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United States Department of Energy

Savannah River Site

Treatability Study Work Plan for Groundwater Injection and Discharge Canal Treatment at the D-Area Groundwater (OU) (U)

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DISCLAIMER

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Aiken, South Carolina

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LIST OF ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CPRB	Coal Pile Runoff Basin
DAG	D-Area Groundwater
ft	feet
gpm	gallons per minute
m	meters
µg/L	microgram per liter
MCL	maximum contaminant level
OU	operable unit
psi	pounds per square inch
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
WSRC	Westinghouse Savannah River Company LLC (before October 2005)
WSRC	Washington Savannah River Company LLC (October 2005- July 2008)

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1.0 INTRODUCTION

D Area is located on an alluvial terrace in the southwest quadrant of the Savannah River Site (SRS) approximately 915 meters (m) (3,050 feet [ft]) east of the Savannah River (Figure 1) at an elevation approximately 37.5 m (125 ft) above mean sea level (msl). Local topography is relatively flat with a general slope from the northeast to southwest.

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 Coal Storage Area (484-17D), the 489-D Coal Pile Runoff Basin (CPRB), and four ash basins (Figure 2). For over 60 years, the 484-17D Coal Storage Area 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 484-17D Coal Storage Area, associated storm water runoff, and groundwater underlying the area have been acidified. The acidification lead to leaching of metals from both the coal and the natural minerals in the underlying soils in the vadose zone and aquifer have resulted in a sulfate and metals groundwater plume in the Upper Three Runs Aquifer (UTRA) (Figure 3). Currently, acidic groundwater is discharging downgradient into the D-Area Discharge Canal at pH levels generally below 4.

Maintenance actions conducted in 2012 and 2013 removed the majority of coal present at the 484-17D Coal Storage Area; however, the vadose zone soils beneath the storage area remain acidified. A Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) to conduct a non-time critical removal action for neutralization of the soils at the 484-17D Coal Storage Area was submitted in November 2018 (SRNS 2018). This treatability study is designed to address the acidic pH conditions in the groundwater beneath the 484-17D Coal Storage Area and 489-D CPRB and the discharge to surface water in the D-Area Discharge Canal.

2.0 PROJECT DESCRIPTION

The vadose zone and groundwater beneath the 484-17D Coal Storage Area and the 489-D CPRB are impacted by low pH conditions (< pH of 4) from approximately 60 years of coal fed power plant operations. The presence of a low-pH plume in the groundwater is expected to last for decades under natural groundwater conditions. The low-pH groundwater is currently discharging into the D-Area 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 Discharge Canal would improve.

This project proposes to test the viability of an approach to remediation that contains two relatively simple elements:

- Potable groundwater with higher pH characteristics will be injected into the aquifer upgradient of the low-pH, metals, and sulfate plumes. The higher-pH injected water will also serve as a buffering treatment agent to help reduce the acidic conditions currently present in the water table aquifer by reacting/neutralizing a portion of the groundwater acidity. The injected water will also create a hydraulic head and displace the low-pH groundwater in the aquifer.
- Treat the low-pH surface water that discharges into the D-Area Discharge Canal by adjusting the pH with calcium carbonate ($CaCO_3$) reactive structure(s).

<u>Injection of Potable Groundwater</u>

Potable groundwater 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. Two potable water wells (PW 3D and PW 136D) are present in D-Area northwest of the 484-D Powerhouse that produce groundwater with a pH of approximately 6.0 to 6.5 containing low, but measurable, levels of carbonate alkalinity that will serve as a buffering treatment agent and will react with and partially neutralize acidity in the aquifer. Both wells were used for operations and are screened approximately 152 m (500 ft) below the surface. The wells are artesian and are estimated to 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 (psi) and is expected to support enough flow and pressure to deliver large volumes of water to the proposed injection field. Artesian flow testing is planned to be conducted in the Spring of 2019 on both production wells.

The artesian groundwater will be piped to the 484-17D Coal Storage Area and 489-D CPRB and injected into the UTRA water table with a series of injection wells. Creating a water mound of 1.5 m (5 ft) above current conditions is expected to increase the groundwater discharge into the D-Area Discharge Canal. It is estimated that the production wells could 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 is calculated by multiplying the surface area of the 484-17D Coal Storage Area and the 489-D CPRB by the proposed rise in water elevation (1.5 m [5 ft]) by 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 artesian conditions of 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 higher-pH potable 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 D-Area Coal Storage Area RSER/EE/CA action to add neutralization amendments to the vadose zone soils (SRNS 2018) is intended to reduce the acidic vadose zone source that has contributed to groundwater contamination. Acidity is expected to be released from the lower vadose zone soils into the groundwater, but 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. The combined (or synergistic) effects of the two actions have not been estimated or considered but will be apparent from the measurements using the parameters described in this treatability study, the D-Area Coal Storage

Area RSER/EE/CA (SRNS 2018), and the regular D-Area Groundwater (DAG) Operable Unit (OU) groundwater and surface water monitoring.

Reactive Structures in D-Area Discharge Canal

An increase in the amount of acidic water discharging to the D-Area Discharge Canal is expected to occur as groundwater elevations rise and low-pH groundwater is displaced. Titration test results using water from the D-Area 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 5 shows the carbonate consumption rates associated with the neutralization of the sulfuric acid and illustrates a titration curve of the test. The velocity of the water passing through the reactive structure can be estimated using Darcy's Law which is valid for laminar flow through sediments. The flow calculations using estimates from other studies on hydraulics in gravels were used to determine contact time needed for the surface water to flow through the reactive structures to effectively raise the pH levels. These factors are then translated into the amount of material needed for the reactive structure. The preliminary design for each reactive structure, based on assumptions and calculations described above, includes approximately 61 cubic meters (80 cubic yards) (~ 5 dump truckloads) of high-purity $CaCO_3$ aggregate. The final selected $CaCO_3$ marble chips purity and size will determine the exact amounts of material used. Installation of two reactive structures is planned to account for uncertainties in the actual flow and contact behavior and the potential for metal cladding of the carbonate surface with time. $CaCO_3$ marble chips, engineered in two sections downgradient of the acidic groundwater discharge point within the D-Area Discharge Canal, are expected to allow enough contact time with the surface water for pH adjustment to natural conditions (Figure 4 and Figure 6). The use of high purity $CaCO_3$ (typically greater than 90% $CaCO_3$) limits the introduction of undesirable constituents into the surface water (silt, clay, reactive minerals, etc.). A source for high purity $CaCO_3$ marble chips is available in northern Georgia.

3.0 TEST OBJECTIVES

The objective of this treatability study is to determine the ability of injected clean groundwater to:

- Displace the acidic groundwater out of the upper water table aquifer of the UTRA in the vicinity of and downgradient of the 484-17D Coal Storage Area 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 $CaCO_3$ reactive structures prior to discharge into Beaver Dam Creek and the Savannah River floodplain and river.

This treatability study will be used to support the development of the DAG OU Feasibility Study.

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 groundwater injections. Stream flow measurements will document the increase in flow in the D-Area Discharge Canal from the groundwater injections.

4.0 EXPERIMENTAL DESIGN AND PROCEDURES

It is estimated that 10 pore space volumes are sufficient to displace the low-pH groundwater within the aquifer with an estimated duration of three years to meet treatability study objectives. However, actual observation of field conditions and data collected will help determine the exact impact and potential timeframes and feasibility of the action.

Water from the D-Area Discharge Canal was used in titration tests to estimate the amount of $CaCO_3$ material required to successfully raise the pH of the acidic surface water to more natural levels (SRNS 2016b) (Figure 5). Monitoring of stream pH will be conducted upgradient, between, and downgradient of the two $CaCO_3$ reactive structures to determine the efficiency of both the $CaCO_3$ material (including the potential for metal cladding to occur) and design. 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, then remixing and/or replacement of calcium carbonate material will be made.

Measurements of water table elevations, stream flow, pH, and sample collection for metal analyses will be conducted following the SRS 3Q1 Manual, *Environmental Requirements and Program Documents*, similar to other routine sampling and monitoring events at SRS such as the DAG OU monitoring. Locations to be sampled are described in Section 6.0, *Sampling and Analysis*.

Testing of the artesian flow rates of the two production wells will occur during the Spring of 2019 before the field start date of the Treatability Study (January 31, 2020). Groundwater samples from the two production wells were collected in December 2018 to support the application for an Underground Injection Control permit. Falling-head slug tests (also known as slug-in tests) will be performed in the Spring of 2019 on three existing monitoring wells to measure the aquifer characteristics during injection. This includes the two proposed monitoring wells (DCB 2A and DCB 43A) to be used as part of the injection field (see section 5.0 *Equipment and Materials*), and also at DCB 8. Complete detailed design will be done in the Fall of 2019 and will incorporate information collected during artesian flow test and the falling-head slug tests.

As field conditions warrant, adjustments such as varying injection flows, pulsating flows or connecting wells from one injection field to the other injection field are theoretical ways to optimize injection. Other traditional methods such as re-development of the wells could also be employed.

5.0 EQUIPMENT AND MATERIALS

The two production wells already exist northwest of the 484-17D Coal Storage Area and 489-D CPRB. Approximately 7,100 feet of pipes/hoses will be installed to transport the potable groundwater to the injection field (Figure 4). Due to little change in elevation, enough natural pressure from the artesian conditions is expected to be sufficient to feed the injection field of approximately 22 injection wells without the use of mechanical pumps. Two separate pipe runs will be made, one from each of the production wells. Each production well will supply half of the injection wells; i.e., well PW 3D will supply the western injection field and well PW 136D will supply the eastern injection field. Adjustments to the configuration of the injection field may be made based on the actual field conditions to optimize performance once the action is underway.

The injection wells will be screened in the upper water table of the UTRA. The water table is approximately 3 m (10 ft) below ground surface (bgs). In the vicinity of the 484-17D Coal Storage Area and the 489-D CPRB, the UTRA aquifer is present down to approximately 12.2 to 18.3 m (40 to 60 ft) bgs. The UTRA consists of interbedded and laterally discontinuous sand, silt, and clay beds. West of the D-Area Ash Basins and Landfill, which is 610 m (2,000 ft) or more from the injection field, the UTRA is incised by a 13.7 m (45 ft) thick sequence of Quaternary Savannah River deposits consisting of fluvial clay, silt, and sand. Actual screen placement will be determined based on the geologic core collected during drilling activities for the installation of the injection wells. Screens are to be placed in higher permeability (sandy) zones preferable for injection. Screen lengths between 1.5 m (5 ft) and 3 m (20 ft) are expected to be used and will based on the lithology experienced at each injection well location. Two existing monitoring wells screened within the upper water table (well DCB 43A in the western field and well DCB 2A in the eastern field) will be used as injection wells. Valves will be placed on all injection wells to control injection flow.

Groundwater injection is anticipated to cause a localized groundwater mound in the general vicinity of the 484-17D Coal Storage Area and the 489-D CPRB and is expected to increase groundwater discharge to the D-Area Discharge Canal downgradient of the injection field. Negative impacts that could occur as a result of injecting groundwater with a more neutral pH include precipitation of metals or minerals near the point of injection that may cause well fouling and decreased injection rates. This treatability study will include measurement of injection rates and, if necessary, conducting camera surveys inside the injection wells to confirm if fouling has occurred.

The two $CaCO_3$ reactive structure areas will be constructed of high-grade marble chips sourced from a facility in northern Georgia and placed directly in the D-Area Discharge Canal. Riprap will be placed on the downstream side of the marble chips to prevent erosion (Figure 6). Construction equipment will aid in the placement of the marble chips and riprap. The reactive structures will be constructed to a height of 0.9 m (3 ft) above current stream levels to account for increased flow and potential flooding events. The trees and vegetation north of the $CaCO_3$ reactive structures will be cleared and a sampling platform will be constructed to aid in the safe collection of surface water samples upstream of and downstream of each of the two structures.

Measurements of water table elevations, stream flow, pH, and sample collection for metal analyses will be conducted following the SRS 3Q1 Manual, *Environmental Requirements and Program Documents*, similar to other routine sampling and monitoring events at SRS such as the DAG OU monitoring.

6.0 SAMPLING AND ANALYSIS

Table 1 and Figure 7 show the locations of the monitoring network and the sampling schedule for the treatability study. Water table elevations will be measured at the injection wells and numerous wells surrounding the 484-17D Coal Storage Area and the 489-D CPRB to adjust the injection well flow and monitor the effects of the groundwater injections. Stream flow measurements will be collected at all surface water station locations within the D-Area Discharge Canal and the tributary to the east. Groundwater and surface water samples will be monitored for the metals that are part of the DAG OU monitoring network (Table 2). Field pH measurements, and other routine field measurements (oxidation/reduction potential, dissolved oxygen, specific conductance, total alkalinity [as $CaCO_3$], turbidity, water temperature, water elevation [at wells], and stream flow measurements [at surface water stations]) will be taken (Table 3). One round of sampling will occur before groundwater injections begin. Sampling of the two production wells will analyze for metals and other common groundwater constituents prior to beginning injection campaigns. A total of 34 wells and 9 surface water stations outside of the injection field will be monitored. Twenty monitoring wells and all 9 surface water stations will include metal, pH and other routine field analyses.

After groundwater injection begins, monthly measurements and sampling will be collected for the first eight months, followed by quarterly monitoring. Monitoring of the D-Area Discharge Canal surface water pH upgradient and downgradient of the $CaCO_3$ reactive structures will occur monthly after the initial eight-month monitoring ends. 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 Core Team 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.

7.0 DATA MANAGEMENT

Similar to other routine sampling events for groundwater and surface water, field measurements and sample data will be entered into the SRS Environmental Restoration Data Management System (ERDMS). Other field observations, including notes on the production well performance, drilling activities, system performance, field observations, etc., will be recorded in field notebooks or daily activities sheets. Photographs of the injection field components and CaCO3 reactive structures will be taken periodically to document the treatability study action.

8.0 DATA ANALYSIS AND INTERPRETATION

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 (see section 11.0 *Data Reports*).

9.0 HEALTH AND SAFETY

A site-specific health and safety plan and work package will be prepared before work begins for the treatability study. Hazards including, but not limited to, heat stress or frostbite, hand safety, harmful plants and animals, heavy construction equipment, tripping hazards, hearing protection, personal protective equipment, etc. will be examined.

10.0 RESIDUALS MANAGEMENT

Since the injections are of potable groundwater, many of the physical components of the treatability study will be sanitary waste once the action is complete. There is a possibility that metal cladding could occur on the $CaCO_3$ reactive structures marble chips due to the reactive pH adjustment of surface water and dissolution of metals. Based on field observations and measurements, the disposal of and replacement of marble chips may be required. Analysis of field and sample data and visual observation of the $CaCO_3$ reactive structures will help determine the action required, if any. Additional residuals will attempt to be identified in the development of the site-specific health and safety plan and work package.

11.0 REPORTS

A treatability study report will be submitted one year after field start. Currently, the field start date is planned for January 31, 2020. The first report is expected to the submitted by January 31, 2021. Future reports will be proposed at a later date based on the initial performance of the treatability study, but will be no later than a year following the initial report.

12.0 SCHEDULE

The anticipated length of the treatability study is approximately three years of groundwater injection. Analysis of the production well flow rates, injection operation, aquifer acceptance, field data, sample data, and performance of the $CaCO_3$ reactive structures will help determine the actual length of the treatability study. Construction of the $CaCO_3$ reactive structures and installation of the injection wells and associated piping from the production wells is not expected to occur until the field start date of January 31, 2020. Prior to the field start date, some field testing will occur. This includes sampling of the production wells in December 2018, artesian flow tests will be conducted on the two production wells and falling-head slug tests will be done on three existing monitoring wells in the Spring of 2019. Results from the Spring 2019 testing will be used to complete the detailed design of the injection system in the Fall of 2019.

13.0 REFERENCES

SRNS, 2016a. *Remediation of the Acidic Groundwater Impacting the Discharge Canal in D Area*; Interoffice Memo, Savannah River Site, October, Savannah River Nuclear Solutions LLC, Aiken, SC

SRNS, 2016b. *Feasibility Study of the Reactive Structures for the D-Area Discharge Canal*; ERD-EN-2016-0042, Savannah River Site, Rev. 0, October, Savannah River Nuclear Solutions LLC, Aiken, SC

SRNS, 2017a. *2016 Groundwater Monitoring Report for the D-Area Groundwater OU (U)*, SRNS-RP-2017-00383, Savannah River Site, Rev. 0, July, Savannah River Nuclear Solutions LLC, Aiken, SC

SRNS, 2018. *Removal Site Evaluation Report / Engineering Evaluation / Cost Analysis (RSER/EE/CA) for the D-Area Coal Storage Area (484-17D) (U)*, SRNS-RP-2018-00813, Savannah River Site, Rev. 0, November, Savannah River Nuclear Solutions LLC, Aiken, SC

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

Monitoring Well Information				Sampling			
					After Injections start		
Station	Station Type	Total Depth (ft bgs)	Screened Interval (ft msl)	Before Injection	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. Proposed Metals Included in Sample Analyses

ALUMINUM
ANTIMONY
ARSENIC
BARIUM
BERYLLIUM
CADMIUM
CALCIUM
CHROMIUM, TOTAL
CHROMIUM, HEXAVALENT*
COBALT
COPPER
IRON
LEAD
MAGNESIUM
MANGANESE
MERCURY
NICKEL
POTASSIUM
SELENIUM
SILVER
SODIUM
SULFATE
THALLIUM
URANIUM
VANADIUM
ZINC

*if chromium exceeds 100 µg/L, chromium-6+ will be analyzed during the next sampling event

Table 3. Proposed Field Measurements

OXIDATION/REDUCTION POTENTIAL
DISOLVED OXYGEN
PH
SPECIFIC CONDUCTANCE
TOTAL ALKALINITY (AS CACO3)
TURBIDITY
WATER TEMPERATURE
WATER ELEVATION (Wells)
STREAM FLOW MEASUREMENT (Surface Water)

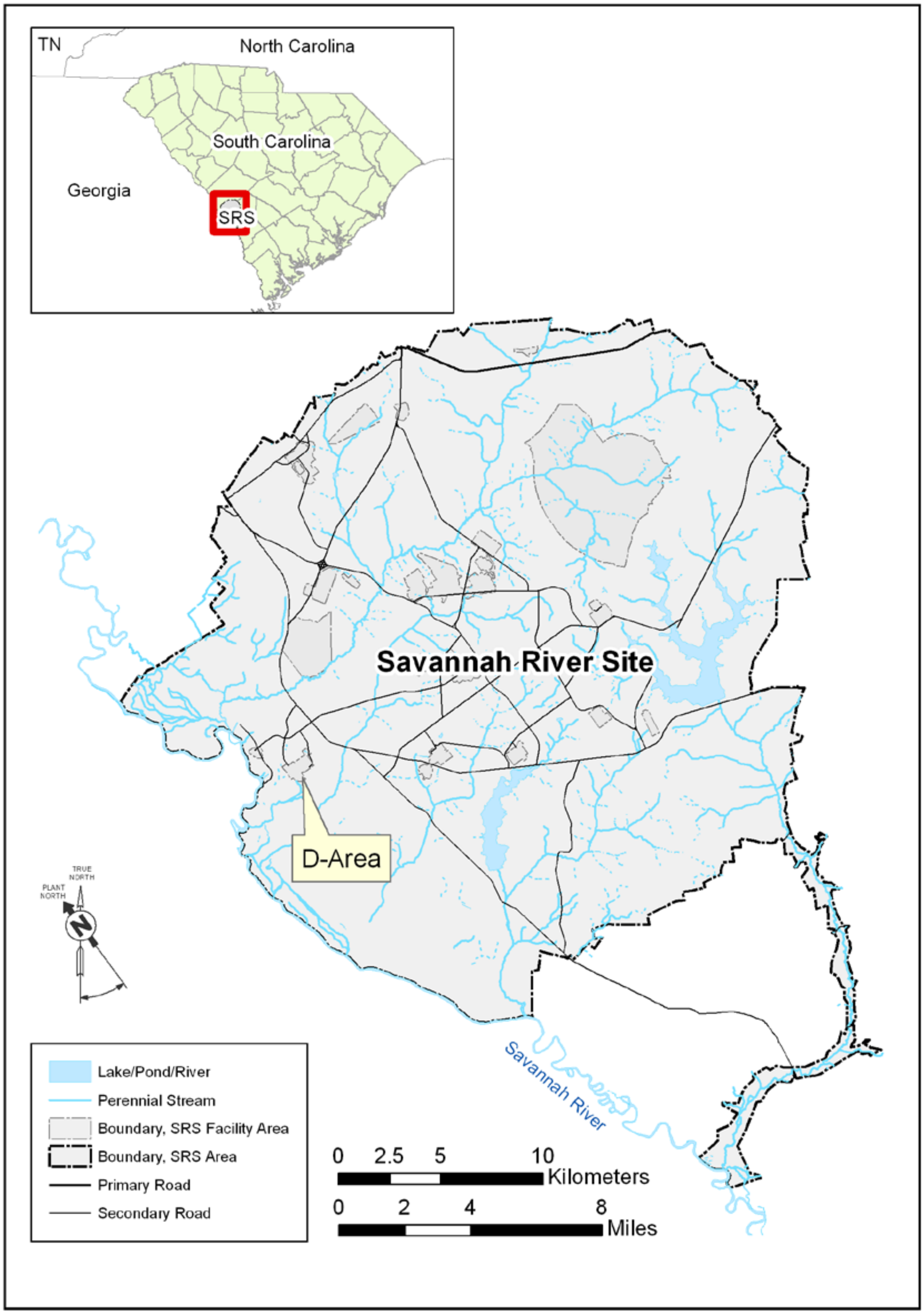

Figure 1. Location of D-Area at SRS

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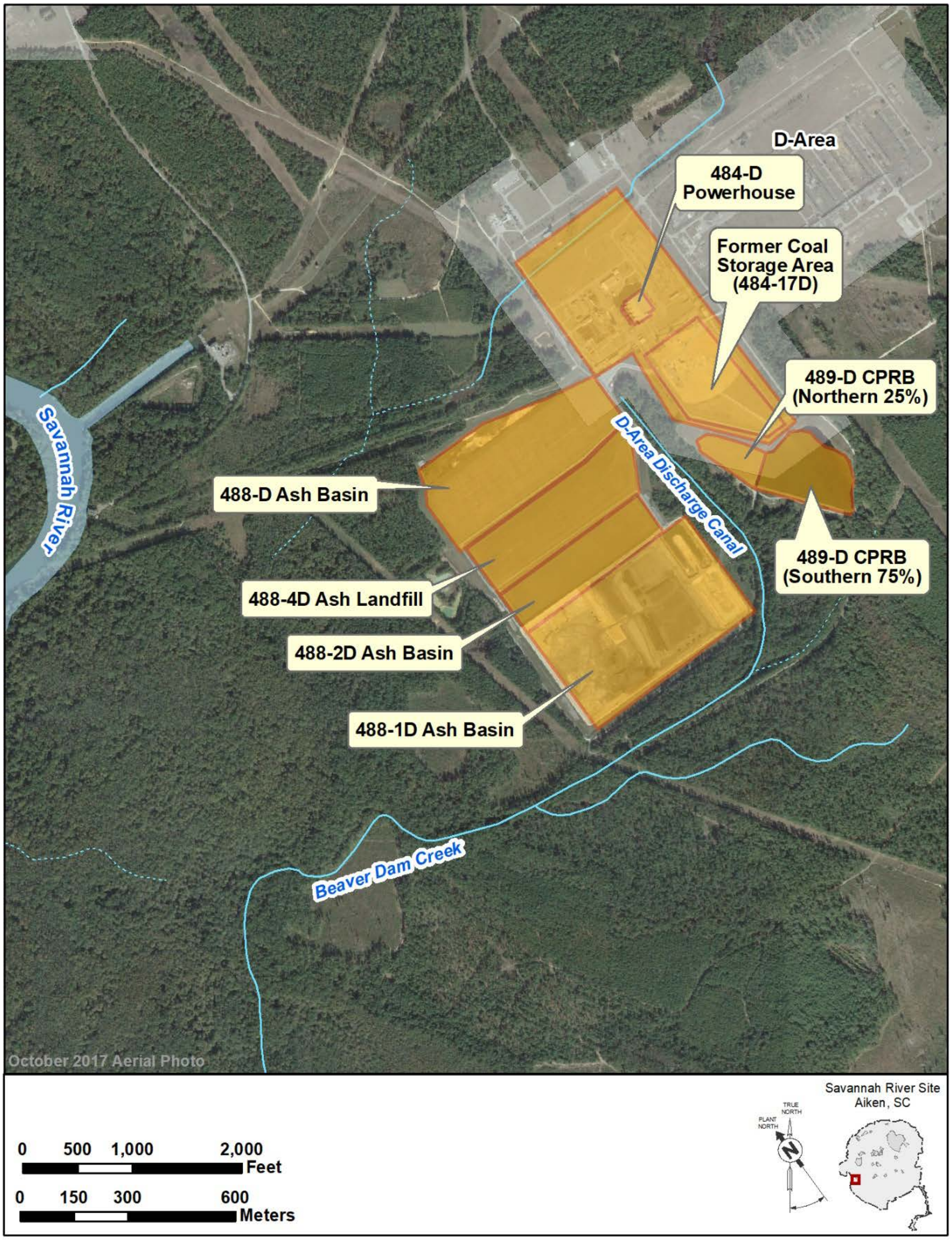

Figure 2. D-Area Powerhouse Associated Facilities

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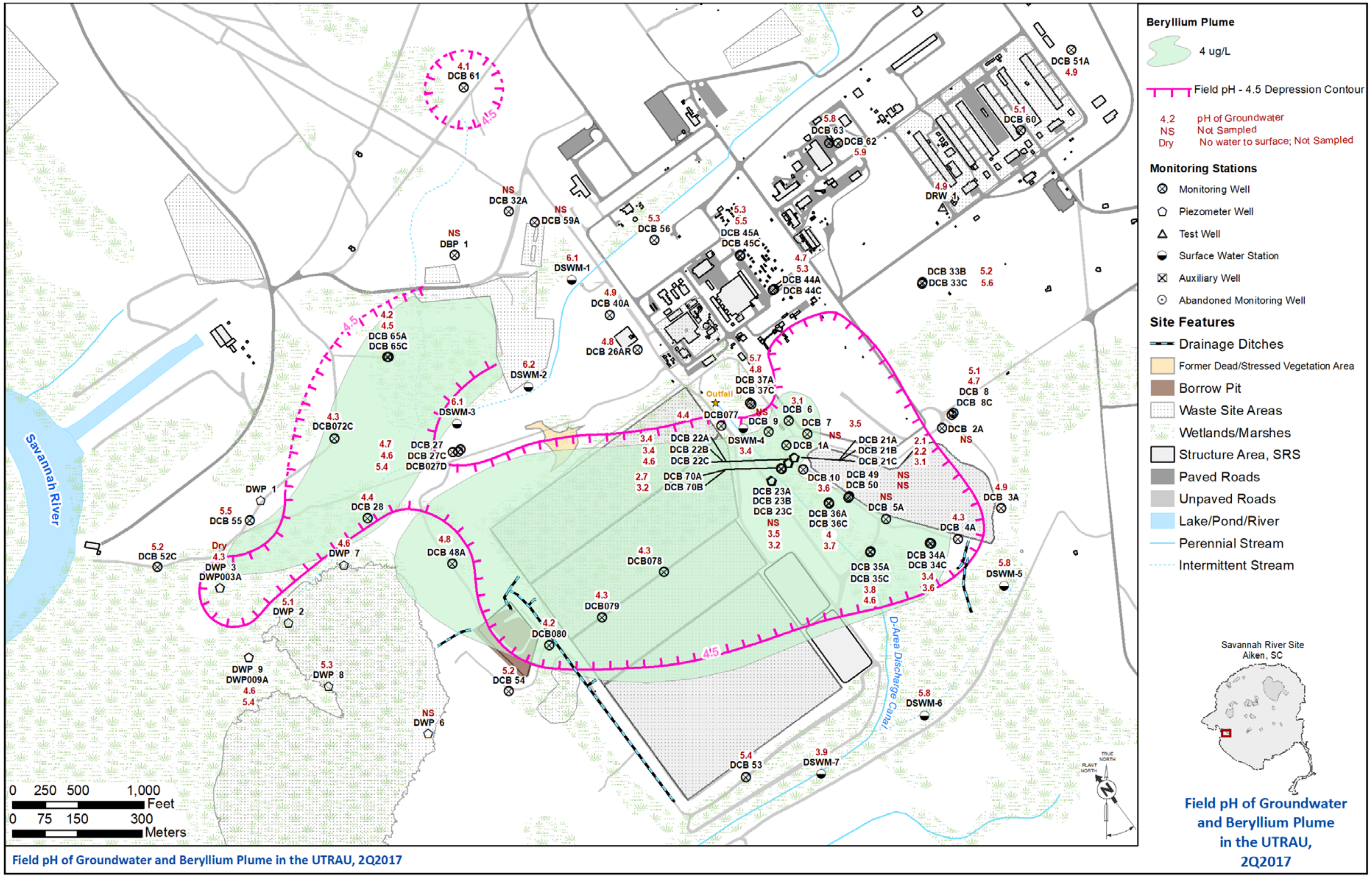

Figure 3. D-Area Groundwater 2Q2017 pH and Beryllium Plume

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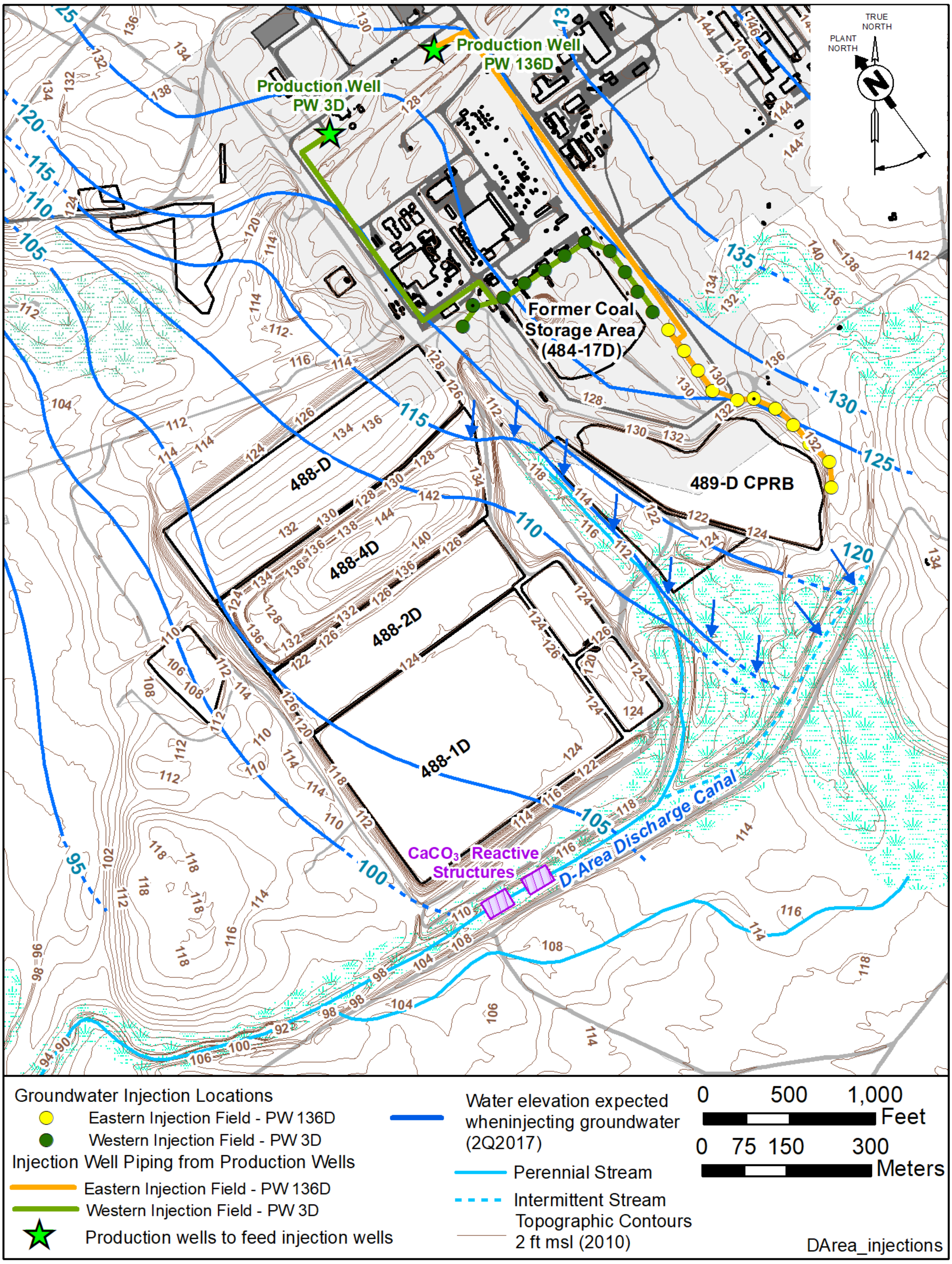

Figure 4. **D-Area Treatability Study Injection Wells, Reactive Structure, and Expected Water Table Elevation**

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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

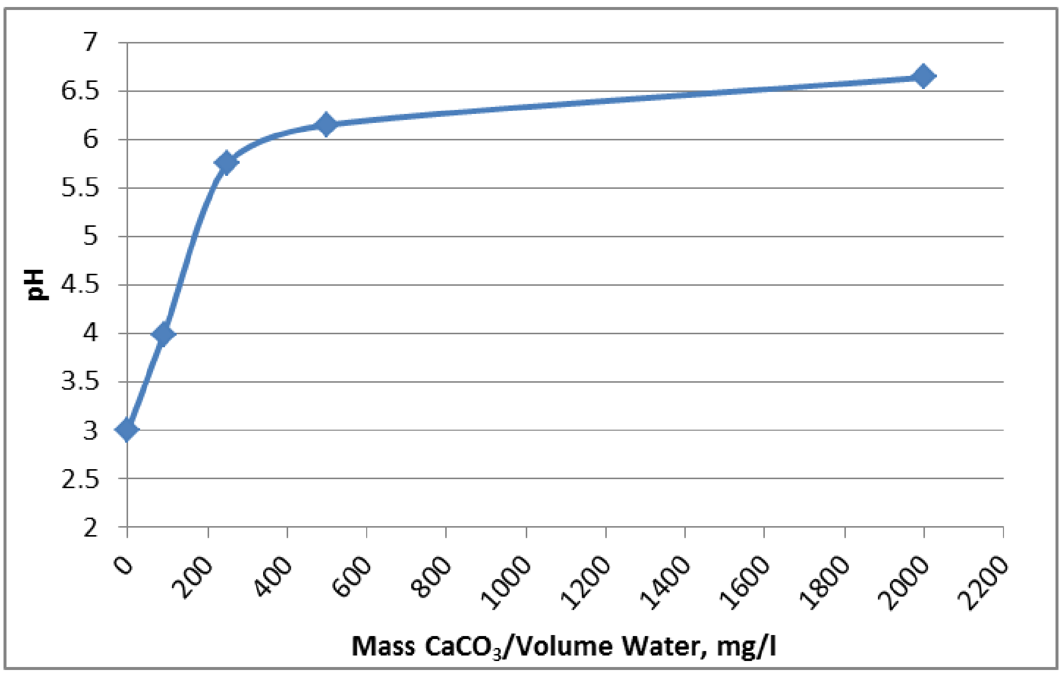

Figure 5. Titration Test Chart and Graph of D-Area Discharge Canal Acidic Surface Water with Calcium Carbonate Additions

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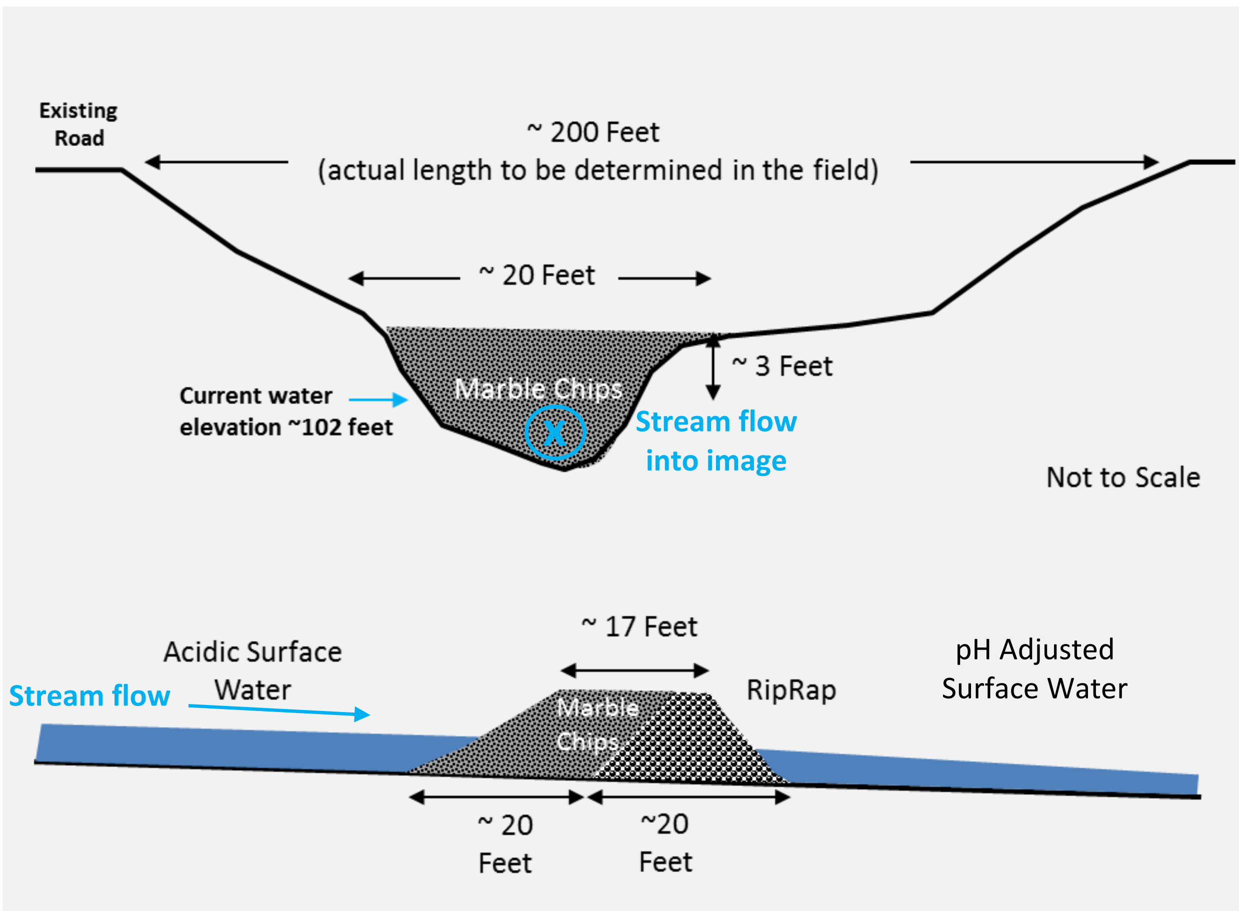

Figure 6. **Conceptual Diagram of $CaCO_3$ Reactive Structures in the D-Area Discharge Canal**

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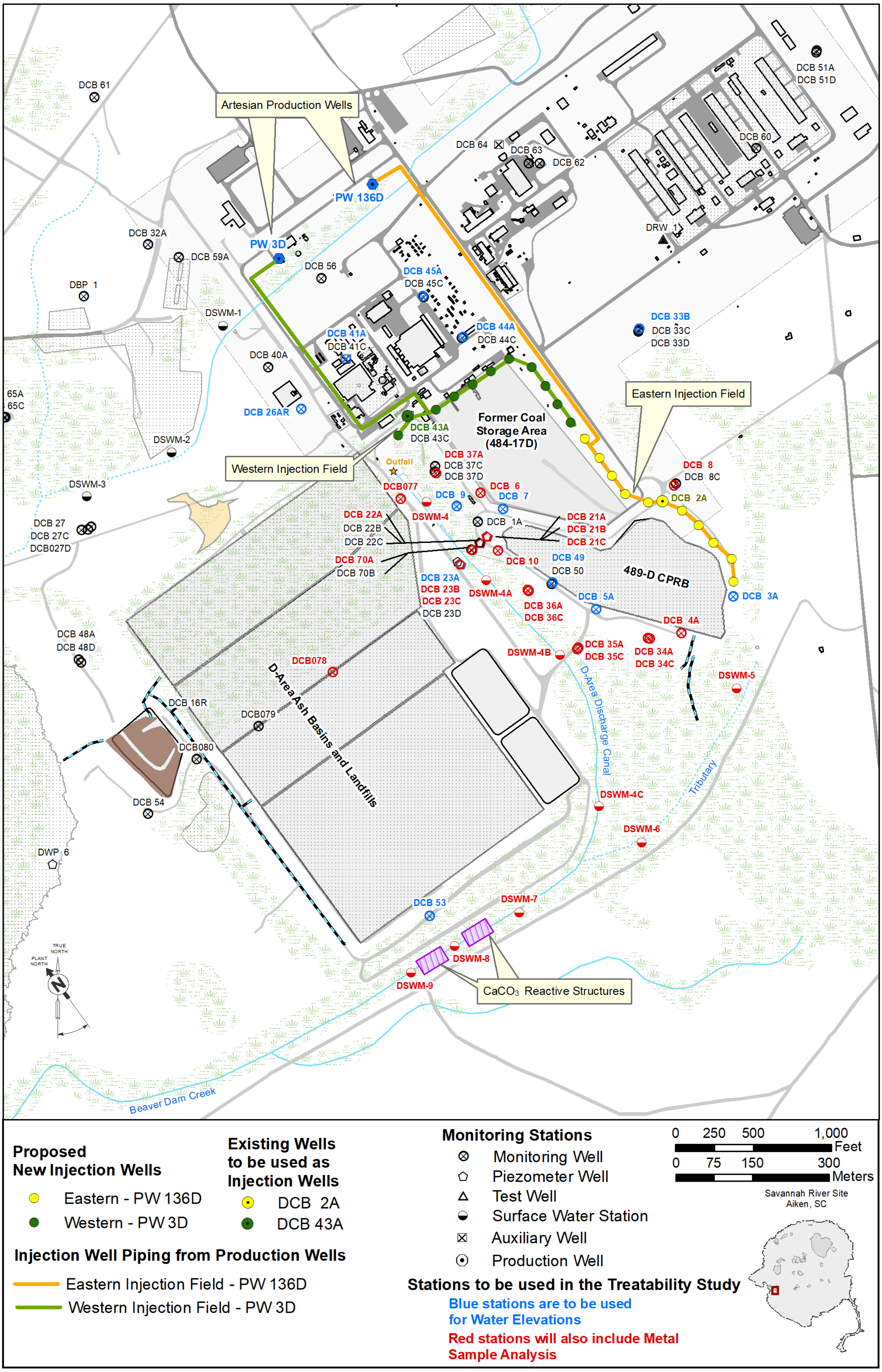

Figure 7. Proposed D-Area Treatability Study Monitoring Locations

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