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F-Area Tank Farm Vadose Zone Material Property Recommendations

Summary

Input to the F-Area Tank Farm (FTF) Performance Assessment (PA) requires vadose zone characteristics for the materials surrounding the tanks. This information is important for closure cap design and groundwater modeling. For the areas excavated for tank construction, the existing FTF vadose zone consists of the undisturbed vadose zone soil between the water table and the bottom of the excavations, the concrete work slab on the floor of the excavation, and the soil backfill around and over (if applicable) the tanks. For areas outside the tank excavations, the vadose zone comprises primarily undisturbed vadose zone soil and, to a lesser extent, backfilled soils placed around buried pipelines and utilities. This memo provides material property estimates for the undisturbed vadose zone soils, the concrete work slabs, and the soil backfill associated with each tank group.

1.0 Background

The FTF includes twenty-two tanks, which were emplaced between 1951 and 1976. The tanks were installed during four separate construction episodes leading to the designation of four different tank groups. The earliest-constructed, Group 1 (tanks 1 through 8), was constructed in 1951. Group 2 (tanks 17-20) was constructed in 1956. Group 3 (tanks 33 and 34) was constructed in 1969. Group 4 (tanks 25-28 and 44-47) was constructed in 1975 and 1976, respectively. In general the construction of each tank group consisted of digging an excavation roughly 45 ft below original land surface and stockpiling the excavated soil, emplacing a concrete work slab on the floor of the excavation to provide a stable work platform for tank construction activities, constructing the tanks, and backfilling around the tanks utilizing the previously stockpiled soil. Table 1 provides a construction summary for each group of tanks

relative to descriptions of the excavations, concrete work slab, and backfill. Figure 1 illustrates the four FTF tank groups.

Information regarding the excavations, concrete work slabs, and backfill associated with the FTF is important to the closure cap design and groundwater modeling. The bottom elevations of the excavations dug for placement of the tanks allow for the determination of depth to groundwater and thickness of the undisturbed vadose zone soils beneath the tanks. The concrete work slabs are important since they could possibly be an impediment to the downward flow of infiltrating water and result in a perched water zone. Consideration of the concrete work slabs for the groundwater modeling is only important if it is determined that they can negatively impact downward flow. The backfill characteristics are important for the estimation of material properties for input to the groundwater model and in determining whether or not lateral drainage capabilities are required directly above the tanks.

For the areas excavated for tank construction, the existing FTF vadose zone consists of the undisturbed vadose zone soil between the water table and the bottom of the excavations, the concrete work slab on the floor of the excavation, and the soil backfill around and over (if applicable) the tanks. For areas outside the tank excavations, the vadose zone comprises primarily undisturbed vadose zone soil and, to a lesser extent, backfilled soils placed around buried pipelines and utilities. The existing FTF vadose zone as described herein does not include information on the tanks or their contents, since this will be described in a separate package. Presented herein is information on the undisturbed vadose zone soil, the concrete work slabs, and the soil backfill associated with each tank group.

2.0 Undisturbed Vadose Zone Soil

A great deal of geologic and geotechnical characterization in addition to hydrogeologic modeling has been performed for the Savannah River Site (SRS) General Separations Area (GSA). The GSA includes the H-Area Tank Farm (HTF), the E-Area Low Level Waste Facility (LLWF), the E-Area Old Radioactive Waste Burial Ground (ORWBG), the F-Area Tank Farm (FTF) and Z-Area. Earlier geotechnical work has noted the similarities between the geology in H-Area and the geology in F-Area (WSRC-TR-96-00069). The E-Area LLWF, which is located between H-Area and F-Area and is approximately 5,000 ft northeast of the FTF (see Figure 2), has a highly characterized vadose zone. The relative proximity of E-Area and F-Area, physiographic data, and geologic information suggest that the geology at the E-Area LLWF and FTF are very similar.

Figure 2 provides a topographic location map for F-Area and E-Area. Both areas are located atop a ridge running southwest-northeast that forms the drainage divide between Upper Three Runs to the north and Fourmile Branch to the south. Because the FTF and E-Area LLWF are located parallel to both paleoshorelines and upland clastic source areas and the FTF and LLWF are at approximately the same elevation, one would expect that these two areas had similar depositional environments and therefore, they would have similar geologic sediments.

A preliminary review of available geologic information from E-Area as well as F-Area is provided herein. Additional geologic and material properties information may be available in SRS geotechnical reports not reviewed as part of this effort. Reviews of such geotechnical reports should be performed as part of the PA data gathering effort.

2.1 E-Area Vadose Zone Compared to F-Area Vadose Zone

For subsurface transport modeling, the E-Area LLWF vadose zone has been divided into an upper, finer-grained zone and a lower coarser-grained zone (i.e. upper sand with more silt and clay compared to the underlying sand with less silt and clay). Figure 3 illustrates this general 2-layer division with sieve analyses and cone penetrometer technology (CPT) log data. The sieve data and CPT log data were collected from adjacent locations at the E-Area LLWF.

The geology in F-Area and E-Area is expected to be similar based on their proximity to each other and physiographic location. Comparisons of foot-by-foot core descriptions from the FTF and E-Area LLWF provide further evidence of their similar geology, which includes an upper, finer-grained zone and a lower, coarser-grained zone. Figure 4 presents the locations of three cores: FCH5, located southwest of the FTF; BGO-53AA, located mid-way between the FTF and the E-Area LLWF; and BGX-2B, located in the E-Area LLWF. Core descriptions and associated gamma ray logs, the water table location, and picks between the upper and lower vadose zones are presented in Figure 5. The boundary between the upper and lower vadose zones is picked at about 30 ft below land surface (bls) in the E-Area LLWF, at about 21 ft bls between the E-Area LLWF and the FTF, and at about 16 ft bls southwest of the FTF.

Picks between the upper and lower vadose zones as well as some geologic formations can also be made from CPT data. Figure 6 shows the location of a CPT "push" FTNK C17, outside and north of the FTF. Figure 7 presents the FTNK C17 subsurface data compared to that of a CPT located in the E-Area LLWF. Upper and lower vadose zone areas are highlighted in pink and yellow shading, respectively. The thickness of the upper vadose zone is about 21 ft in the E-Area LLWF CPT versus about 35 ft in the FTF CPT (i.e. FTNK C17). At the FTF the 16-ft thickness of the upper vadose zone seen in core FCH-5 (284 ft-msl in Figure 5) versus the 35-ft thickness seen in FTNK C17 (292 ft-msl in Figure 7) is primarily a result of topographic elevation, where the upper vadose zone layer thins with decreasing elevation.

Available geologic and geotechnical data reviewed to date show that the FTF has both an upper and lower vadose zone similar to that designated and described for the E-Area LLWF. This information further indicates the upper vadose zone at the FTF is approximately 35-ft thick and that the interface between the upper and lower vadose zones occurs at an elevation near 257 ft-msl (292 ft-msl minus 35 ft). Since physiographic data and geologic information suggest that the geology at the E-Area LLWF and FTF are similar, modeling approaches used for the E-Area LLWF should be reasonable for the FTF. Recommendations for the FTF vadose zone material properties are described below.

2.2 Vadose Zone Material Properties & F-Area Tank Elevations

Material property estimates for the upper and lower vadose zone at the E-Area LLWF have been evaluated and described in a recent geotechnical report "Hydraulic Property Estimation for the E-Area and Z-Area Vadose Zone Soils, Cementitious Materials, and Waste Zones" (WSRC-STI-2006-00198). These material properties were based on existing soils data from the General Separations Area and were gathered from SRS databases, SRS documents, and subcontractor laboratory reports. The primary types of soils data used in the evaluation included grain size (sieve analyses), hydraulic property datasets (laboratory measurements of vertical hydraulic conductivity and water retention), bulk property measurements (bulk density and porosity), piezocone penetration test or CPT (cone penetration test) logs, and continuous core descriptions/geophysical logs.

Excavations for the various tank groups involved removing approximately 45 ft of soil resulting in bottom of excavation elevations ranging from 227 to 246 ft-msl (Table 1). Consequently, these excavations likely removed the entire upper vadose zone as well as a portion of the lower vadose zone (i.e. upper and lower vadose zone interface is at approximately 257 ft-msl). The undisturbed vadose zone soil remaining beneath the FTF tanks corresponds to the coarser-grained lower vadose zone that was not excavated during the tank installations. Therefore, for the FTF closure cap design and groundwater modeling, the lower vadose zone material properties can be used as a reasonable representation of the undisturbed vadose zone soil beneath the tanks.

A summary of tank bottom elevations, water table elevations, and distance to water (i.e., lower vadose zone thickness beneath the tanks) is presented in Table 2. As seen in Table 2 approximately 2 to 20 ft of undisturbed lower vadose zone material lies between the concrete slabs beneath the tank bottoms and the water table. A depiction of tank locations relative to the water table using Tanks 26 and 46 as examples is presented in Figure 8. CPT subsurface data from a location between the tanks is included, with the lower vadose zone, water table aquifer (Upper Aquifer Zone) and the "Tan Clay Confining Zone" (a non-contiguous, semi-confining zone) identified. A detailed view of the CPT is presented in Figure 9.

Recommended material property estimates for the FTF undisturbed vadose zone soils are derived from the E-Area LLWF material property values presented in WSRC-STI-2006-00198. Table 3 in this memo provides the material property estimates for the upper and lower vadose zone. As noted in WSRC-STI-2006-00198 and in Figure 10, most of the vadose zone sieve samples can be classified as clayey sands. Vadose zone water retention properties are also presented here in Figures 11 (saturation vs. suction) and Figure 12 (hydraulic conductivity vs. suction). For further descriptions of how these values were derived and uncertainties associated with each of the material properties, refer to WSRC-STI-2006-00198.

Recommendations for distribution coefficient estimates (*Kd* values) for radionuclides can be found in WSRC-TR-2006-00004, Rev. 0, "Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site (U)". In Table 10 of this technical report (WSRC-TR-2006-00004), *Kd* values are provided for "clayey sediment" and "sandy sediment". "Clayey sediment" *Kd* values can be used to approximate the *Kd* values of the upper vadose zone soils. "Sandy sediment" *Kd* values can be used to approximate the *Kd* values of the lower vadose zone soils. Uncertainties associated with the *Kd* values are currently under evaluation and SRS data are expected to be available by the Fall of 2007.

3.0 Concrete Work Slabs and Soil Backfill within Tank Excavation Areas

Table 1 provides information on the FTF excavations, concrete work slabs, and backfill for each tank group. It includes the dimensions of the excavations and elevation of the undisturbed vadose zone soil directly beneath each tank. This information was extracted primarily from FTF engineering drawings.

3.1 Concrete Work Slabs

Table 1 also provides information on the concrete work slabs associated with each set of tank installations. It should be noted that none of the work slabs contained rebar. In addition, the concrete work slabs associated with tanks 25-28/44-47 were either broken or punched with holes prior to placement of backfill. Based upon this information, the concrete work slabs associated with these tanks

should not negatively impact downward flow and would not need to be explicitly considered in the modeling effort. However, the drawings provide no immediately apparent information indicating the condition of the concrete work slabs for tanks 1-8, 17-20, and 33-34. Therefore, these work slabs should be considered in relation to groundwater modeling unless additional information is obtained that indicates that the slabs would not be an impediment to the downward flow of infiltrating water.

Information from standard engineering specifications and drawings indicate that the FTF work slabs were 1500 – 2500 psi material (Standard Engineering Specification SB-6-A; WSRC-STI-2006-00198). If the concrete work slabs need to be considered in the groundwater modeling (for tanks 1-8, 17-20, and 33-34), the low quality concrete material properties described in WSRC-STI-2006-00198 may provide rough estimates for the FTF work slab properties (refer to WSRC-STI-2006-00198 for specific material property values). It should be noted that the hydraulic conductivity estimate for the low quality concrete is probably lower than the hydraulic conductivity of the FTF work slabs. Since the FTF work slabs were not constructed with rebar, the slabs likely cracked from the heavy equipment used during the construction of the tanks. This cracking would increase the hydraulic conductivity of the work slabs.

Recommendations for distribution coefficient estimates (*Kd* values) for radionuclides can be found in WSRC-TR-2006-00004, Rev. 0, "Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site (U)". In Table 13 of this technical report (WSRC-TR-2006-00004), *Kd* values are provided for concrete and can be used to represent the FTF work slabs.

3.2 Backfill

Table 1 also provides information on the backfill around each set of tank installations. As outlined in Section 2.2 the excavated soil consisted of predominately upper vadose zone soil (i.e. sand with a significant silt and clay content) with some lower vadose zone soil (i.e. a coarser-grained soil). In general the soil excavated for the tanks (probably either SC (clayey sand) or SM (silty sand) material per the Unified Soil Classification system) was stockpiled for later backfilling around the tanks. Soil which was considered too sandy was not utilized as backfill. The backfill was variously placed by standard compaction or by test-controlled compaction. Standard compaction consisted of rolling damp, maximum 12-inch lifts of soil with mechanical compaction equipment until visually uniform compaction was obtained (Standard Engineering Specification SC-4-E). Test-controlled compaction consisted of compacting moisture conditioned soil with mechanical compaction equipment until densities greater than or equal to the 95% modified Proctor density were obtained as determined by testing (Standard Engineering Specification SC-5-E). The two possible exceptions to this general rule are as follows:

- For tanks 17-20 bags of vermiculite were placed immediately adjacent to the tank walls. This is such a limited amount of material that it should make little difference to the closure cap design and groundwater modeling.
- For tanks 25-28 the use of Controlled Low Strength Material (CLSM) was allowed to fill new excavations that were at least 7 ft away from the tanks only after initial soil backfill placement. The use of CLSM as backfill around tanks 25-28 appears to be very limited and therefore it should make little difference to the closure cap design and groundwater modeling.

Figure 13 shows a photograph of F-Area tanks in various stages of construction. The tanks on the left in the photograph (tanks 44-47) are still being constructed and show the excavation hole and work slab.

The tanks on the right (tanks 25-28) have been completed further and have backfill material around the tanks. The orange to red color of the backfill is typical of upper vadose zone soils in the GSA and other SC backfill soils used at the SRS.

FTF backfill material properties have been estimated based on material properties presented in WSRC-STI-2006-00198 for controlled compacted backfill. These values are summarized in Table 4 and were derived from laboratory measurements of similar backfill soils including onsite borrow pit material used in the Old Radioactive Waste Burial Ground (ORWBG located between the FTF and E-Area LLWF, see Figure 2), and from Z Area, located approximately 8,000 ft northeast of the E-Area LLWF. A textural triangle for the backfill samples is presented in Figure 14. Water retention properties are presented in Figures 15 (saturation vs. suction) and Figure 16 (hydraulic conductivity vs. suction). For a detailed description of how these values were derived and uncertainties associated with each material property, refer to WSRC-STI-2006-00198.

The values presented are representative of controlled compacted backfill materials thought to be similar to those used in the FTF, and they were not derived from actual samples of the FTF controlled compacted backfill. Therefore soil moisture curves and other data should be considered rough estimates for the potential properties of the FTF controlled compacted backfill.

Pipelines and utility lines run both within each of the four tank groups and between groups. Because the material used for backfill around the tanks would have been available for backfill beneath pipelines and utilities, it is assumed that excavations for pipelines and utilities were backfilled with soils having properties similar to those used for backfill around the tanks. Therefore, if the backfill beneath pipelines and utilities is included in the modeling, it would be reasonable to use the backfill property estimates presented in Table 4.

Recommendations for distribution coefficient estimates (*Kd* values) for radionuclides can be found in WSRC-TR-2006-00004, Rev. 0, "Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site (U)". In Table 10 of this technical report (WSRC-TR-2006-00004), *Kd* values are provided for "clayey sediment" and "sandy sediment". "Clayey sediment" *Kd* values can be used to approximate the *Kd* values of the backfill soils since the backfill was derived from upper vadose zone soils and from lower vadose zone soils that were not considered too sandy for use as backfill. Uncertainties associated with the *Kd* values are currently under evaluation and SRS data are expected to be available by the Fall of 2007.

4.0 Recommendations for Further Work

The following recommendations are suggested to improve the material property estimations for the FTF Vadose Zone:

Concrete Work Slabs

- Additional effort should be made to determine if the concrete work slabs associated with tanks 1-8, 17-20, and 33-34 were left intact for backfilling.
- The concrete formulation(s) for these work slabs should be determined to aid in the assignment of material property values.

- If it is determined that these work slabs were left intact for backfilling, consideration should be given to:
    1) obtaining samples from similar concrete work slabs for hydraulic testing;
    2) determining whether it is likely that the slabs would have been cracked up due to the heavy equipment used to place the backfill, since they do not contain rebar.

Review of Geotechnical Documents
Additional review of available SRS geotechnical reports associated with the FTF should be conducted as part of the PA data gathering effort since pertinent material properties information may be available in them.

Field Sampling
Consideration should be given to performing the following in two or more locations within the F-Area Tank Farm area (at least one location associated with tanks 1-8, 17-20, and 33-34, and at least one location associated with tanks 25-28 and 44-47):

1. Conduct a CPT to the water table
2. Take a continuous core to the water table and produce a geologic log
3. Take Shelby tubes (i.e. undisturbed samples) within the tank backfill and underlying undisturbed vadose zone soil (located based upon the CPT and continuous core information) and perform laboratory testing for the hydraulic properties (this would only need to include testing by a standard geotechnical testing firm).

5.0 References

Daniel, A. N., 1960. *Underground Storage of Low Level Radioactive Wastes at the Savannah River Plant Engineering Considerations*, DP-0478, E. I. du Pont de Nemours & Co., Wilmington, Delaware. June 1960.

Standard Engineering Specification SC-4-E

Standard Engineering Specification SC-5-E

Standard Engineering Specification SB-6-A

Engineering Drawings:
W145225
W145491
W167482
W167808
W238154
W238875
W700283
W701330 Rev 61
W701330 Rev 62
W700598

W704824

WSRC-TR-96-00069, 1996. *F-Area Geotechnical Characterization Report (U)*, Vol. 1, p. 5-1, Westinghouse Savannah River Company, Aiken, SC 29808.

WSRC-TR-2003-00250, Rev. 0, 2003. *An Updated Regional Water Table of the Savannah River Site and Related Coverages*, Westinghouse Savannah River Company, Aiken, SC 29808.

WSRC-TR-2004-00106, Rev. 0, 2004. *Groundwater Flow Model of the General Separations Area Using PORFLOW,* Westinghouse Savannah River Company, Aiken, SC 29808.

WSRC-TR-2006-00004, Rev. 0, 2006. *Geochemical Data Package for Performance Assessment Calculations Related to the Savannah River Site (U)*, Washington Savannah River Company, Aiken, SC 29808.

WSRC-STI-2006-00198, 2006. *Hydraulic Property Estimation for the E-Area And Z-Area Vadose Zone Soils, Cementitious Materials, and Waste Zones*, Washington Savannah River Company, Aiken, SC 29808.

Table 1. F-Area Tank Farm Excavations, Concrete Work Slabs, and Backfill Information

Tank Numbers	Tank Type	~Year of Excavation	Excavation Bottom Dimensions and Slope of Side-Slopes	Tank Bottom Elevation (ft-msl)	Concrete Work Slab	Backfill
1-8	I	1951	From W145491: 423.34' by 227.34' N77,023.33 to N77,446.67 E53,054.33 to E53,281.67 Slope TBD in field	From W145491 (elevation at top of ≈3" lean concrete) [1]: • 240.82 ft-msl for Tanks 1 & 2 • 239.40 ft-msl for Tanks 3 & 4 • 237.98 ft-msl for Tanks 5 & 6 • 236.56 ft-msl for Tanks 7 & 8	Bottom of entire excavation filled with ≈3" lean concrete to form a working surface for tank installation (W145491)	• It appears that excavated soil was compacted around and over tanks. It is uncertain whether it was placed by standard compaction (SC-4-E) or test-controlled compaction (SC-5-E) (W145225) • 9' of backfill over the tank tops (W145491)
17-20	IV	1956	From W167808: 237' by 237' no coordinate or slope information available on drawings	From W167482: • 228.31 ft-msl for North Tanks (17 & 18) • 227.39 ft-msl for South Tanks (19 & 20)	2" drainage and maintenance slab between tanks (W167808)	• Vermiculite bags immediately adjacent to tank walls (DP-478) • Standard compaction (SC-4-E) of excavated soil (sandy clay) around and over tanks (W167486)
33-34	III	1969	From W238154: 164' by 272.5' N76,638.83 to N76,802.83 E52,962.5 to E53235.0 1:1 slope	From W238154 the elevation of the top of the 4" working slab is 244.0 ft-msl under the tanks and slopes away from the tanks at ¼"/ft to the edge of the excavation where it is ≈234.0 ft-msl. [1]	Bottom of entire excavation filled with minimum 4" working slab (W238154)	• The grading plan (W238875) does not provide any notes on the backfill around the tanks. • It appears that excavated soil was compacted around and over tanks. It is uncertain whether it was placed by standard compaction (SC-4-E) or test-controlled compaction (SC-5-E)

[1] Top elevation of the undisturbed vadose zone = elevation at top of working slab – thickness of working slab

Table 1. F-Area Tank Farm Excavations, Concrete Work Slabs, and Backfill Information (continued)

Tank Numbers	Tank Type	~Year of Excavation	Excavation Bottom Dimensions and Slope of Side-Slopes	Tank Bottom Elevation (ft-msl)	Concrete Work Slab	Backfill
25-28	IIIA	1975	From W700283 and W700598: Tanks 25-28/44-47 are in the same excavation 520.2' by 380' N76,622.40 to N77,142.60 E52,482.5 to E52,862.5 1:1 slope	From W700283 (elevation at top of 4" working slab) [1]: • 244.28 ft-msl for Tank 25 • 245.63 ft-msl for Tank 26 • 245.63 ft-msl for Tank 27 • 244.28 ft-msl for Tank 28 Working slab slopes away from the tanks at ¼"/ft between tanks and ⅛"/ft to the edge of the excavation	Bottom of entire excavation was filled with minimum 4" working slab which was either broken up or punched with 4" diameter holes on 18" centers prior to backfilling (W700283 and W701330)	From W701330 Rev 61: • It appears that excavated soil was compacted around the tanks. • Backfill around tanks conducted in accordance with Eng. Doc. 02224-01-R • All backfill around the tanks placed in accordance with SC-5-E and compacted to 95% of modified Proctor (ASTM D1557 Method C) From W701330 Rev 62: • Allowed use of CLSM as backfill outside of 7 ft from the tanks
and 44-47	IIIA	1976	From W700283 and W700598: Tanks 25-28/44-47 are in the same excavation 520.2' by 380' N76,622.40 to N77,142.60 E52,482.5 to E52,862.5 1:1 slope	From W700598 (elevation at top of 4" working slab) [1]: • 243.96 ft-msl for Tank 44 • 245.39 ft-msl for Tank 45 • 245.39 ft-msl for Tank 46 • 243.96 ft-msl for Tank 47 Working slab slopes away from the tanks	Bottom of entire excavation was filled with minimum 4" working slab which was either broken up or punched with 4" diameter holes on 18" centers prior to backfilling (W700598 and W704824)	From W704824: • It appears that excavated soil was compacted around the tanks. • All backfill around the tanks placed in accordance with SC-5-E and compacted to 95% of modified Proctor (ASTM D1557 Method C)

[1] Top elevation of the undisturbed vadose zone = elevation at top of working slab – thickness of working slab

Table 2. FTF Concrete Work Slab Bottom Elevations, Water Table Elevations, and Distance to Water (Lower Vadose Zone Thickness)

Tank Group	Tank Number	Concrete Slab Bottom Elevation (ft msl)	Approximate Water Table Elevation (ft msl)	Distance from Slab Bottom to Water Table (Lower Vadose Zone Thickness; ft)
1	1	240.57	227.1	13.5
	2	240.57	227.5	13.1
	3	239.15	227.1	12.1
	4	239.15	227.5	11.7
	5	237.64	227.0	10.6
	6	237.64	227.4	10.2
	7	236.31	226.9	9.4
	8	236.31	227.3	9.0
2	17	228.31	225.8	2.5
	18	228.31	226.2	2.1
	19	229.39	225.7	3.7
	20	229.39	226.2	3.2
3	33	243.67	226.3	17.4
	34	243.67	226.6	17.1
4	25	243.95	225.9	18.1
	26	245.30	225.8	19.5
	27	245.30	225.7	19.6
	28	243.95	225.6	18.4
	44	243.63	225.3	18.3
	45	245.06	225.3	19.8
	46	245.06	225.2	19.9
	47	243.63	225.1	18.5

Note: concrete slab bottom elevations based on drawings referenced in Table 1; water table elevations based on WSRC-TR-2004-00106, Rev. 0 and WSRC-TR-2003-00250, Rev. 0.

Table 3. Estimated Vadose Zone Material Properties

Material	Saturated Effective Diffusion Coefficient (cm^2/s)	Average Total Porosity (%)	Average Dry Bulk Density (g/cm)	Average Particle Density (g/cm^3)	Saturated Horizontal Hydraulic Conductivity (cm/s)	Saturated Vertical Hydraulic Conductivity (cm/s)
Upper Vadose Zone	5.3E-06	39	1.65	2.70	6.2E-05	8.7E-06
Lower Vadose Zone	5.3E-06	39	1.62	2.66	3.3E-04	9.1E-05

Notes: data from WSRC-STI-2006-00198; all property values except for saturated effective diffusion coefficient are based on laboratory data; saturated effective diffusion coefficient values are based on literature values.

Table 4. Estimated Backfill Material Properties

Saturated Effective Diffusion Coefficient (cm^2/s)	Average Total Porosity (%)	Average Dry Bulk Density (g/cm)	Average Particle Density (g/cm^3)	Saturated Horizontal Hydraulic Conductivity (cm/s)	Saturated Vertical Hydraulic Conductivity (cm/s)
5.3E-06	35	1.71	2.63	7.6E-05	4.1E-05

Notes: data from WSRC-STI-2006-00198; all property values except for saturated effective diffusion coefficient are based on laboratory data; saturated effective diffusion coefficient values are based on literature values.

Figure 1: F-Area Tanks Grouped by Installation Episodes

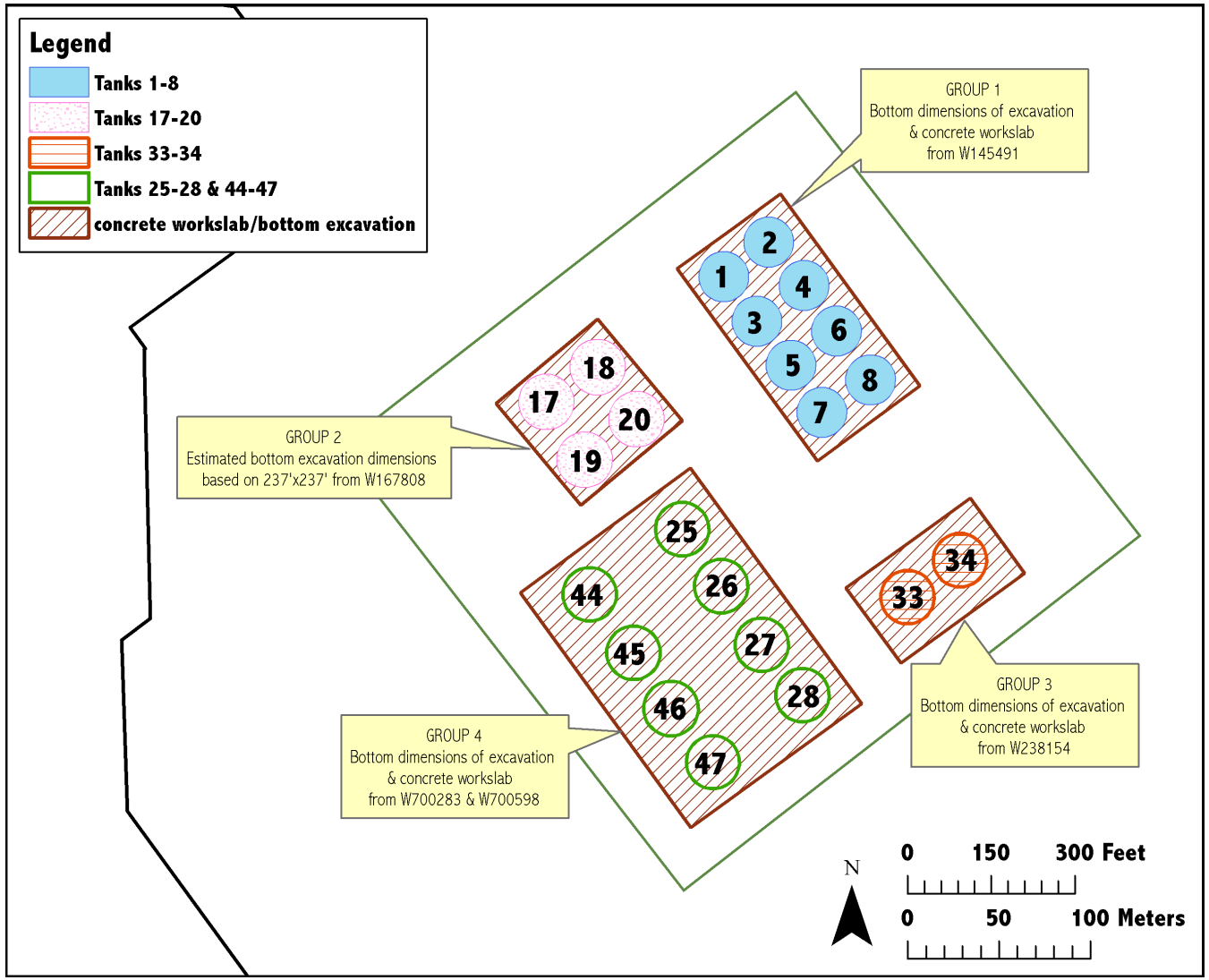
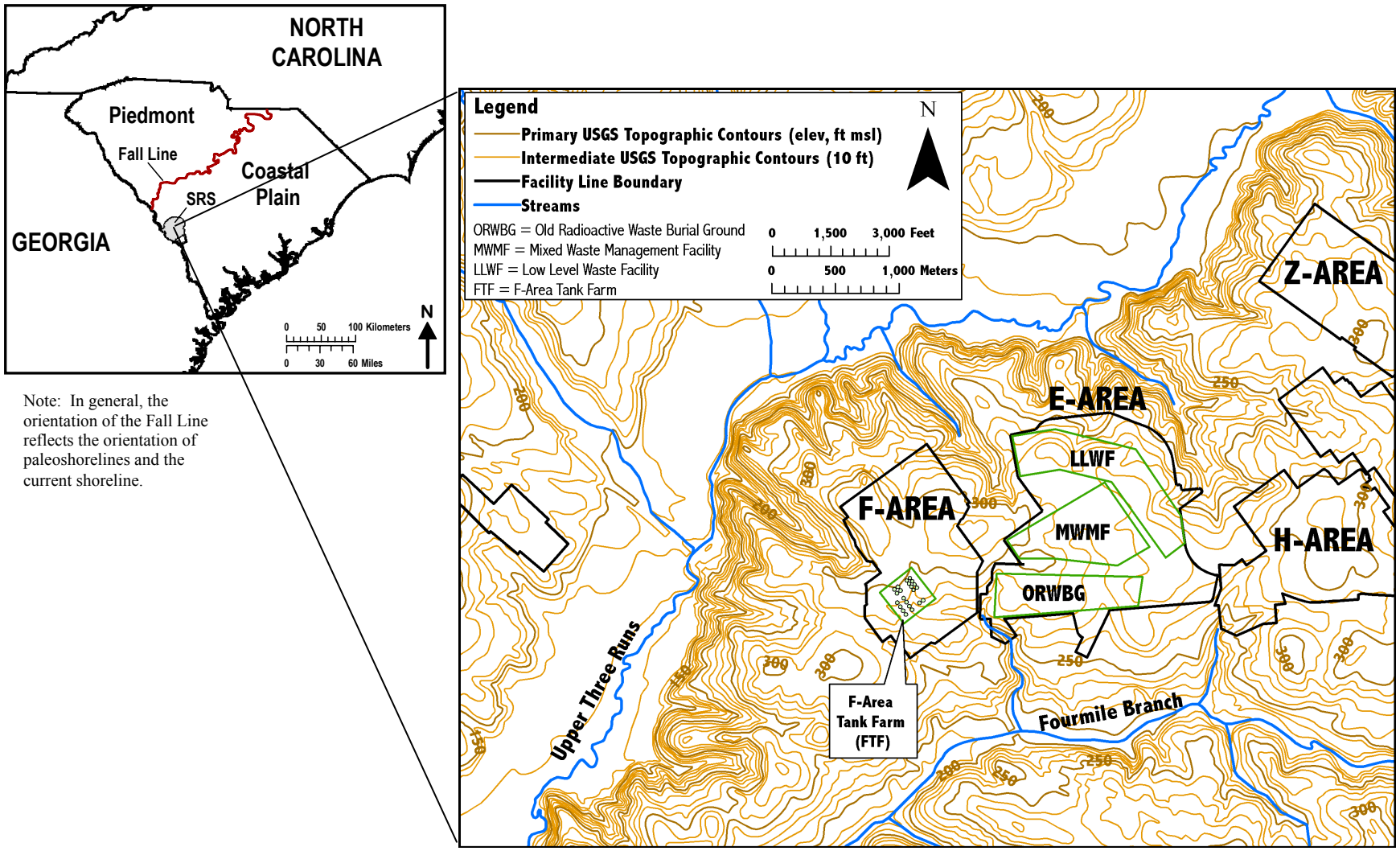
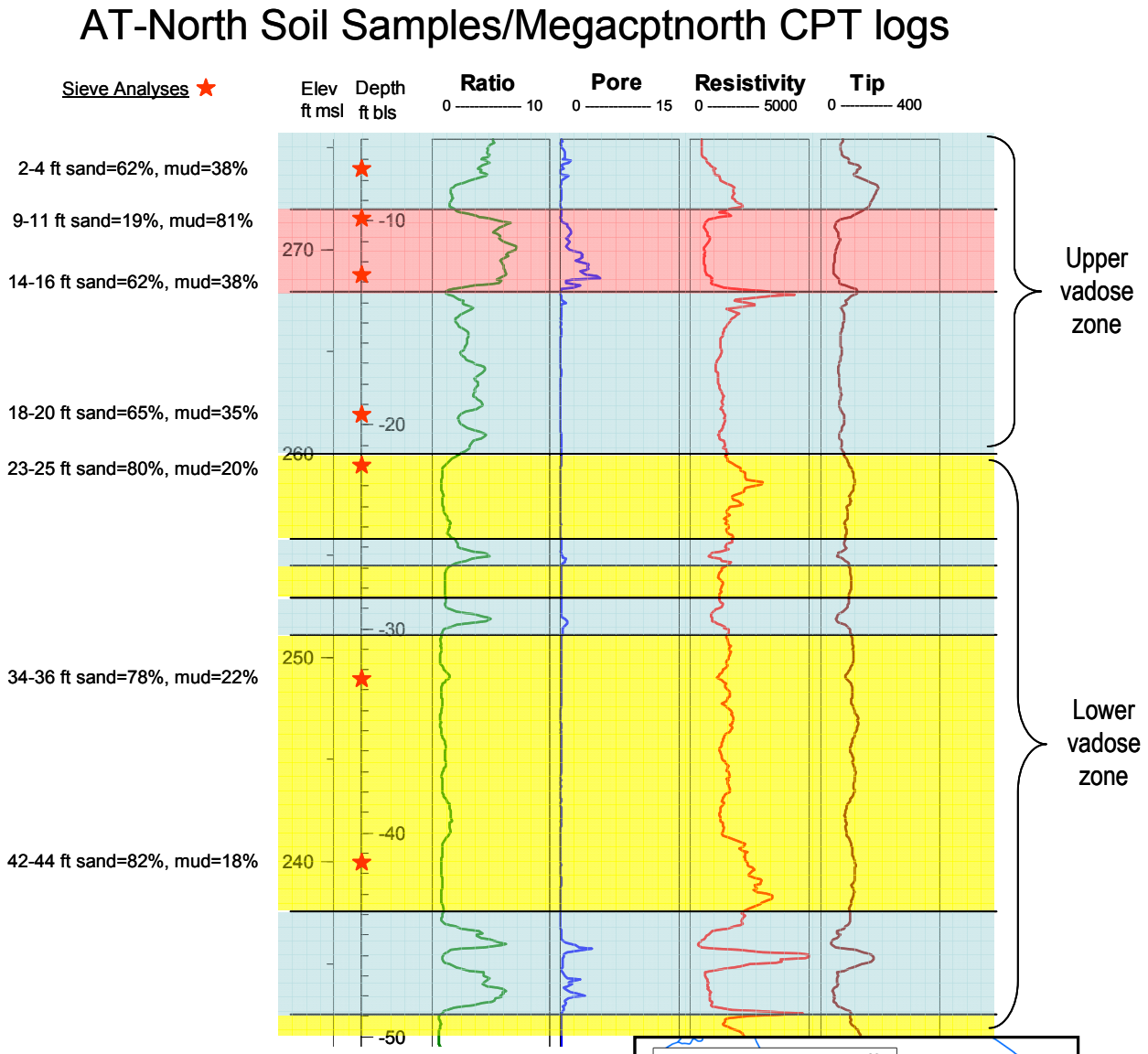


Figure 2: Location and Topography of F-Area and E-Area



Note: In general, the orientation of the Fall Line reflects the orientation of paleoshorelines and the current shoreline.

Figure 3. E-Area Vadose Zone Characterization



ft msl = feet mean sea level; ft bls = feet below land surface; ratio = friction ratio (sleeve resistance/tip resistance, in %); pore = pore pressure (psi); electrical resistivity (ohms-meters); tip = tip resistance (tsf); mud includes silt and clay size fraction; tend to see higher ratio and lower tip response in clay-rich zones whereas lower ratio and higher tip in sand-rich zones

Figure modified from WSRC-STI-2006-00198

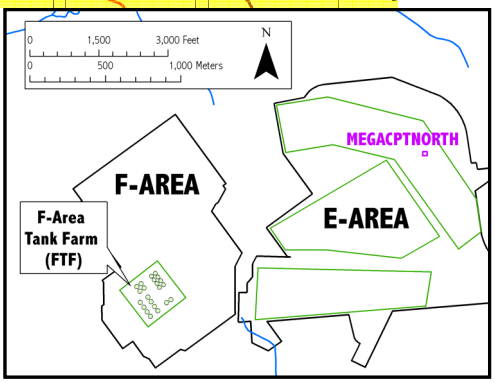


Figure 4. Locations of Borings Used in Comparison of E-Area and F-Area Geology

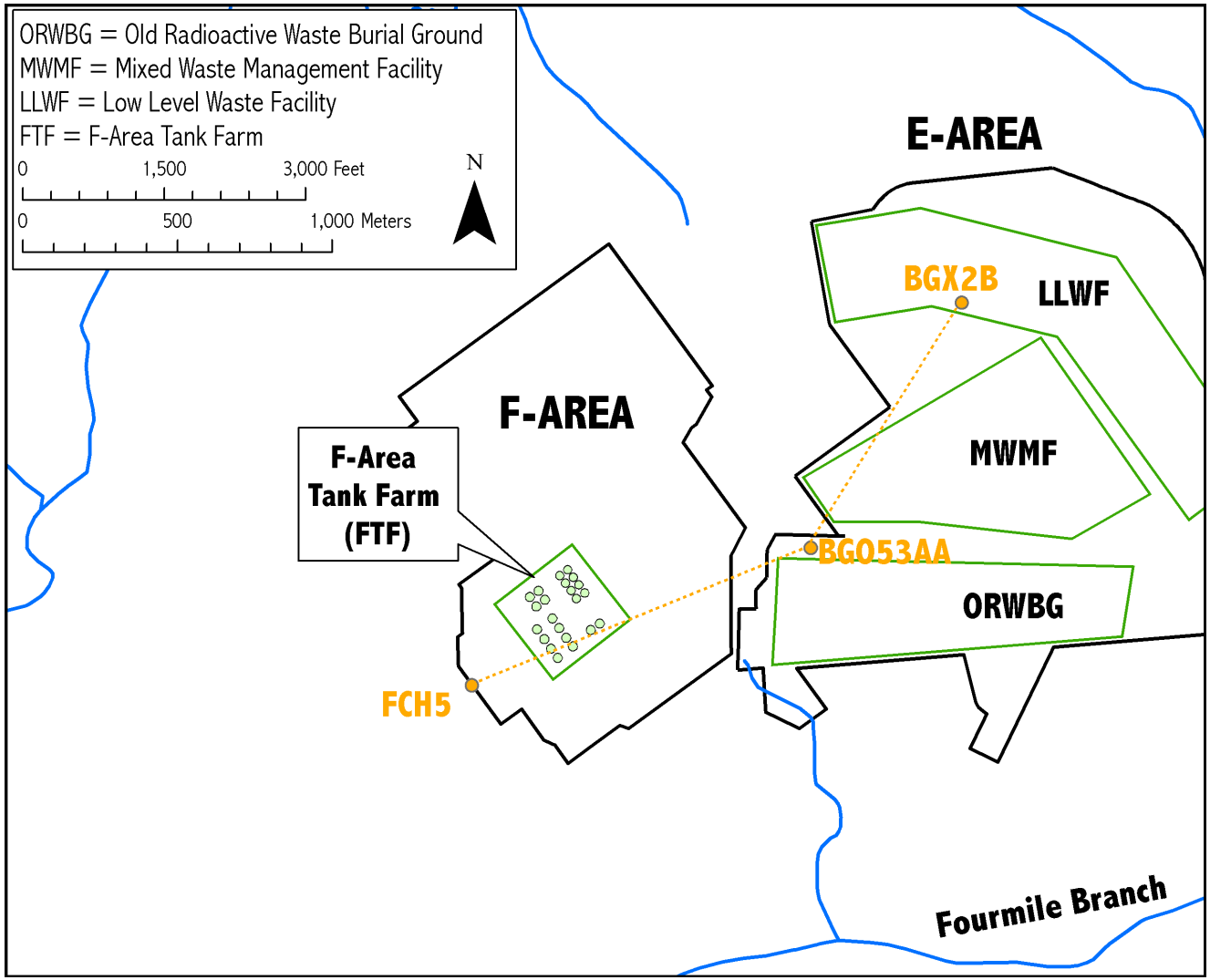
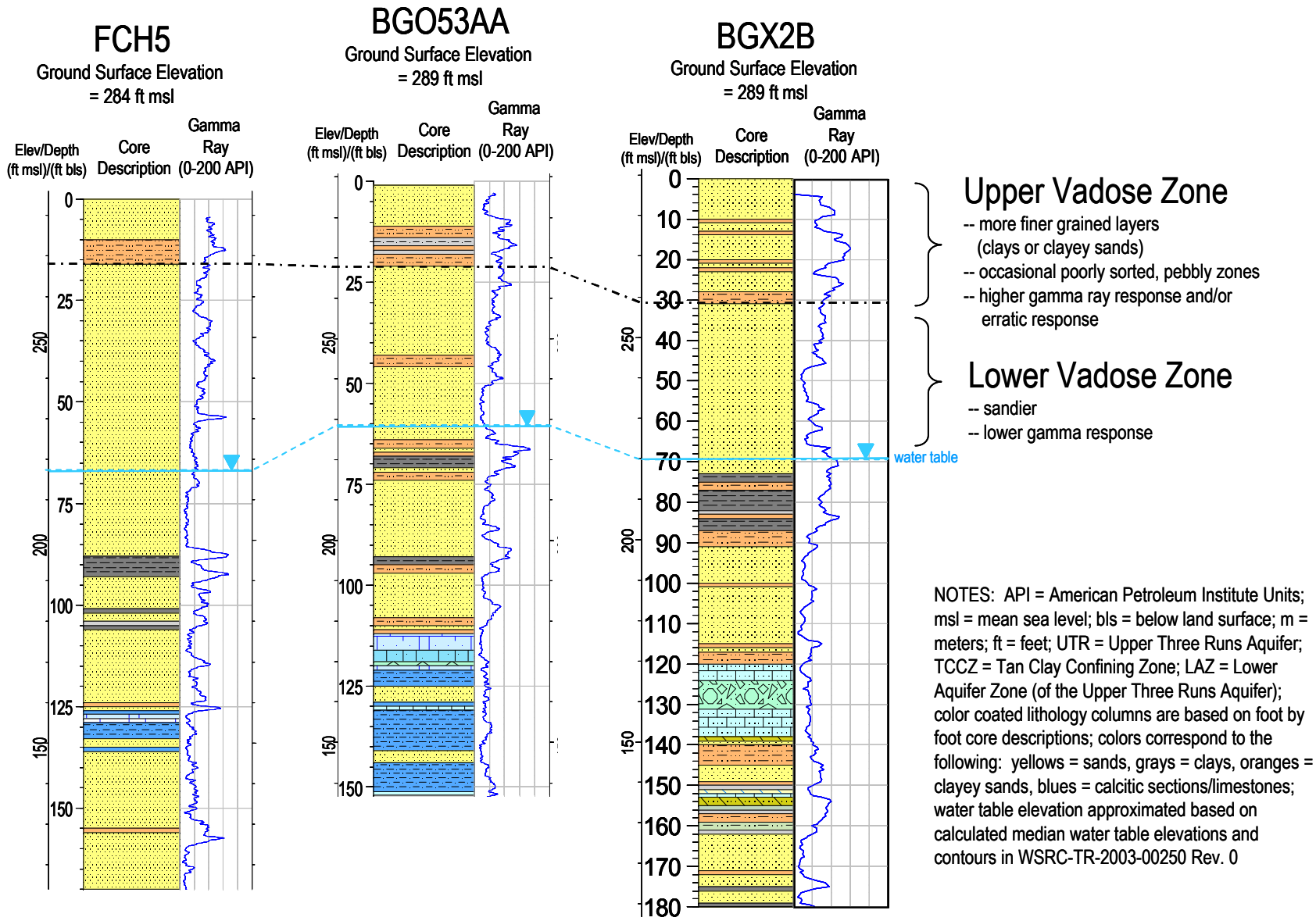


Figure 5. Comparison of E-Area and F-Area Geology Using Foot-by-foot Core Descriptions and Gamma Ray Logs



NOTES: API = American Petroleum Institute Units; msl = mean sea level; bls = below land surface; m = meters; ft = feet; UTR = Upper Three Runs Aquifer; TCCZ = Tan Clay Confining Zone; LAZ = Lower Aquifer Zone (of the Upper Three Runs Aquifer); color coated lithology columns are based on foot by foot core descriptions; colors correspond to the following: yellows = sands, grays = clays, oranges = clayey sands, blues = calcitic sections/limestones; water table elevation approximated based on calculated median water table elevations and contours in WSRC-TR-2003-00250 Rev. 0

Figure 6. Location of CPT FTNKC17 for Comparison of E-Area and F-Area Geology Using CPT Logs

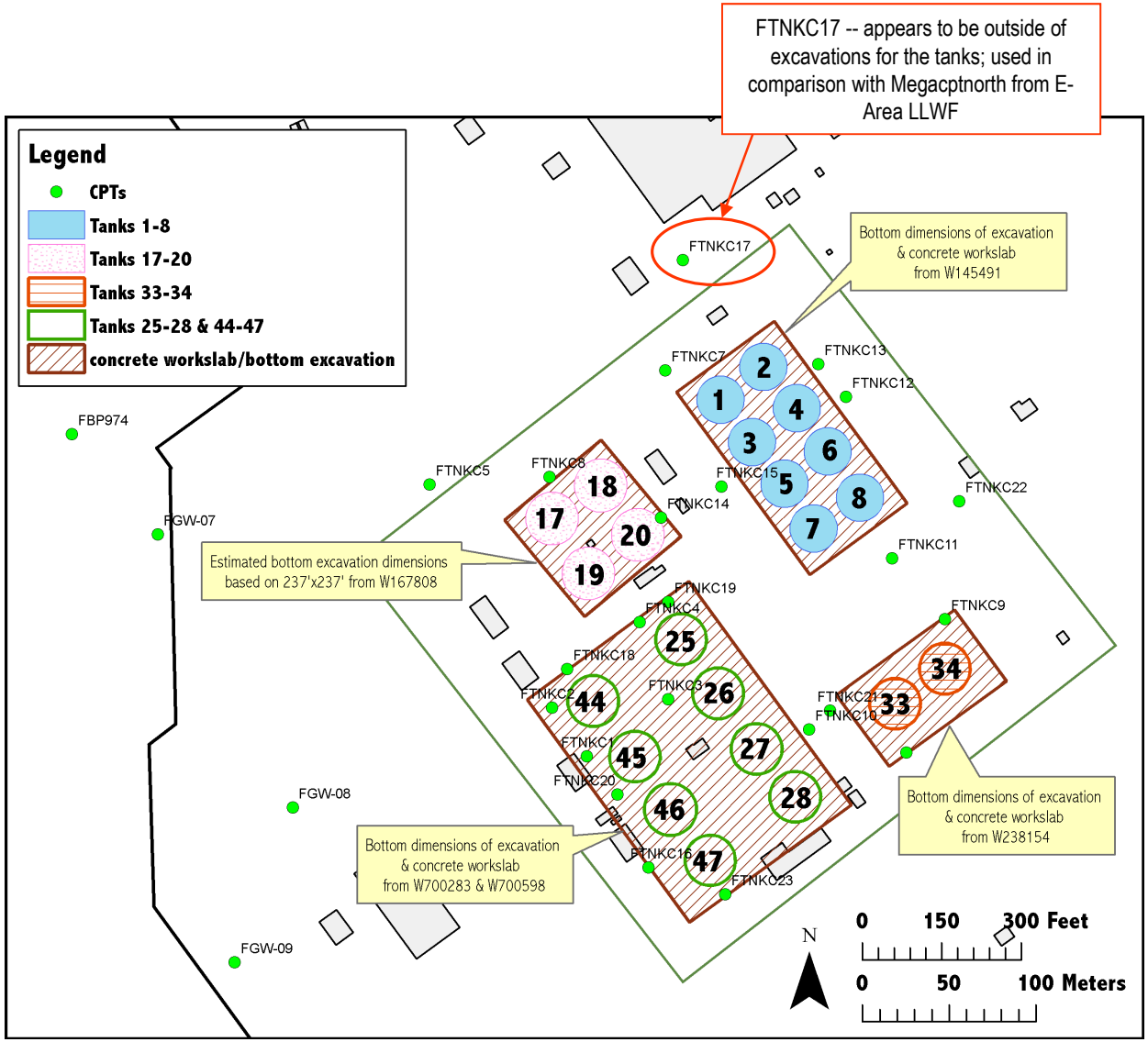
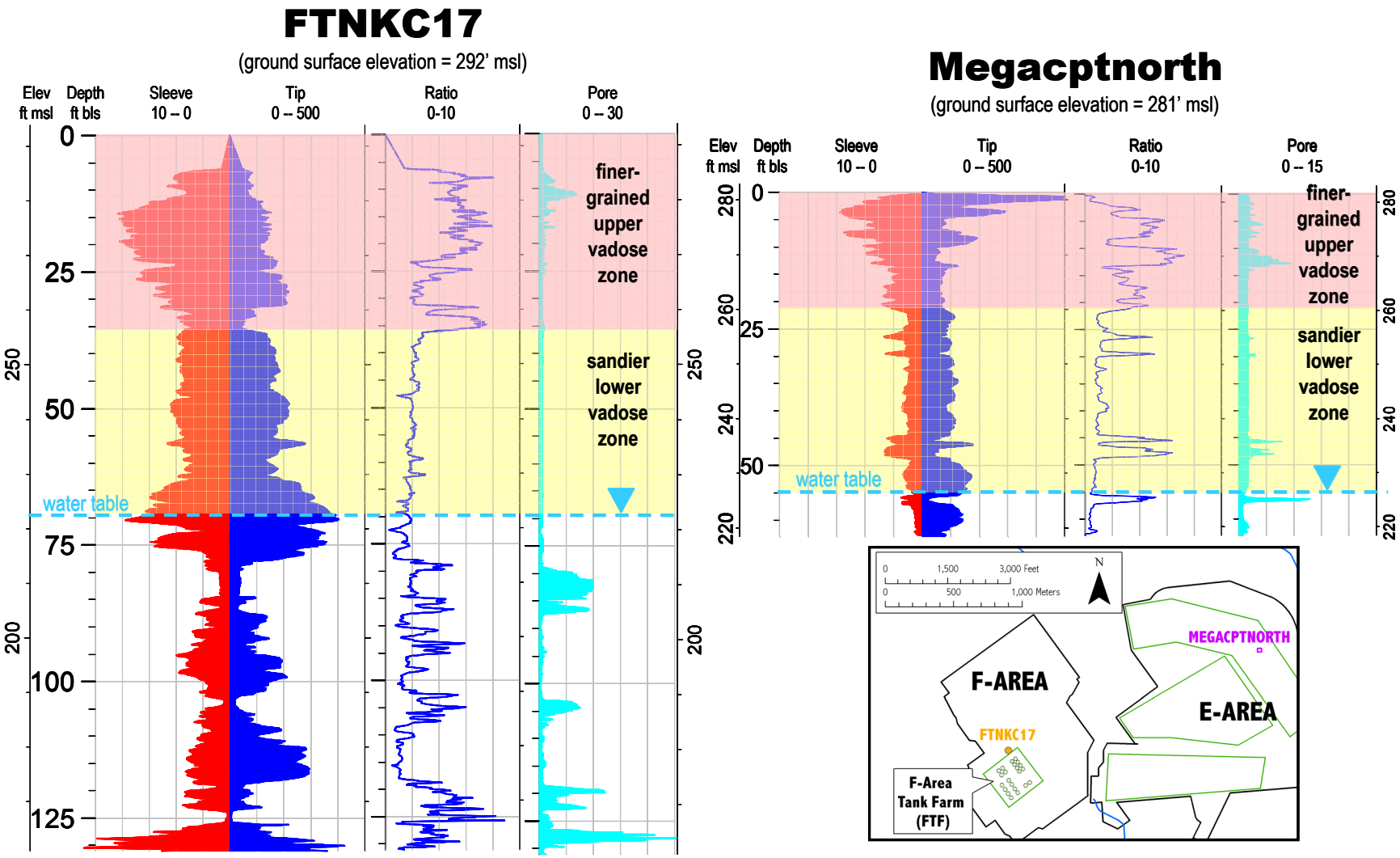
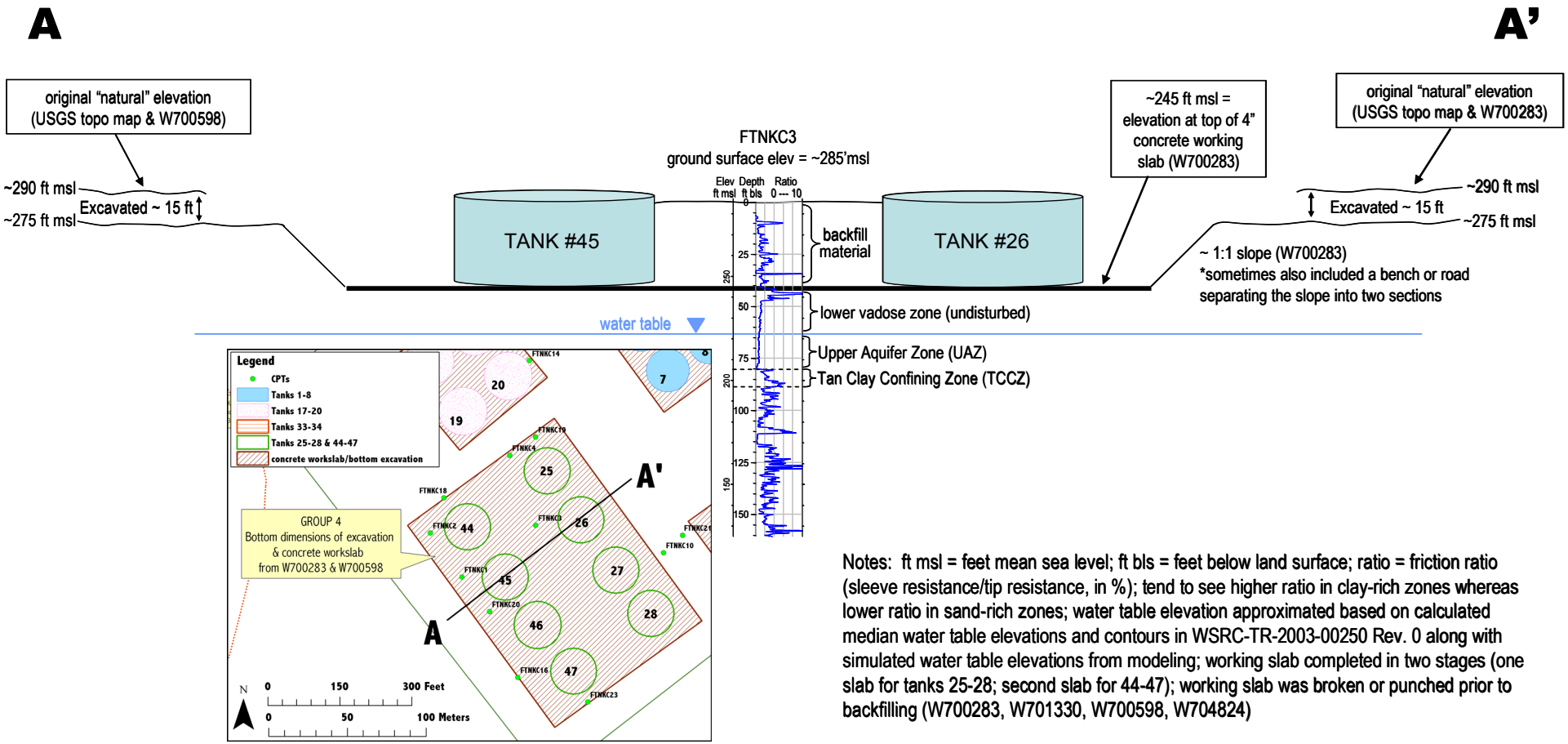


Figure 7. Comparison of E-Area and F-Area Geology Using CPT Logs



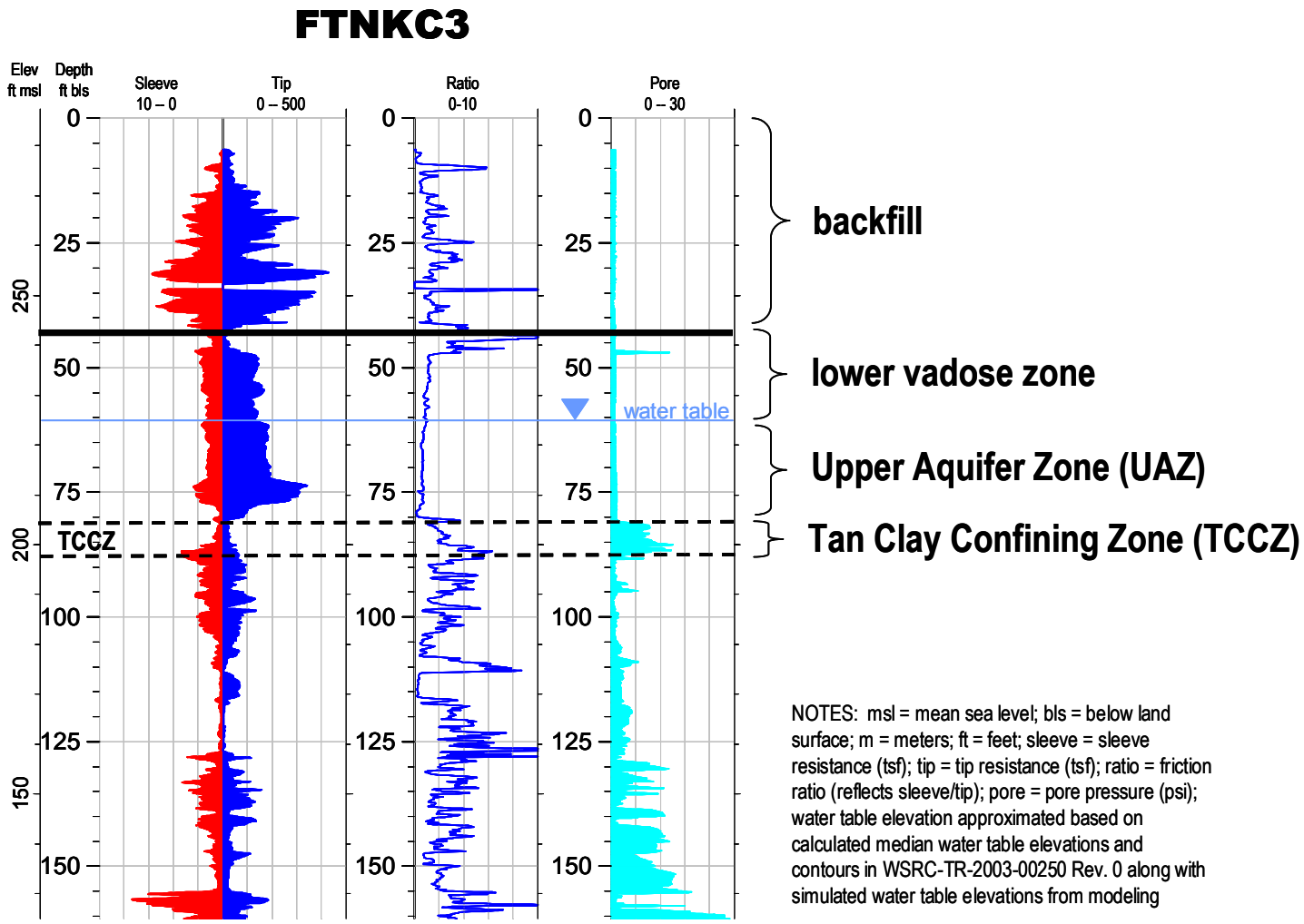
Elev = elevation; msl = mean sea level; bls = below land surface; ft = feet; sleeve = sleeve resistance (tsf); tip = tip resistance (tsf); ratio = friction ratio (reflects sleeve/tip); pore = pore pressure (psi); in general, lower tip, higher sleeve, higher ratio, higher pore observed in finer-grained (e.g., clay rich) zones whereas higher tip, lower sleeve, lower ratio, lower pore pressures observed in sandier zones; water table elevation approximated based on calculated median water table elevations for nearby water table wells and water table contours in WSRC-TR-2003-00250 Rev. 0; pink background corresponds to finer-grained upper vadose zone; yellow background corresponds to sandier lower vadose zone

Figure 8. FTF Group 4 Tank Bottom Elevations Relative to F-Area Vadose Zone and Water Table



Notes: ft msl = feet mean sea level; ft bls = feet below land surface; ratio = friction ratio (sleeve resistance/tip resistance, in %); tend to see higher ratio in clay-rich zones whereas lower ratio in sand-rich zones; water table elevation approximated based on calculated median water table elevations and contours in WSRC-TR-2003-00250 Rev. 0 along with simulated water table elevations from modeling; working slab completed in two stages (one slab for tanks 25-28; second slab for 44-47); working slab was broken or punched prior to backfilling (W700283, W701330, W700598, W704824)

Figure 9. CPT FTNKC3 Subsurface Data with Backfill, Lower Vadose Zone, Water Table and Water Table Aquifer (Upper Aquifer Zone) and Tan Clay Confining Zone



NOTES: msl = mean sea level; bls = below land surface; m = meters; ft = feet; sleeve = sleeve resistance (tsf); tip = tip resistance (tsf); ratio = friction ratio (reflects sleeve/tip); pore = pore pressure (psi); water table elevation approximated based on calculated median water table elevations and contours in WSRC-TR-2003-00250 Rev. 0 along with simulated water table elevations from modeling

Figure 10. Textural Triangle for E-Area and Z-Area Vadose Zone Soils

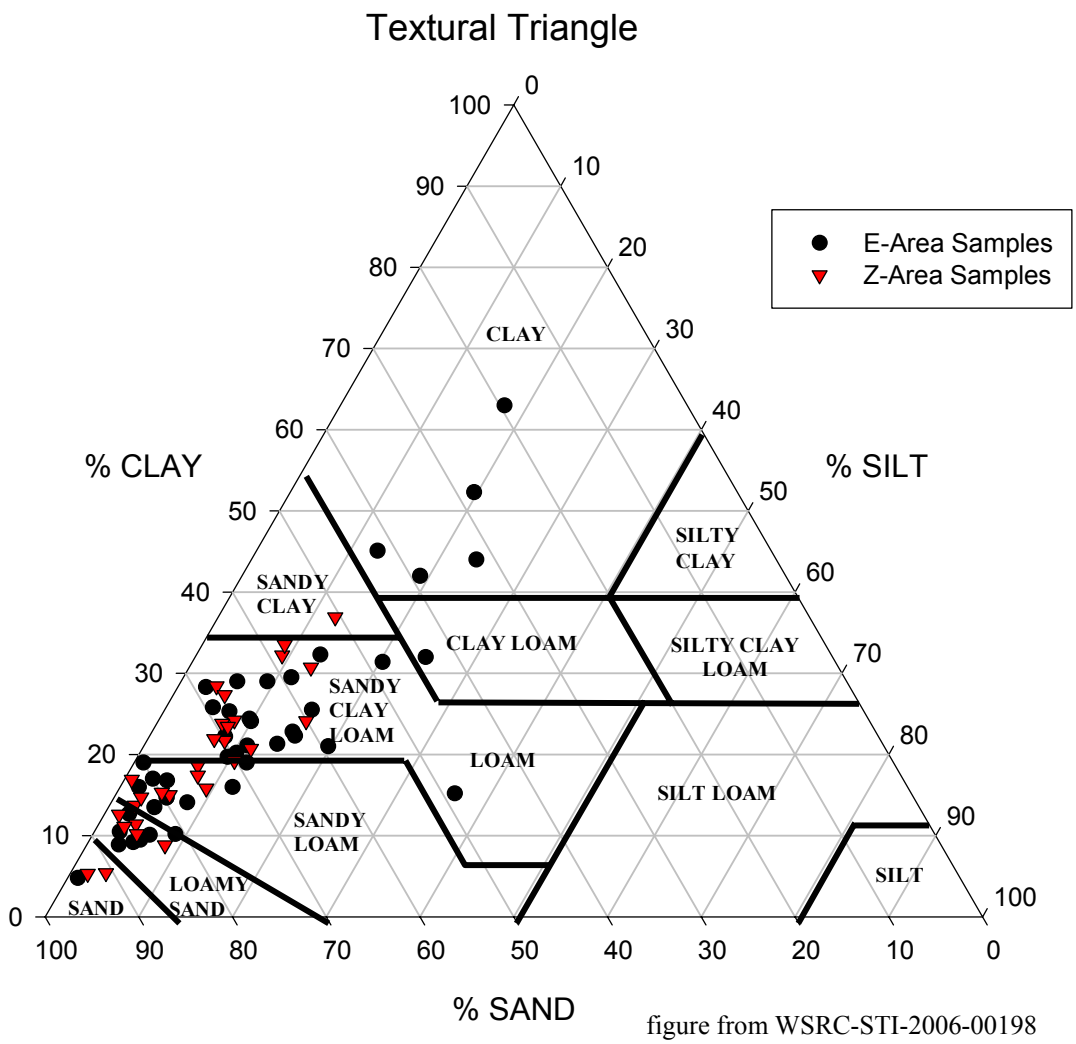


figure from WSRC-STI-2006-00198

Figure 11. Saturation versus Suction for the Undisturbed Upper and Lower Vadose Zone Soils

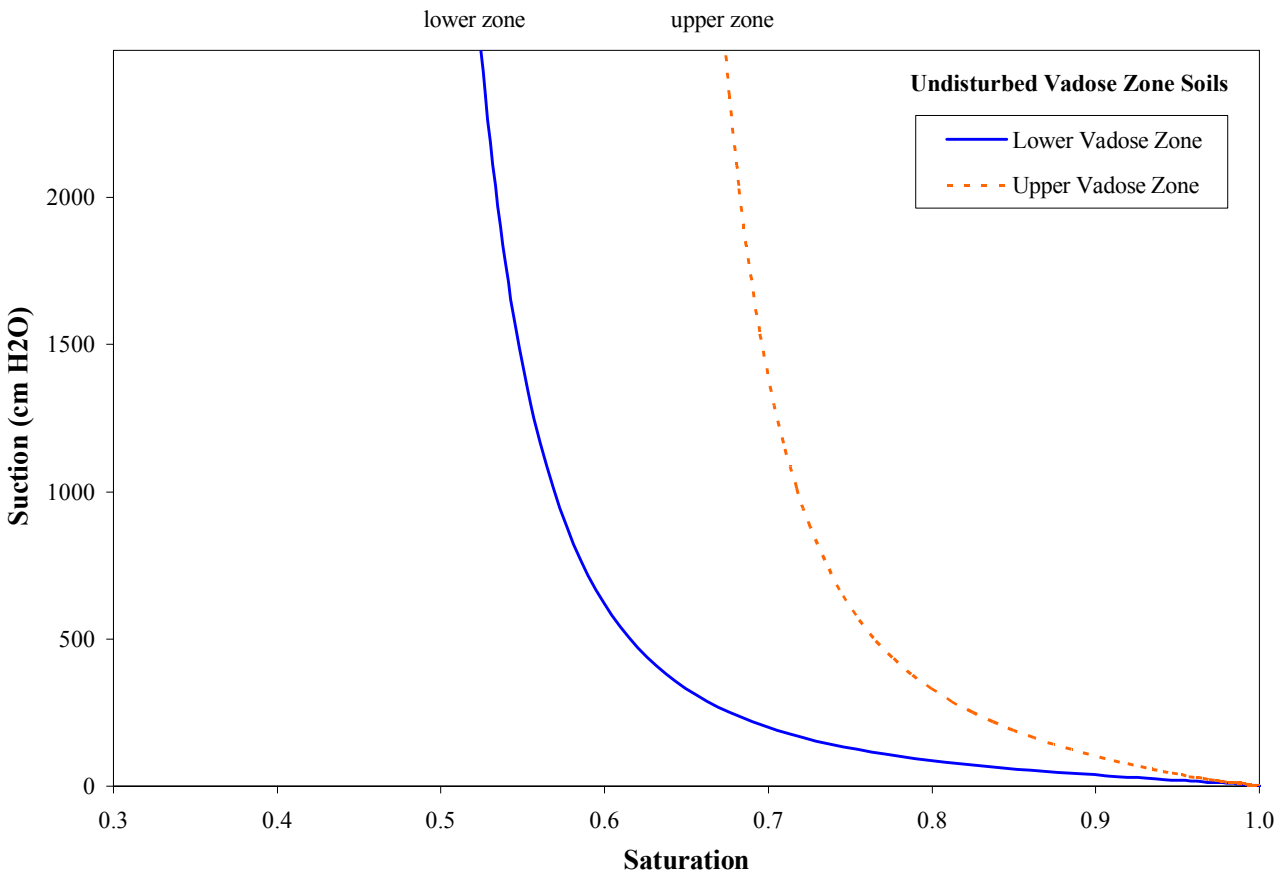


Figure 12. Suction versus Relative Hydraulic Conductivity (Kr) for the Undisturbed Upper and Lower Vadose Zone Soils

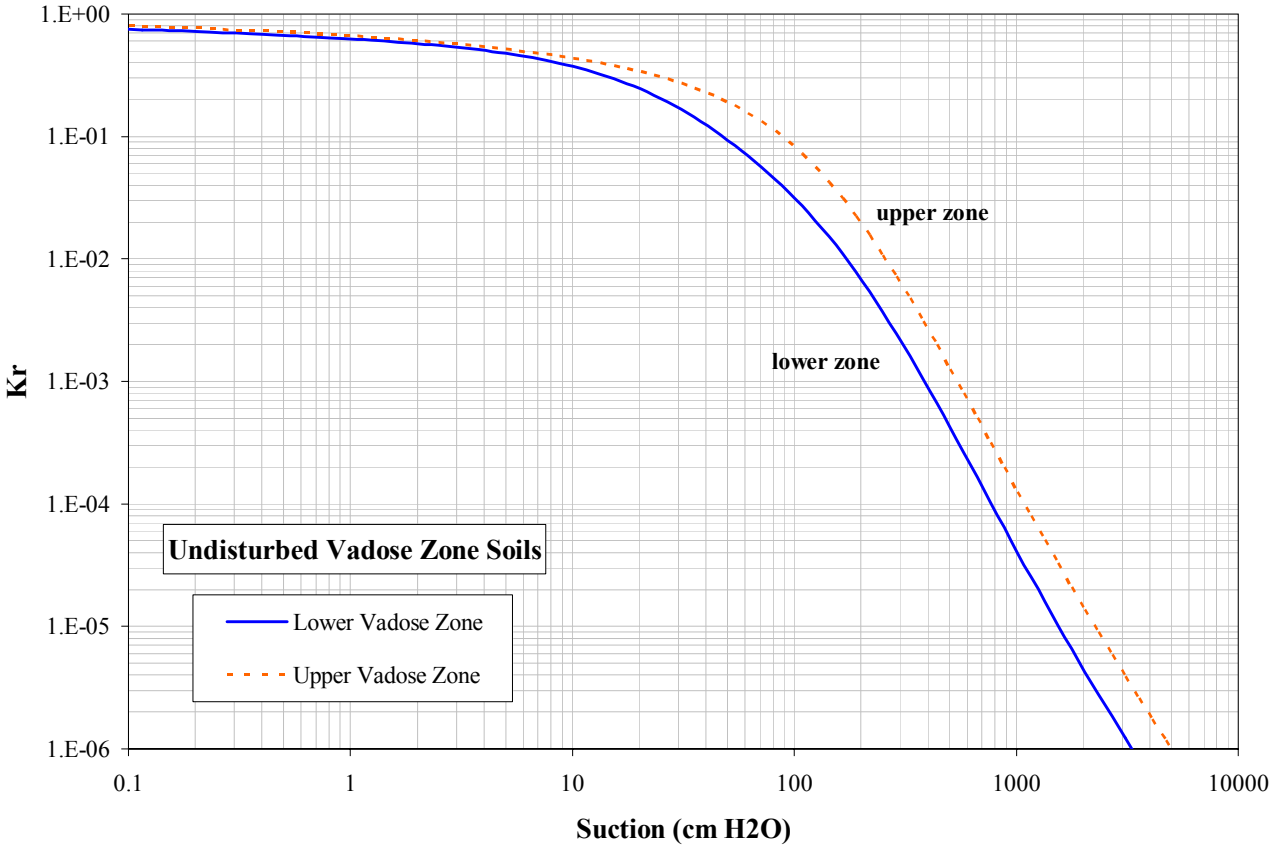


Figure 13: Photograph of Backfill Material Used at the FTF

Note: The tanks presented in this photograph are in various stages of construction. The tanks on the left (tanks 44-47) are still being constructed and show the excavation hole and work slab. The tanks on the right (tanks 25-28) have been further completed and have backfill material around the tanks. The orange to red color of the backfill is typical of upper vadose zone soils in the GSA and other backfill soils used at the SRS.

Figure 14. Textural Triangle for Controlled Compacted Backfill Samples from the Old Radioactive Waste Burial Ground (ORWBG) and Z-Area

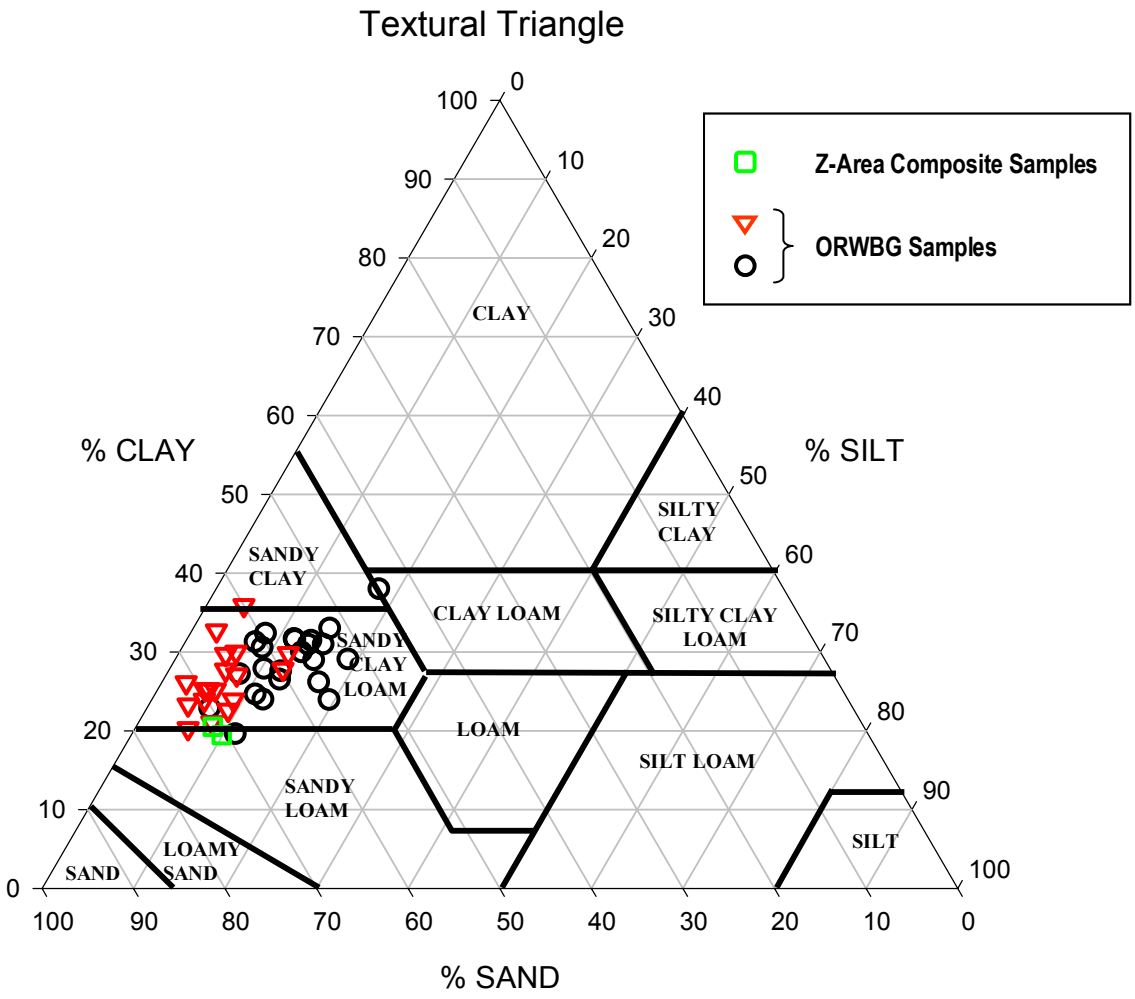


Figure 15. Saturation versus Suction for Controlled Compacted Backfill

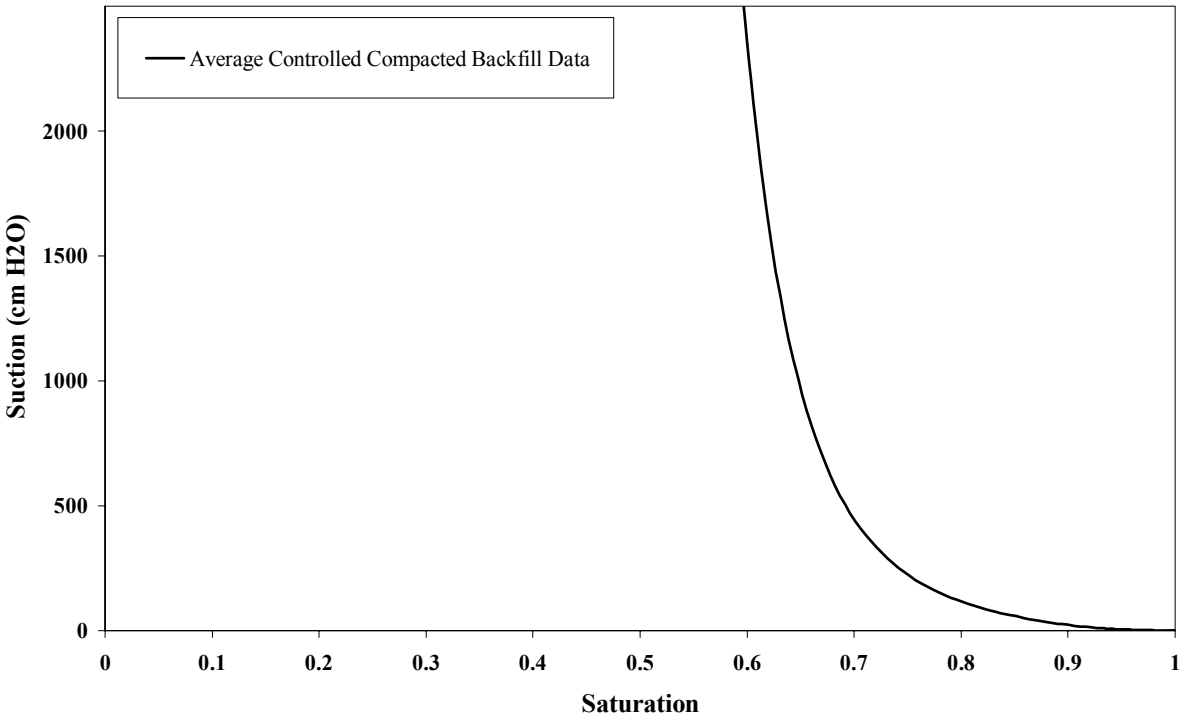


Figure 16. Suction versus Relative Hydraulic Conductivity (Kr) for Controlled Compacted Backfill