shell frag	1430 ↓
	7				
	8				
	9				
	4 0				
	4 0				

Field Geologic Log

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
Project		D-Area Injection - Monitoring Well Installation		Start Date	Sheet 3 of 3
Well Number		DGI-010		Location	S3 W7
Logs Prepared By		Matt Malin		Drilling Subcontractor	Cascade
Company		North Wind		Driller	Donald Myles
				Drilling Method	Roto-Sonic
5	4 0			CLAY 1 5/11 10yR, soft, fat CLAY 40.5-42.0, w/occ shell frag.	PID = 0.0
	1				↓ 14410 Ashley asks for 10' more to 56.0. PID = 0.0
	2			10yR 5/8 - f-m-c graded silty clayey SAND, w/shell frags	
	3			42-43.5 - dump.	
	4			10yR 6/4 f. gr. silty SAND, poorly sorted subang. sub sand dump	
	5			43.5-46.0	
	4 6				
	7				
	8			10yR 6/8 f. gr. silty SAND, poorly sorted subangular to subrand. dump, silt content increases w/ depth	
	9			47.5-50.5	
6	5 0		85	10yR 6/8 f. gr. clayey-silty SAND - (more clay than above) poorly sorted, subang subrand 50.5-52.25	↓
	1			10yR 7/2 med stiff CLAY, 52.25-53.25	
	2			10yR 5/4 f. gr. sandy CLAY to silty CLAY 53.25-55	
	3			10yR 7/2 f-m gr silty SAND, subang-subrand. dum 55.0-55.5	
	4			10yR 5/4 f. gr. sandy, silty CLAY 55.5- 56.0	
	5 6				
	7				
	8				
	9				
	0				
				TD @ 56' - 6"	

Field Geologic Log

Project		D-Area Injection and Monitoring Wells		Start Date	2-4-20	Sheet	1 of 3	
Well Number		DGI014	Location		S307	Drilling Subcontractor		Cascade Drilling
Logs Prepared By		Matt Malin		Driller		Donald Myles		
Company		North Wind Portage		Drilling Method		Roto-Sonic		
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description		Drilling Comments/Remarks		
1	0							
	1							
	2		50					
	3			SY 3/1 dense, stiff f. gr. sandy CLAY (CL) 3.0-4.5		PID=0.0		
	4			SY 5/1 f. gr. silty SAND, clay, calcareous (SM) subang. subrand. 3.5-4.0		↓		
	5			SY 5/1 dense stiff sandy CLAY 4.0-5.0 (CL)				
2	6							
	7							
	8			2.5Y 3/1-4/1 soft, f. gr. sandy CLAY (CL) poorly sorted, subang-subrand 8.0-9.0		PID=0.0		
	9			2.5Y 6/2 stiff-v. stiff f. gr. sandy CLAY (CL) 9.0-10.5'		↓		
	10			2.5Y 5/2 stiff-v. stiff f. gr. sandy CLAY (CL) poorly sorted, subang-subrand 10.5-15.0 ; 10/rd. cobbles 14.0-14.75				
	11							
	12							
	3	13			5.0Y 1.5/1 silty, vf. f. gr. silty SAND, tr. clay, poorly sorted, subang-subrand. (SM) 15.0-16.0			
		14						
		15		50				
16		2						

Field Geologic Log

Project D-Area Injection and Monitoring Wells		Start Date 2-4-20		Sheet 2 of 3	
Well Number DGI #14		Location S3W7		Drilling Subcontractor Cascade Drilling	
Logs Prepared By Matt Malin		Driller Donald Myles			
Company North Wind Portage		Drilling Method Roto-Sonic			
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
3	2.0				PID = 0.0 ↓
	1			6 LEY 1 5/1 5/4 f. gr. silty SAND, tr. (sm) clay, poorly sorted, subang-sub rnl. 21.0-24.0	
	2				
	3		50		
	4			10 yr 6/6-6/8 soft silty f. gr. sandy (CL) CLAY 24.0-26.0	
4	2.6				PID = 0.0
	7				
	8				
	9				
	0			10 yr 6/6-6/8 f. gr. silty SAND, tr. clay, (sm) tr. m. gr. sand, poorly sorted, subang-sub rnl. 30.0-31.30	
5	3.0				PID = 0.0
	1		60	10 yr 6/6-6/8 silty CLAY, soft, w/ (CL) f. gr. sand coming in at 35-36.0 31.3-36.0	
	2				
	3				
	4				
5	4.0				PID = 0.0
	1			10 yr 6/6-6/8 f. gr., tr. m. gr. silty clayey (sm) SAND, poorly sorted, subang-sub rnl. 31.0-40.5	
	2				
	3				
	4				

5930

5940

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection and Monitoring Wells		2-4-20		3 of 3	
Well Number		Location		Drilling Subcontractor	
DGI 014		S3 W7		Cascade Drilling	
Logs Prepared By		Driller			
Matt Malin		Donald Myles			
Company		Drilling Method			
North Wind Portage		Roto-Sonic			
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
5	0			10 yr 6/6-7/6 v.f. gr. silty SAND, (SM) tr. clay poorly sorted, subang-subrnd. \$0.5 - \$6.0	PID = 0.0 ↓
	1		70		
	2				
	3				
	4				
6	4				10 yr 6/6-7/6 v.f. gr. silty SAND, poorly sorted, subang-subrnd. damp \$0.5 - \$3.5
	5		75		
	6				
	7				
	8				
005	4				10 yr 3/3-3/4 f. gr. silty SAND w/ indurated (SM) cobbles (54.5-55.0) zone, poorly sorted, subang-subrnd. damp 53.5-55.0.
	5			10 yr 5/6 f. gr. silty SAND, poorly sorted, subang-subrnd damp. 55.0-56.0	
	6			drillers observed ~ 3" of greenish black sediment (CLAY?) in bottom of catchall - but it went into the mud pan. (CL)?	
	7				
	8				

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection & Monitoring Well Installation		1-6-2020		1 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-016		S307		Cascade	
Logs Prepared By				Driller	
Matt Malin				Donald Myles	
Company				Drilling Method	
North Wind				Roto-Sonic	

Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
1	0		100	2.5 y 6/1-7/1, M. reddish gray, v. stiff (CL) CLAY w/ red & yellow orange mottling dry. 0-6.0' 5.0-6.0 sandy CLAY - dense.	PID = 0.0 0-6'
	1				
	2				
	3				
	4				
	5				
2	6		70	2.5 y 6/1-7/1 v. dense, stiff, sandy (CL) CLAY, f. gr. w/ occ red. gravel clasts, red - org. mottling, more sand towards bottom of run, dry. 9.0-16.0	PID = 0.0 9-16'
	7				
	8				
	9				
	10				
	11				
3	16		100	2.5 y 6/1 - 16 y 6/6 med. stiff sandy (CL) CLAY, getting softer & gr sand. partly saturated, sub ang-sub rnd. 16.0-26.0	W goes fr with 1330 PID = 0.0 16-26'
	17				
	18				
	19				
	20				
	21				

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection - Monitoring Well Installation		1-6-2020		2 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-016		5307		Cascade	
Logs Prepared By				Driller	
Matt Malin				Donald Myles	
Company				Drilling Method	
North Wind				Roto-Sonic	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
3	2.0		100	10yr 5/8 - 5/8 f. gr. sandy, silty	PID = 0.0 16-26'
	1			(CL) CLAY - med. stiff to soft, damp.	
	2			poorly sorted, subang-subind-	
	3			20.0-26.0	
	4				
	5				
4	2.6		80	10yr 4/6 f. gr. silty, sandy CLAY.	PID = 0.0 28.0-36.0
	7			(CL) med-stiff-soft. 28.0-31.0	
	8				
	9				
	3.0				
	1				
5	1		80	10yr 7/1 - 10yr 6/4 mottled f. gr. sandy, silty	PID 0.0 38.0-46.0
	2			(CL) CLAY. soft 28.0-31.0	
	3			10yr 4/4 f. gr. sandy silty CLAY. med stiff to	
	4			(CL) soft. 31.0-34.5	
	5			10yr 5/6 clayey SILT, soft, damp	
	6			(ML) 34.5-36.0	
5	3.6		80	10yr 7/2 - 10yr 6/6. clayey SILT/silty CLAY.	PID 0.0 38.0-46.0
	7			(ML) 38.0-4.0	
	8				
	9				
	0				

1353

1397

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection & Monitoring Well Installation		1-6-2020		3 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-016		53W7		Cascade	
Logs Prepared By				Driller	
Matt Malin				Donald Myles	
Company				Drilling Method	
North Wind				Roto-Sonic	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
5	0		80	10 yr 6/6 vt. gr. sandy SILT, soft, poorly sorted, dump 40.0-43.5	PID = 0.0 38.0-46.0
	1			10 yr 6/6 w/f gr silty SAND, poorly sorted, subang - subind. dump 43.5-46.0	
	2				
	3				
	4				
4	6	10 yr 5/6 fm gr. to coar. gr. silty SAND, poorly sorted, subang - subind. dump 47.8-56.0'	1416 - stop drilling - no sands - call for H. Shull. 1455 resume drilling directed to go to 56' PID = 0.0 47.8-56.0'		
5	82				
6					
6	0		82	10 yr 5/6 fm gr. to coar. gr. silty SAND, poorly sorted, subang - subind. dump 47.8-56.0'	1525
	1				
	2				
	3				
	4				

Field Geologic Log

Project		Start Date		Sheet	
D-Area Injection & Monitoring Wells		1-7-2020		1 of 3	
Well Number		Location		Drilling Subcontractor	
DGI-019		S4W7		Cascade	
Logs Prepared By		Driller			
Matt Malin		Donald Myles			
Company		Drilling Method			
North Wind		Roto-Sonic			
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
1	0	X			PID = 0.0 1.0 - 5.0'
	1	10YR 4/1 f. gr. silty SAND w/ organic roots (SM)		poorly sorted - cover soil 10-2.0	
	2	10YR 5/1-5/2 f. gr. sandy CLAY, poorly sorted, v. stiff, dense, dry 2.0-3.75	80		
	3	10R 5/6 f. gr. silty CLAY - w/ org. mottling v. stiff, dense, dry 3.75-5.0			
	4				
2	5	X			PID = 0.1 9.0 - 15.0
	6				
	7				
	8				
	9	10YR 5/1 f. gr. sandy silty CLAY - soft, (CL) w/ organic roots 9.0-11.0	60		
3	10				PID = 0.1 17.0 - 25.0
	11	2.5 YR 4/0 dense, dry f. gr. sandy CLAY (CL) w/ up to 1" subang-subang pebbles w/ gray mottling/layers 11.0-13.75			
	12				
	13	2.5 YR 5/6 f. gr. silty clayey SAND, dry poorly sorted, subang-subang w/ 2" x rad. cobble 13.75-15.0			
	14				
3	15	X			PID = 0.1 17.0 - 25.0
	16				
	17				
	18	10YR 5/6 med. stiff f. gr. sandy CLAY, poorly sorted, subang-subang dense 17.0-20.0	80		
	19				
	20				

Field Geologic Log

Project		D-Area Injection + Monitoring Wells		Start Date	1-7-2020 <th>Sheet</th> <td>2 of 3</td>	Sheet	2 of 3
Well Number		DGI-019 <th colspan="2">Location</th> <td colspan="2">S4W7</td>		Location		S4W7	
Logs Prepared By		Matt Malin <th colspan="2">Drilling Subcontractor</th> <td colspan="2">Cascade </td>		Drilling Subcontractor		Cascade	
Company		North Wind <th colspan="2">Driller</th> <td colspan="2">Donald Myles </td>		Driller		Donald Myles	
Depth Below Ground Surface (Feet)		Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks		
3	2 0		80	10 yr 5/6 med. sandy CLAY w/ frag. (CL) poorly sorted, subang-subrnd. 20.0-22.0	PID = 0.1 17.0-25.0	1555	
	1						
	2			10 yr 5/6 med. stiff, f. gr. sandy CLAY, (CL) sorted, subang-subrnd. damp 22.0-23.7			
	3			10 yr 5/6 f. gr. sandy clayey SILT. (ML) 23.7-25.0			
	4						
4	2 5		90	10 yr 5/6 f. m. gr. silty SAND, poorly sorted (SM) subang-subrnd. damp 26.0-30.0	PID = 0.1 26.0-35.0	1607	
	6						
	7						
	8						
	9						
5	3 0		85	10 yr 5/6 f. gr. silty, tr. clay SAND. (SM) poorly sorted, subang-subrnd. damp. 30.0-35.0	PID = 0.1 36.5-45.0	1607	
	1						
	2						
	3						
	4						
4	3 5		85	10 yr 7/2-7/3 f. gr. silty SAND w/ tr. clay, poorly sorted, subang-subrnd. (SM) damp 36.5-42.0	PID = 0.1 36.5-45.0	1607	
	6						
	7						
	8						
	9						

Field Geologic Log

Project <i>D. Area Injection + Monitoring Wells</i>		Start Date <i>1-7-2020</i>		Sheet <i>3 of 3</i>	
Well Number <i>D61-019</i>		Location <i>S3W7</i>		Drilling Subcontractor Cascade	
Logs Prepared By <i>Matt Malin</i>				Driller <i>Donald Myles</i>	
Company North Wind				Drilling Method Roto-Sonic	
Run Number	Depth Below Ground Surface (Feet)	Lithology	Percent Recovery	Sample Description	Drilling Comments/Remarks
<i>5</i>	0		<i>85</i>	<i>10 yr s/g f.g. silty SAND, tr. med gr. sand poorly sorted, subang-subrnd, damp. less to no clay compared to above.</i>	<i>PID = 0.1</i>
	1				<i>36.5 - 45.0</i>
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	0				
					<i>TD = 45.2' +/- 1/6"</i> <i>1020</i>

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APPENDIX B

D-Area Groundwater Treatability Study Data Table (2020)

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