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Development of Alternative Digital Geologic Models of Waste Management Area C

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LIST OF TERMS

Abbreviations and Acronyms

2-D	two-dimensional
3-D	three-dimensional
bgs	below ground surface
DOE	U.S. Department of Energy
HGSL	Hanford Geotechnical Sediment Library
K-U-T	potassium-40, uranium-238, and thorium-228
LIDAR	Laser Imaging, Detection and Ranging
PA	performance assessment
PDF	Portable Document Format
PNNL	Pacific Northwest National Laboratory
RCRA	*Resource Conservation and Recovery Act of 1976*
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases (numeric code)
UPR	unplanned release
WIDL	Well Information Data Lookup
WMA	waste management area
WRPS	Washington River Protection Solutions

Units

ft	foot
g	gram
gal	gallon
in.	inch
L	liter
m	meter
mg	milligram
mi^2	square mile
µg	microgram
pCi	picocurie

Primary Stratigraphic Units in sequence:

Backfill	Backfilled area around the single-shell tanks
H1 unit	Hanford 1 upper gravel-dominated sequence
H2 Sand unit	Hanford 2 sand-dominated sequence
H2 Coarse Gravelly Sand unit	Hanford 2 gravel/coarse-grained facies sequence
H2 Silt unit	Hanford 2 silt dominated sequence
H3/CC_U/RF unit	Undifferentiated Hanford formation gravel and/or CC_U gravel and/or Ringold Formation, unit A
CC_U	Cold Creek unit

Conversions

English to Metric			Metric to English		
Multiply	**by**	**To get**	**Multiply**	**by**	**To get**
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092903	square meters	square meters	10.7639	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.40469	hectares	hectares	2.471	acres
square miles	2.58999	square kilometers	square kilometers	0.3861	square miles
Length			**Length**		
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Temperature			**Temperature**		
degrees Fahrenheit	Subtract 32, then multiply by 0.55556	degrees Celsius	degrees Celsius	Multiply by 1.8, then add 32	degrees Fahrenheit
Volume			**Volume**		
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight			**Weight**		
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.45360	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons

1.0 INTRODUCTION

This report describes the development of two alternative digital geologic models for the general area of Waste Management Area C (WMA C) that will be used in a long-term performance assessment (PA) for a closed WMA C facility. Over the past 15 years, the geologic strata underlying WMA C has been characterized in conjunction with soil sampling and borehole logging for radionuclides and hazardous waste constituents. The borehole and geologic logging has been used to identify the elevations of tops of the geologic units in the vicinity of WMA C.

This information has been used to create the two alternative geologic models of WMA C.

The first digital geologic model (Alternative Geologic Model I) is primarily based on interpretations by Washington River Protection Solutions (WRPS) and its subcontractors that consider the following sources of information.

- Geologic interpretations of geophysical logs in selected dry wells, boreholes, direct pushes, and groundwater wells in the vicinity of WMA C by Kent Reynolds of Energy*Solutions*, Inc. These interpretations are summarized in FS-NW-LT-5367, "Submittal of C Farm Geology/Geophyics *[sic]* Review, Task 26," a letter report prepared by Energy*Solutions* for WRPS in 2010. This project letter report is provided in its entirety in Appendix A of this report.

- Geologic interpretations from more recent direct push completion reports that contain information on interpreted elevations of tops of geologic units from geophysical logs of direct push locations developed after completion of Letter Report FS-NW-LT-5367. These interpretations were also provided to WRPS by Kent Reynolds of Energy*Solutions*, Inc.

- Geologic interpretations provided for selected groundwater wells in the vicinity of WMA C that were not included in the Energy*Solutions* 2010 report. For these specific wells, the information came from other published reports identified in Section 3.1.

The second digital geologic model (Alternative Geologic Model II) is primarily based on the interpretations made by Dr. Stanley Sobczyk of the Environmental Restoration & Waste Management Program of the Nez Perce Tribe. Dr. Sobczyk provided a spreadsheet to WRPS in July 2013 containing basic data and information associated with his interpretations of the tops of the same geologic units in many of the same dry wells, boreholes, direct pushes, and groundwater wells identified in Letter Report FS-NW-LT-5367 for the WMA C area. In constructing this digital alternative geologic model, the information supplied by the Nez Perce was also supplemented with tops of the geologic units provided in the Hanford Site GeoContacts Database[1] for other selected wells which were also used in Alternative Geologic Model I. These wells are located outside of WMA C. The originated sources of the interpretations for these wells are cited in Section 3.1 of this report.

[1] The Hanford Site GeoContacts Database is maintained and updated via the CH2M HILL Plateau Remediation Company Environmental Program and Strategic Planning – Risk and Data Integration Task. Contact for authorized access is provided by William Webber at William_D_Webber@rl.gov.

1.1 OBJECTIVE

The objective of this report is to document the process by which the alternative digital geologic models developed from WMA C were built. These models will be used to develop the geologic framework in numerical models to be used in the WMA C PA.

The following steps were used to create the geologic models of WMA C.

1) Compilation of the data identifying the tops of geologic units included in:
    a. Energy*Solutions* Letter Report FS-NW-LT-5367 (see Appendix A)
    b. Spreadsheet provided by the Nez Perce Tribe
    c. Selected Direct Push Completion Reports
    d. Hanford Site GeoContacts Database
2) Building an Access®[2] Database for WMA C Geologic Information
    a. Database tables
    b. Database queries
3) Importing geologic data into Tecplot®[3]
    a. Designing and building a mesh
    b. Interpolation of geologic data onto mesh
        i. Laser Imaging, Detection and Ranging (LIDAR) data for ground surface
        ii. Backfill data for bottom of Tank Farm
        iii. Top of each geologic unit
        iv. Creating geologic strata.

A description of each of these steps is provided in this document.

1.2 SCOPE AND CONTENT OF REPORT

General topics presented to facilitate technical discussions of these geologic models summarized in this document include the following.

Section 1.0, Introduction – Describes the objectives and scope of this report.

Section 2.0, Background – Provides a brief summary of the WMA C facilities.

Section 3.0, Data Used In Alternative Geologic Model(s) of Waste Management Area C – Presents a general description of the units identified in the alternative geologic model; locations of wells, boreholes and direct push; and tables identifying the tops of the units.

Section 4.0, Access® Database for Top of Units in the Region of Waste Management Area C – Provides a description of the tables and queries used to create the dataset for Tecplot®.

[2] Access® is a registered trademark of Microsoft Corporation in the U.S. and other countries.
[3] Tecplot® is a registered trademark of Tecplot, Inc., 3535 Factoria Blvd. SE, Bellevue, Washington.

Section 5.0, Building the Alternative Geologic Model I in Tecplot® – Describes the process used to build the digital geologic model in Tecplot®.

Section 6.0, Comparison of Waste Management Area C Geologic Models I and II – Provides a comparison of the alternative geologic models I and II using tops of major units and selected geologic cross-sections.

Section 7.0, Evaluation of Geologic Logs and Archived Core Samples in Selected Wells – Provides a summary of additional evaluations of geologic logs and archive soil samples from selected wells in vicinity of the WMA C and in WMA B-BX-BY.

Section 8.0, Summary and Recommendations – Provides a summary of the process to develop two alternative digital geologic models for WMA C with recommendations for their use in the WMA C PA.

Section 9.0, References – Lists reference documents cited in this report.

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2.0 BACKGROUND INFORMATION

This Section provides an overview of WMA C. Waste Management Area C (WMA C or the 241-C Tank Farm), part of the single-shell tank (SST) system, is located in the Central Plateau (see Figure 2-1), near the eastern edge of the 200 East Area. One of the first tank farms built, it was constructed in 1944 and 1945. The WMA C contains twelve 100-series tanks and four 200-series tanks (see Figures 2-2 and 2-3). The 100-series tanks are 23 m (75 ft) in diameter, have a 5-m (15-ft) operating depth, and have an operating capacity of 1,892,700 L (530,000 gal) each. The 200-series tanks are 6 m (20 ft) in diameter with a 7.32-m (24-ft) operating depth and an operating capacity of 208,000 L (55,000 gal) each. Only tanks 241-C-101 (C-101) through 241-C-106 (C-106) have concrete pits. The other 100-series tanks are equipped with centrally located salt well pump pits. The tanks sit below grade with at least 2 m (7 ft) of soil cover to provide shielding from radiation exposure to operating personnel. Tank pits are located on top of the tanks and provide access to the tank, pumps, and monitoring equipment.

The transfer and storage of waste within WMA C SSTs was supported by a complex waste transfer system of pipelines (transfer lines), diversion boxes, vaults, valve pits, and other miscellaneous structures.

Fourteen unplanned releases (UPRs) have occurred within or near to WMA C. The largest ones are associated with leaks in pipelines or diversion boxes, with releases from inlet/outlet ports of the SSTs, or with leaks from the SSTs. RPP-PLAN-39114, *Phase 2 RCRA Facility Investigation/Corrective Measures Study Work Plan for Waste Management Area C* provides more detail on these UPR sites.

Ten tanks have been retrieved, which are shown in green in Figure 2-3 and are listed below.

241-C-101 (C-101)*	241-C-103 (C-103)	241-C-104 (C-104)
241-C-106 (C-106)	241-C-108 (C-108)	241-C-109 (C-109)
241-C-110 (C-110)	241-C-201 (C-201)	241-C-202 (C-202)
241-C-203 (C-203)	241-C-204 (C-204)	

* Tank C-101 retrieval completion status is under review.

Three tanks are currently being retrieved (light blue in Figure 2-3) and are listed below.

241-C-107 (C-107)	241-C-111 (C-111)	241-C-112 (C-112)

Initial retrieval construction and planning activities are underway for tanks 241-C-102 (C-102) and 241-C-105 (C-105) (dark blue in Figure 2-3).

No retrieval activities have started on the catch tank 241-C-301 (C-301) shown in orange in Figure 2-3.

Figure 2-1. Hanford Site and its Location in Washington State.

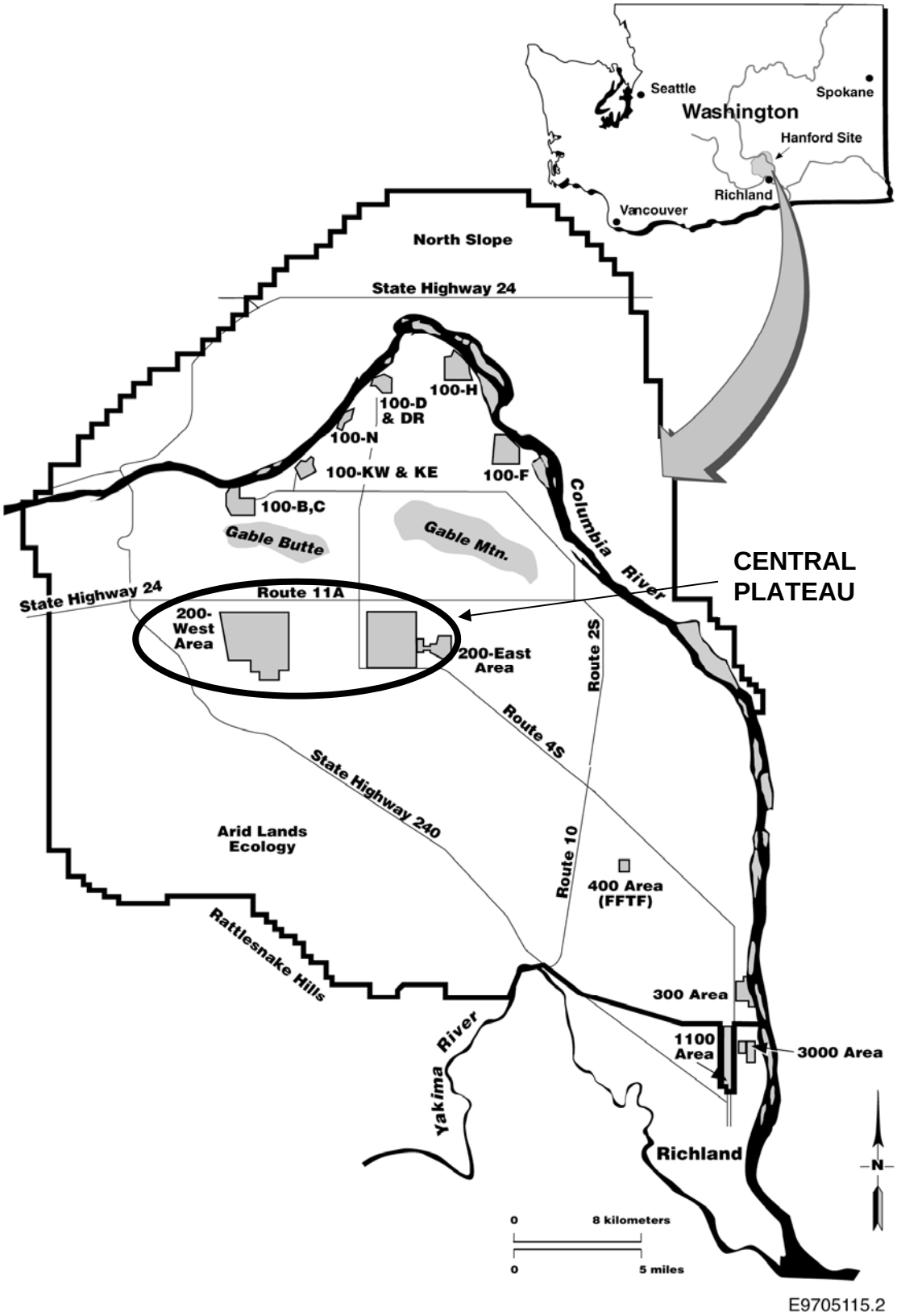


Figure 2-2. Facilities in the 200 Areas of Hanford's Central Plateau.

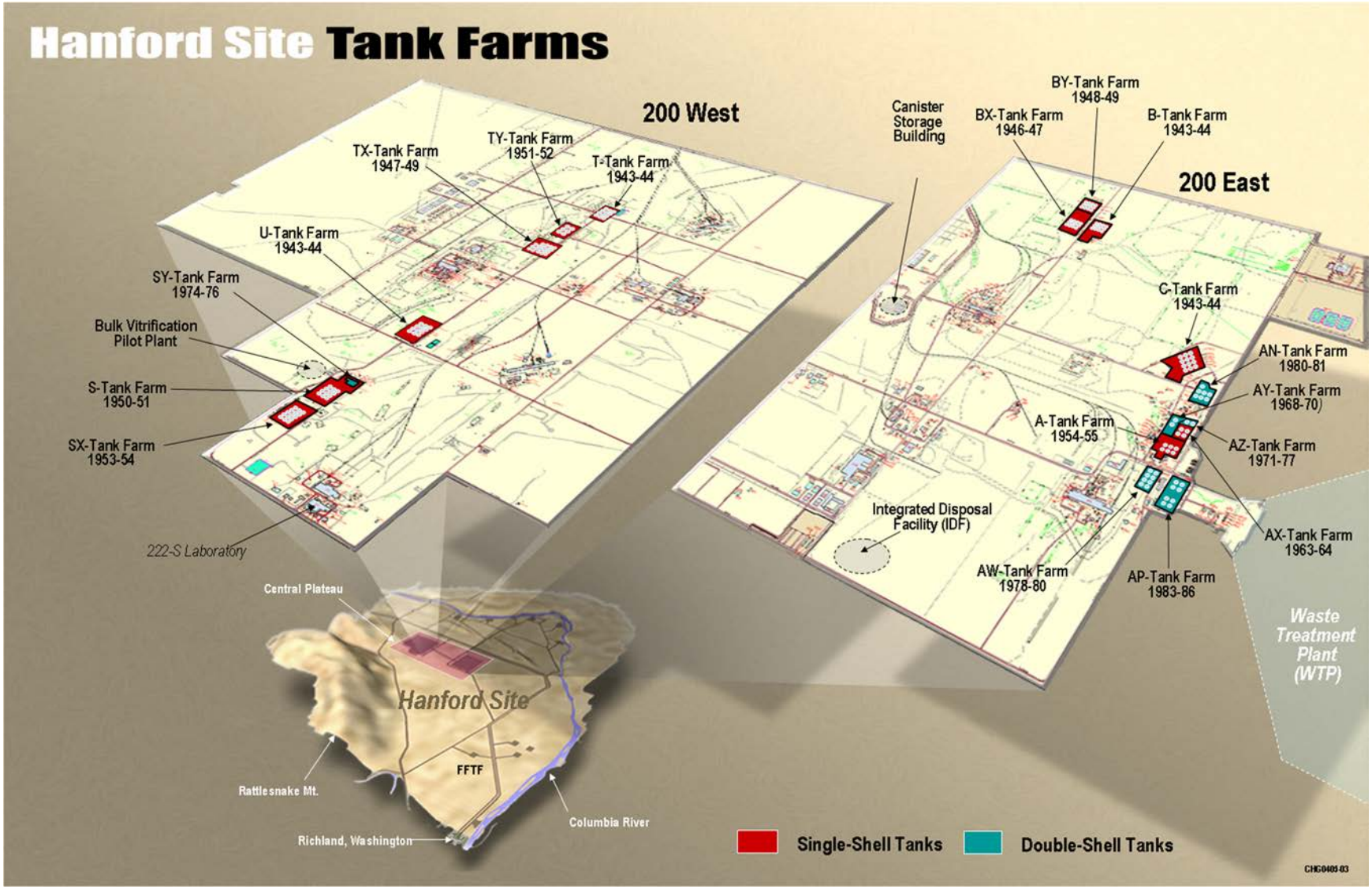
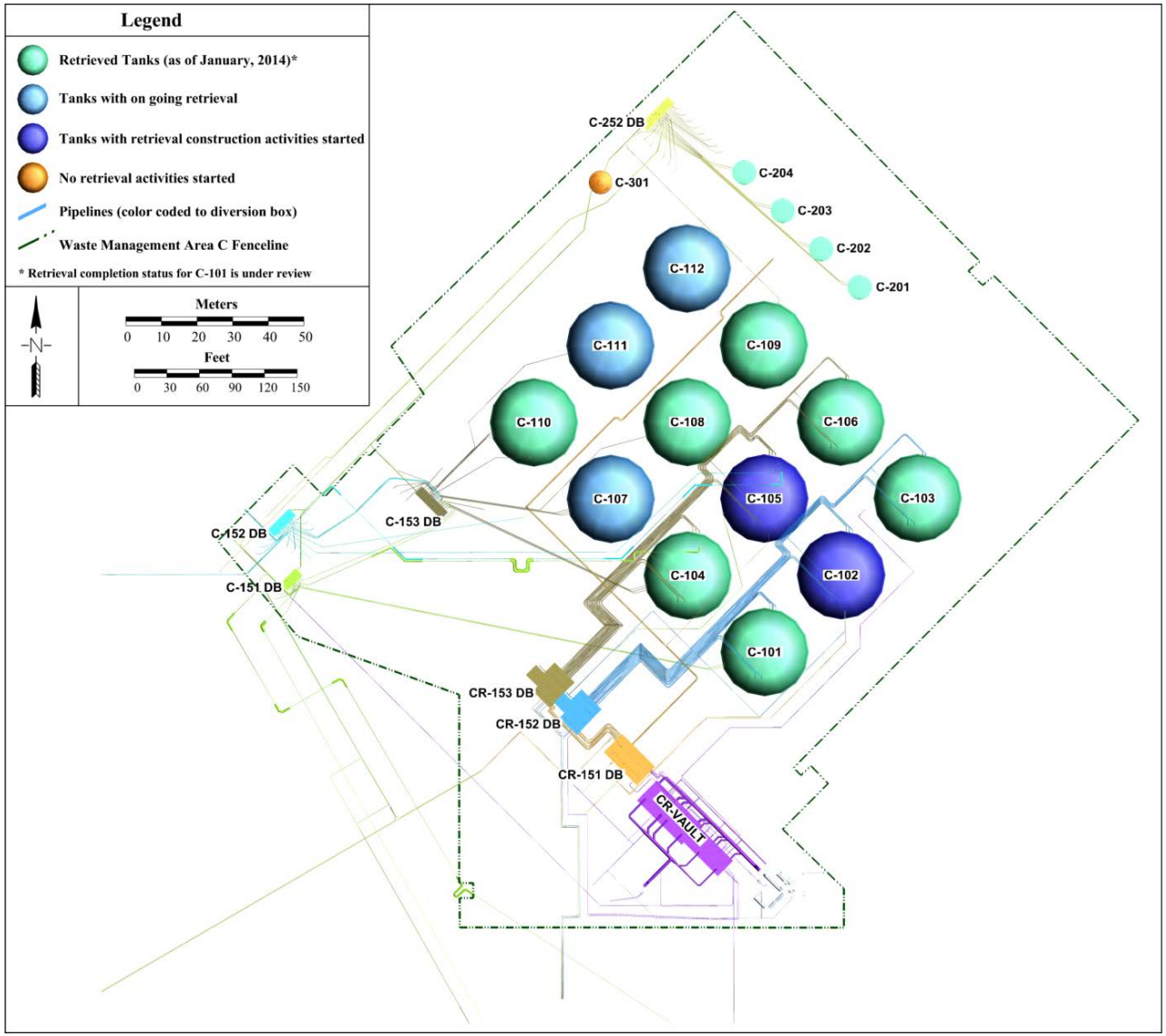


Figure 2-3. Map of Waste Management Area C and Surrounding Area Showing Locations of Single-Shell Tanks, Diversion Boxes, Pipelines, and a Catch Tank.



All seven diversion boxes within WMA C and the CR-Vault are also located in Figure 2-3. They are color coded so the reader may follow the pipelines coming out of these diversion boxes. Approximately seven miles of pipelines are estimated to exist within WMA C (RPP-PLAN-47559, *Single-Shell Tank Waste Management Area C Pipeline Feasibility Evaluation*).

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3.0 DATA USED IN ALTERNATIVE GEOLOGIC MODEL(S) OF WASTE MANAGEMENT AREA C

The regional and local geologic and hydrologic framework is discussed in Revision 1 of RPP-RPT-46088, *Flow and Transport in the Natural System at Waste Management Area C* and will not be repeated here. Interpretations provided in the WRPS and Nez Perce alternative geologic models have identified the tops of the seven separate geologic units within WMA C. Descriptions of these units, provided below, are taken from Letter Report FS-NW-LT-5367 (see Appendix A) and are provided in a shallow (upper) to deep (lower) sequence.

Backfill – Gravel-dominated consisting of poorly to moderately sorted cobbles, pebbles, and coarse to medium sand with some silt derived from coarse-grained Hanford formation (H1 unit) excavated around tanks; occasional layers of sand to silty sand occur near the base of the backfill sequence.

Hanford H1 Unit – Hanford H1 unit is gravel-dominated, generally identified as gravel or very coarse sand comprising greater than 70% of the lithology. It is assumed to have been deposited in a high energy environment (i.e., high energy depositional system-pebble cobble gravels, sandy gravels, gravelly sands, very low percentage silt or very fine to fine sands and are represented by low total potassium concentrations usually 10 to 15 pCi/gr). Hanford H1 has low total gross gamma count rates (e.g., less than 150 to 200 counts per second for large diameter wells high-purity germanium tools, 70 to 80 counts per second total count rates and less than 2 pCi eq. Ra for processed logs in direct push boreholes logged with sodium iodide and/or bismuth germanate oxide tools).

Hanford H2 Sand Unit – Hanford H2 Sand unit is a sand-dominated facies generally identified as fining upward sequences of gravel, sandy/gravel to sand to very fine sand. It is assumed to have been deposited distant from the main channel/high energy flow, and is dominated by trough cross-bedded depositional features. These are represented on logs compared to H1 by an increase in gross gamma count rate of 25 to 30% with an associated potassium (K) increase. Some logs have only gradual gross gamma increases but still have easily recognizable percentage potassium increases. The increase in total gamma and potassium count rates is indicative of a higher felsic fine-grained component of the sediments.

Hanford H2 Coarse Gravelly Sand Unit – Hanford H2 Coarse Gravelly Sand unit is coarse sediments that underlie the H2 Sand Unit. This unit is the equivalent of the “H2 coarse” unit described in Letter Report FS-NW-LT-5367. Again, this is a gravel/coarse-grained facies, which is indicated by a 15 to 20% total gross gamma and potassium count rate reduction when compared to the H2 sands above it.

Hanford H2 Silt Unit – Hanford H2 Silt unit is only observed in deep groundwater wells and the presence of a mappable unit may not be readily identified. When present, a very strong potassium peak and occasionally strong natural uranium peak with or without a total gamma change is possible. Strongest evidence for the presence is observed on driller and geologist logs.

Undifferentiated Hanford H3 Gravels, Cold Creek and Ringold Unit – Waste Management Areas A-AX and C lie along the edge of a paleochannel that eroded much or all of the Ringold Formation during Cold Creek unit (CC_U) and/or Hanford time. Because of the difficulty in distinguishing reworked Ringold Formation gravels and pre-Missoula mainstream Columbia River gravels from original Ringold Formation gravels, these units are undifferentiated here (H3/CC_U/RF).

This unit is found in the vicinity of WMA C and consists of a significant thickness of basalt-dominated gravels as described by Pacific Northwest National Laboratory (PNNL) from well 299-E27-155 drilling logs. Similar descriptions and log responses are present in other deep wells. The response is a significantly reduced total gamma count rate directly below the H2 silt that is not entirely attributable to the presence of groundwater. The top of groundwater is usually well below the overlying H2 unit. This facies is generally described as a coarse-grained open framework gravel to sandy gravel, high energy system which in outcrop and drilled sample contains significant percentages of Ringold, Columbia River Basalt and far-derived granites, Belt Rocks, and other terrains from north of the Pasco Basin (multi-lithic).

Columbia River Basalt – Columbia River Basalt is only noted in one or two wells. Resolution of this unit from gamma rate changes and potassium-uranium-thorium ratios is problematic. The best evidence of basalt contact depths is from geologic logs.

3.1 DIGITAL ALTERNATIVE GEOLOGIC MODEL I OF WASTE MANAGEMENT AREA C (*WASHINGTON RIVER PROTECTION SOLUTIONS INTERPRETATION*)

Alternative Geologic Model I of WMA C, based primarily on interpretations by WRPS subcontractor support staff, makes use of data on the top of the geologic units presented in Tables 3-1 through 3-4. The source of the data given in Table 3-1 is based on interpretations of the tops of the geologic units in dry wells, boreholes, and selected direct push locations provided by Energy*Solutions* (Letter Report FS-NW-LT-5367, see Appendix A).

Table 3-1. Top of Units Identified in Energy*Solutions* Letter Report FS-NW-LT-5367 (Appendix A). (sheet 1 of 5)

Count	Well ID	Well Name	Tank Farm Name	Well Type	Log Date	Elevation (m^1 bgs)	Backfill (m^1 bgs)	H1 (m^1 bgs)	H2 – Sand (m^1 bgs)	H2 – Coarse Gravelly Sand (m^1 bgs)	H2 – Silt (m^1 bgs)	Undifferentiated H3 Gravels, Cold Creek, and Ringold (m^1 bgs)	Confidence	Notes
1	A6676	299-E27-51	30-08-03	Dry Well	3/20/1997	197.95	0.0	11.28	short	short	short	short	high	—
2	A6677	299-E27-52	30-00-12	Dry Well	4/15/1997	197.71	0.0	N/D	24.08	short	short	short	low	well construction interference – cemented liner?[2]
3	A6678	299-E27-53	30-00-10	Dry Well	4/8/1997	198.75	0.0	N/D	15.54	short	short	short	low	drilled to 150 - but only logged to 60[2]
4	A6679	299-E27-54	30-00-03	Dry Well	4/15/1997	199.85	0.0	N/D	26.67	short	short	short	low	hole construction artifact - cement & liner?[2]
5	A6680	299-E27-55	30-00-06	Dry Well	3/25/1997	200.43	0.0	N/D	22.56	short	short	short	low	cemented liner?[2]
6	A6681	299-E27-56	30-00-01	Dry Well	4/14/1997	197.37	0.0	N/D	short	short	short	short	low	liner w/cement between 12" and current casing? – no logging data below 68'[2]
7	A6682	299-E27-57	30-00-09	Dry Well	4/1/1997	200.66	0.0	N/D	12.50	short	short	short	high	drilled to 150 – but only logged to 60
8	A6683	299-E27-58	30-01-09	Dry Well	3/24/1997	198.39	0.0	11.73	18.14	short	short	short	high	—
9	A6684	299-E27-59	30-01-06	Dry Well	3/28/1997	198.50	0.0	11.73	20.27	short	short	short	high	—
10	A6685	299-E27-60	30-01-01	Dry Well	3/26/1997	198.11	0.0	11.43	21.79	short	short	short	high	—
11	A6686	299-E27-61	30-01-12	Dry Well	3/20/1997	198.26	0.0	11.58	20.42	short	short	short	high	—
12	A6687	299-E27-62	30-11-09	Dry Well	3/7/1997	198.14	0.0	11.43	15.54	short	short	short	high	—
13	A6688	299-E27-63	30-11-01	Dry Well	2/28/1997	197.95	0.0	11.58	21.03	short	short	short	high	—
14	A6689	299-E27-64	30-11-06	Dry Well	3/5/1997	198.17	0.0	11.43	19.05	short	short	short	high	—
15	A6690	299-E27-65	30-04-12	Dry Well	2/25/1997	198.38	0.0	11.64	17.98	short	short	short	high	—
16	A6691	299-E27-66	30-04-08	Dry Well	4/18/1997	198.95	0.0	11.28	15.85	short	short	short	high	—
17	A6692	299-E27-67	30-04-02	Dry Well	2/19/1997	198.23	0.0	11.89	19.51	short	short	short	high	—
18	A6693	299-E27-68	30-05-10	Dry Well	1/15/1997	198.09	0.0	11.43	22.25	short	short	short	high	—
19	A6694	299-E27-69	30-05-04	Dry Well	1/29/1997	198.03	0.0	11.89	21.95	short	short	short	high	—
20	A6695	299-E27-70	30-05-02	Dry Well	2/5/1997	197.97	0.0	11.43	22.56	short	short	short	high	—
21	A6696	299-E27-71	30-06-10	Dry Well	1/29/1997	197.81	0.0	12.65	22.86	short	short	short	high	—
22	A6697	299-E27-72	30-06-02	Dry Well	1/22/1997	197.64	0.0	12.04	23.77	short	short	short	high	—
23	A6698	299-E27-73	30-06-04	Dry Well	2/5/1997	197.89	0.0	11.58	24.08	short	short	short	high	—
24	A6699	299-E27-74	30-03-01	Dry Well	4/17/1997	197.70	0.0	13.11	25.15	short	short	short	high	orig drilled to 100' in 6/74 – deepened to 125' in 7/83
25	A6700	299-E27-75	30-03-03	Dry Well	4/11/1997	197.60	0.0	13.11	25.76	short	short	short	low	contamination in first 30 feet - H1/H2 change ? – no K value change
26	A6701	299-E27-76	30-03-05	Dry Well	4/14/1997	197.82	0.0	11.73	25.30	short	short	short	high	
27	A6702	299-E27-77	30-03-07	Dry Well	4/11/1997	197.90	0.0	12.04	23.93	short	short	short	high	

Table 3-1. Top of Units Identified in EnergySolutions Letter Report FS-NW-LT-5367 (Appendix A). (sheet 2 of 5)

Count	Well ID	Well Name	Tank Farm Name	Well Type	Log Date	Elevation (m^1 bgs)	Backfill (m^1 bgs)	H1 (m^1 bgs)	H2 – Sand (m^1 bgs)	H2 – Coarse Gravelly Sand (m^1 bgs)	H2 – Silt (m^1 bgs)	Undifferentiated H3 Gravels, Cold Creek, and Ringold (m^1 bgs)	Confidence	Notes
28	A6703	299-E27-78	30-03-09	Dry Well	4/8/1997	197.90	0.0	11.43	22.86	short	short	short	high	—
29	A6704	299-E27-79	30-04-04	Dry Well	2/11/1997	198.20	0.0	11.28	18.75	short	short	short	high	—
30	A6705	299-E27-80	30-04-05	Dry Well	2/6/1997	198.34	0.0	11.58	17.98	short	short	short	high	—
31	A6706	299-E27-81	30-05-03	Dry Well	2/3/1997	198.02	0.0	11.43	22.56	short	short	short	high	—
32	A6707	299-E27-82	30-05-05	Dry Well	1/29/1997	198.08	0.0	11.43	20.42	short	short	short	high	—
33	A6708	299-E27-83	30-05-09	Dry Well	1/24/1997	198.20	0.0	11.43	19.66	short	short	short	high	—
34	A6709	299-E27-84	30-06-03	Dry Well	1/16/1997	197.65	0.0	11.73	24.54	short	short	short	high	—
35	A6710	299-E27-85	30-06-09	Dry Well	2/3/1997	197.98	0.0	11.89	22.71	short	short	short	high	—
36	A6711	299-E27-86	30-06-12	Dry Well	1/27/1997	197.58	0.0	11.43	23.32	short	short	short	high	—
37	A6712	299-E27-87	30-07-01	Dry Well	3/7/1997	198.17	0.0	11.43	18.29	short	short	short	high	—
38	A6713	299-E27-88	30-07-02	Dry Well	3/12/1997	198.15	0.0	11.58	18.14	short	short	short	high	—
39	A6714	299-E27-89	30-07-05	Dry Well	3/19/1997	198.78	0.0	12.04	16.00	short	short	short	high	—
40	A6715	299-E27-90	30-07-07	Dry Well	3/17/1997	198.73	0.0	11.73	14.33	short	short	short	high	—
41	A6716	299-E27-91	30-07-08	Dry Well	3/13/1997	198.59	0.0	11.73	13.56	short	short	short	high	—
42	A6717	299-E27-92	30-07-10	Dry Well	3/12/1997	198.35	0.0	11.73	13.72	short	short	short	high	—
43	A6718	299-E27-93	30-07-11	Dry Well	3/10/1997	198.26	0.0	11.43	15.09	short	short	short	high	—
44	A6719	299-E27-94	30-08-02	Dry Well	3/18/1997	197.95	0.0	11.52	22.65	short	short	short	high	—
45	A6720	299-E27-95	30-08-12	Dry Well	3/14/1997	197.98	0.0	11.43	21.64	short	short	short	high	—
46	A6721	299-E27-96	30-09-01	Dry Well	3/27/1997	197.66	0.0	11.58	22.80	short	short	short	high	—
47	A6722	299-E27-97	30-09-02	Dry Well	3/28/1997	197.76	0.0	11.73	22.86	short	short	short	high	—
48	A6723	299-E27-98	30-09-06	Dry Well	4/1/1997	197.96	0.0	11.67	21.88	short	short	short	high	—
49	A6724	299-E27-99	30-09-10	Dry Well	3/24/1997	197.84	0.0	12.04	22.56	short	short	short	high	—
50	A6725	299-E27-100	30-09-11	Dry Well	3/25/1997	197.71	0.0	12.50	24.08	short	short	short	high	—
51	A6726	299-E27-101	30-10-01	Dry Well	3/4/1997	198.21	0.0	11.58	14.94	short	short	short	high	—
52	A6727	299-E27-102	30-10-02	Dry Well	2/27/1997	198.17	0.0	11.58	16.92	short	short	short	high	—
53	A6728	299-E27-103	30-10-09	Dry Well	2/28/1997	199.31	0.0	12.04	12.65	short	short	short	high	—
54	A6729	299-E27-104	30-10-11	Dry Well	3/5/1997	198.55	0.0	11.58	13.11	short	short	short	high	—
55	A6730	299-E27-105	30-11-05	Dry Well	3/4/1997	198.15	0.0	11.58	20.88	short	short	short	high	—

Table 3-1. Top of Units Identified in EnergySolutions Letter Report FS-NW-LT-5367 (Appendix A). (sheet 3 of 5)

Count	Well ID	Well Name	Tank Farm Name	Well Type	Log Date	Elevation (m^1 bgs)	Backfill (m^1 bgs)	H1 (m^1 bgs)	H2 – Sand (m^1 bgs)	H2 – Coarse Gravelly Sand (m^1 bgs)	H2 – Silt (m^1 bgs)	Undifferentiated H3 Gravels, Cold Creek, and Ringold (m^1 bgs)	Confidence	Notes
56	A6731	299-E27-106	30-11-11	Dry Well	3/10/1997	198.08	0.0	11.58	18.29	short	short	short	high	—
57	A6732	299-E27-107	30-12-01	Dry Well	2/24/1997	197.65	0.0	13.11	24.84	short	short	short	high	—
58	A6733	299-E27-108	30-12-03	Dry Well	3/13/1997	197.59	0.0	12.19	23.93	short	short	short	high	—
59	A6734	299-E27-109	30-12-09	Dry Well	2/27/1997	197.95	0.0	11.73	21.03	short	short	short	high	—
60	A6735	299-E27-115	30-04-01	Dry Well	2/24/1997	198.28	0.0	11.58	short	short	short	short	high	—
61	A6736	299-E27-116	30-04-03	Dry Well	2/14/1997	198.22	0.0	11.28	short	short	short	short	high	—
62	A6737	299-E27-117	30-05-08	Dry Well	1/24/1997	198.17	0.0	11.58	short	short	short	short	high	—
63	A6738	299-E27-118	30-05-07	Dry Well	1/21/1997	198.19	No	—	—	—	—	—	—	values available – off scale contamination
64	A6739	299-E27-119	30-05-06	Dry Well	1/22/1997	198.27	0.0	11.89	short	short	short	short	high	—
65	A6740	299-E27-120	30-00-22	Dry Well	4/4/1997	204.54	0.0	N/D	7.62	short	short	short	high	grouted
66	A6741	299-E27-121	30-00-11	Dry Well	4/17/1997	204.45	0.0	N/D	7.01	short	short	short	high	grouted
67	A6742	299-E27-122	30-00-24	Dry Well	4/3/1997	209.91	0.0	N/D	10.06	short	short	short	high	grouted
68	A6744	299-E27-124	30-11-13	Dry Well	4/8/1997	199.62	0.0	1.52	short	short	short	short	low	grouted liner or H1?
69	A6745	299-E27-125	30-12-13	Dry Well	2/25/1997	197.70	0.0	11.89	23.62	short	short	short	high	—
70	A6754	299-E27-135	30-09-07	Dry Well	3/20/1997	198.46	0.0	12.50	22.25	short	short	short	high	—
71	C4297	unknown	N/A	Deep Characterization	3/23/2004	198.23	0.0	12.19	19.20	49.23	short	short	high	bottom of H2 (+/- 5 ft), moisture change at 132'-135'
72	C4401	N/A	N/A	Direct Push	11/1/2004	203.05	N/A	0.0	6.40	short	short	short	high	—
73	C4403	N/A	N/A	Direct Push	7/14/2005	203.05	N/A	0.0	6.10	short	short	short	high	—
74	C4405	N/A	N/A	Direct Push	7/14/2005	203.26	N/A	0.0	5.79	short	short	short	high	—
75	C4407	N/A	N/A	Direct Push	7/14/2005	203.23	N/A	0.0	6.55	short	short	short	high	—
76	C4409	N/A	N/A	Direct Push	7/12/2005	203.04	N/A	0.0	7.16	short	short	short	high	—
77	C4411	N/A	N/A	Direct Push	7/14/2005	203.20	N/A	0.0	7.16	short	short	short	high	—
78	C4413	N/A	N/A	Direct Push	7/15/2005	203.17	N/A	0.0	7.62	short	short	short	high	—
79	C4415	N/A	N/A	Direct Push	7/15/2005	203.06	N/A	0.0	8.53	short	short	short	high	—
80	C4417	N/A	N/A	Direct Push	7/15/2005	203.04	N/A	0.0	8.69	short	short	short	high	—
81	C4419	N/A	N/A	Direct Push	7/19/2005	202.64	N/A	0.0	9.14	short	short	short	high	—
82	C4421	N/A	N/A	Direct Push	7/19/2005	202.59	N/A	0.0	9.30	short	short	short	high	—
83	C4425	N/A	N/A	Direct Push	8/18/2005	202.49	N/A	short	short	short	short	short	high	short – no contact visible

Table 3-1. Top of Units Identified in EnergySolutions Letter Report FS-NW-LT-5367 (Appendix A). (sheet 4 of 5)

Count	Well ID	Well Name	Tank Farm Name	Well Type	Log Date	Elevation (m^1 bgs)	Backfill (m^1 bgs)	H1 (m^1 bgs)	H2 – Sand (m^1 bgs)	H2 – Coarse Gravelly Sand (m^1 bgs)	H2 – Silt (m^1 bgs)	Undifferentiated H3 Gravels, Cold Creek, and Ringold (m^1 bgs)	Confidence	Notes
84	C4427	N/A	N/A	Direct Push	8/29/2005	201.61	N/A	0.0	6.71	short	short	short	low	problem log
85	C4429	N/A	N/A	Direct Push	8/17/2005	202.03	N/A	0.0	9.91	short	short	short	high	—
86	C4431	N/A	N/A	Direct Push	8/29/2005	201.79	N/A	0.0	11.13	short	short	short	high	—
87	C4433	N/A	N/A	Direct Push	8/18/2005	201.89	N/A	short	short	short	short	short	high	short – no contact visible
88	C4435	N/A	N/A	Direct Push	8/18/2005	201.74	N/A	0.0	9.75	short	short	short	high	—
89	C4437	N/A	N/A	Direct Push	8/18/2005	201.86	N/A	0.0	8.69	short	short	short	high	—
90	C4439	N/A	N/A	Direct Push	8/18/2005	201.96	N/A	0.0	8.99	short	short	short	high	—
91	C4447	N/A	N/A	Direct Push	8/29/2005	201.54	N/A	short	short	short	short	short	low	short, problem log
92	C5943	N/A	N/A	Direct Push	11/8/2007	205.40	N/A	0.0	7.32	short	short	short	high	grain size changes at 45.5 ft indicated by large change in moisture
93	C5947	N/A	N/A	Direct Push	11/8/2007	205.00[3]	N/A	0.0	8.23	55.17	short	short	low	grain size changes at 53.5 ft, strange response at 120.5' – see also 5957
94	C5951	N/A	N/A	Direct Push	11/15/2007	205.13	N/A	0.0	8.38	short	short	short	low	grain size changes at 53.5 ft indicated by large change in moisture
95	C5953	N/A	N/A	Direct Push	12/5/2007	205.60	N/A	0.0	7.77	short	short	short	low	grain size changes at 62.5 ft indicated by large change in moisture
96	C5955	N/A	N/A	Direct Push	11/21/2007	205.42	N/A	0.0	7.62	short	short	short	low	grain size changes at 50.5 ft indicated by large change in moisture
97	C5957	N/A	N/A	Direct Push	12/6/2007	205.66	N/A	0.0	7.92	short	short	short	low	grain size changes at 49 ft, strange response at 118' – see also 5947
98	C5959	N/A	N/A	Direct Push	11/26/2007	205.85	N/A	0.0	7.01	short	short	short	low	—
99	C5961	N/A	N/A	Direct Push	11/20/2007	206.75	N/A	0.0	7.16	short	short	short	low	grain size changes at 50 ft indicated by large change in moisture
100	C5963	N/A	N/A	Direct Push	11/9/2007	205.65	N/A	0.0	7.77	short	short	short	low	grain size changes at 53 ft indicated by large change in moisture
101	C6391	N/A	N/A	Direct Push	5/5/2008	203.51	N/A	0.0	16.15	short	short	short	high	distinct moisture change at 134' – correlates to UPR-86
102	C6393	N/A	N/A	Direct Push	4/29/2008	203.72	N/A	0.0	16.00	52.43	short	short	high	distinct moisture change at 135' – correlates to UPR-86
103	C6395	N/A	N/A	Direct Push	5/23/2008	203.65	N/A	0.0	14.33	short	short	short	high	distinct moisture change at 135' – correlates to UPR-86
104	C6397	N/A	N/A	Direct Push	5/12/2008	203.07	N/A	0.0	17.07	short	short	short	high	distinct moisture change at 135' – correlates to UPR-86
105	C6399	N/A	N/A	Direct Push	5/6/2008	203.07	N/A	0.0	18.14	54.10	short	short	high	distinct moisture change at 137' – correlates to UPR-86
106	C6405	N/A	N/A	Direct Push	3/2/2009	203.11	N/A	0.0	16.92	54.25	short	short	high	distinct moisture change at 135'
107	C7465	N/A	N/A	Direct Push	7/14/2009	197.67	0.0	13.56	24.69	49.07	short	short	high	—
108	C7467	N/A	N/A	Direct Push	7/20/2009	197.49	0.0	13.72	23.47	48.46	short	short	low	0-45' may be backfill or H1, large moisture peak at 98'

Table 3-1. Top of Units Identified in EnergySolutions Letter Report FS-NW-LT-5367 (Appendix A). (sheet 5 of 5)

Count	Well ID	Well Name	Tank Farm Name	Well Type	Log Date	Elevation (m[1] bgs)	Backfill (m[1] bgs)	H1 (m[1] bgs)	H2 – Sand (m[1] bgs)	H2 – Coarse Gravelly Sand (m[1] bgs)	H2 – Silt (m[1] bgs)	Undifferentiated H3 Gravels, Cold Creek, and Ringold (m[1] bgs)	Confidence	Notes
109	C7471	N/A	N/A	Direct Push	12/1/2009	194.89	0.0	12.19	23.47	51.36	short	short	low	0-40' may be backfill or H1, large moisture peaks at 111' and 131'
110	C7667	N/A	N/A	Direct Push	12/17/2009	198.1	0.0	12.50	21.95	47.85	short	short	high	—
111	C7669	N/A	N/A	Direct Push	12/8/2009	197.8	0.0	12.50	23.93	50.29	short	short	high	strange response in moisture at 140'
112	C4125	299-E27-4	N/A	Groundwater Well	8/16/2003	205.57	N/A	0.0	16.00	55.47	70.71	72.24	low	some uncertainty in depths and thickness of H1 and H2, moisture change at 268'
113	A4816	299-E27-7	N/A	Groundwater Well	not listed	195.58	0.0	12.50	24.99	51.51	short	short	low	Geophysical logs difficult to interpret due to well construction which affect the signal from logging tools. This results in low confidence at picking top of units from geophysical logs.
114	A4812	299-E27-14	N/A	Groundwater Well	not listed	201.75	N/A	7.01	27.28	44.81	64.92	72.39	low	Geophysical logs difficult to interpret due to well construction which affect the signal from logging tools. This results in low confidence at picking top of units from geophysical logs.
115	C4127	299-E27-21	N/A	Groundwater Well	not listed	205.73	N/A	N/D	18.59	53.95	81.99	83.21	low	Becker dual wall casing[4] – Difficult to interpret due to well construction resulting in low confidence in picking top of units; top of basalt 312'?
116	C4124	299-E27-22	N/A	Groundwater Well	not listed	193.70	N/D	N/D	23.47	44.96	68.58	70.41	low	Becker dual wall casing[4] – Log difficult to interpret due to well construction resulting in low confidence in picking top of units; top of basalt 266' (drilling reports)
117	C4190	299-E27-23	N/A	Groundwater Well	not listed	206.56	N/A	0.0	8.69	55.47	71.02	74.22	low	Becker dual wall casing[4] – Log difficult to interpret due to well construction resulting in low confidence in picking top of units; low confidence in H2 silt and H3, can't see basalt that should be there
118	C7570	299-E27-24	N/A	Groundwater Well	not listed	202.74	N/A	0.0	18.59	53.34	71.78	74.07	high	—
119	C5852	299-E27-155	N/A	Groundwater Well	not listed	207.51	N/A	0.0	20.73	53.95	85.34	85.95	low	Geophysical logs difficult to interpret due to well construction resulting in low confidence in picking top of units; H1 and H2 intermixed in upper 100 ft, top of basalt at 336'

[1] Letter Report FS-NW-LT-5367 reported units in feet since that is what is measured in the field while logging. However, borehole locations are reported in the metric system. To keep all units consistent, the depth below ground surface has been converted to metric; please see original report for depth units in feet. To convert these units to feet, multiply by 3.2808.

[2] Letter Report FS-NW-LT-5367 placed the confidence of the picks for the tops of the units as low due to poor log quality resulting from drywells which have been rebuilt over the years, many without detailed documentation. These modifications affect the signal from the logging tools and therefore create uncertainty in the data.

[3] Corrected from mistake in FS-NW-LT-5367 reporting the elevation as 2045.00 m at direct push C5947.

[4] Wells that were drilled in Waste Management Area C using a Becker Hammer method are difficult to log due to the double-walled casing used by this method. The Becker Hammer cannot penetrate into the basalt formations, and the double-casing walls (quadruple walls at joints) shield the gamma signature that would normally be used for correlations.

m bgs = meters below ground surface
N/A = Not applicable
N/D = Non determinable
Top of Unit is Depth Below Elevation

Reference: FS-NW-LT-5367, 2010, "Submittal of C Farm Geology/Geophyics Review, Task 26" (letter report from K. D. Reynolds to M. Connelly, Washington River Protection Solutions, June 18), Energy*Solutions*, Richland, Washington.

Table 3-2. Top of Units Identified in Selected Completion Reports of the Slant Direct Pushes.

Count	Well ID	Well Name	TFName	Easting (m)	Northing (m)	Elevation (m)	Top of Unit	Azimuth	Dip	Distance Down Pipe Run (m)	Source
120	C5104	N/A	N/A	575052.010	136546.850	201.7600	Land Surface	221.6500	44.0000	0.00000	RPP-32130
120	C5104	N/A	N/A	575046.473	136540.624	193.7142	H2 - Sand	221.6500	44.0000	11.58240	RPP-32130
121	C5105	N/A	N/A	575051.190	136546.050	201.7500	Land Surface	221.6500	31.5000	0.00000	RPP-32130
121	C5105	N/A	N/A	575042.036	136535.758	193.3096	H2 - Sand	221.6500	31.5000	16.15440	RPP-32130
122	C5106	N/A	N/A	575045.630	136522.310	203.0600	Land Surface	312.0000	58.0000	0.00000	RPP-32130
122	C5106	N/A	N/A	575041.462	136526.063	194.0843	H2 - Sand	312.0000	58.0000	10.58400	RPP-32130
123	C5107	N/A	N/A	575045.230	136522.660	203.0800	Land Surface	312.0700	45.2000	0.00000	RPP-32130
123	C5107	N/A	N/A	575039.331	136527.985	195.0777	H2 - Sand	312.0700	45.2000	11.27760	RPP-32130
124	C5108	N/A	N/A	575026.310	136528.250	203.1500	Land Surface	79.8000	60.7000	0.00000	RPP-32130
124	C5108	N/A	N/A	575030.861	136529.069	194.9107	H2 - Sand	79.8000	60.7000	9.44880	RPP-32130
125	C5109	N/A	N/A	575026.810	136528.480	203.1900	Land Surface	79.0000	45.2500	0.00000	RPP-32130
125	C5109	N/A	N/A	575035.236	136530.118	194.5313	H2 - Sand	79.0000	45.2500	12.19200	RPP-32130
126	C8099	N/A	N/A	575116.690	136514.240	202.3900	Land Surface	63.3200[1]	58.1700[1]	0.00000	RPP-RPT-49956
126	C8099	N/A	N/A	575127.750	136519.798	182.4495	H2 - Sand	63.3200[1]	58.1700[1]	23.46960	RPP-RPT-49956
126	C8099	N/A	N/A	575150.648	136533.257	147.6538	H2 - Gravel	60.7750[1]	54.5850[1]	67.16270	RPP-RPT-49956
127	C8101	N/A	N/A	575140.040	136488.430	202.4880	Land Surface	42.8684[1]	49.6380[1]	0.00000	RPP-RPT-50581
127	C8101	N/A	N/A	575146.352	136495.230	191.5724	H1	42.8684[1]	49.6380[1]	14.32560	RPP-RPT-50581
127	C8101	N/A	N/A	575150.246	136499.425	184.8372	H2 - Sand	42.8684[1]	49.6380[1]	23.16480	RPP-RPT-50581
128	C8103	N/A	N/A	575170.060	136522.430	198.0590	Land Surface	159.6770[1]	59.7313[1]	0.00000	RPP-RPT-50581
128	C8103	N/A	N/A	575172.408	136516.091	186.4761	H1	159.6770[1]	59.7313[1]	13.41120	RPP-RPT-50581
128	C8103	N/A	N/A	575174.489	136510.472	176.2095	H2 - Sand	159.6770[1]	59.7313[1]	25.29840	RPP-RPT-50581
129	C8105	N/A	N/A	575184.940	136641.240	193.6500	Land Surface	234.6223[1]	25.8279[1]	0.00000	RPP-RPT-51384
129	C8105	N/A	N/A	575164.360	136626.627	181.4331	H1	234.6223[1]	25.8279[1]	28.04160	RPP-RPT-51384
129	C8105	N/A	N/A	575148.254	136615.190	171.8721	H2 - Sand	234.6223[1]	25.8279[1]	49.98720	RPP-RPT-51384

[1] These values should not be used to create the path of the direct push, because the path deviated at depth. To replicate the exact path, please use the gyroscope measurements given in the completion reports which have more position measurements.

N/A = Not applicable

References:
RPP-32130, *Summary of Direct Push Exploration at 241-C-152 Diversion Box in 241-C Tank Farm.*
RPP-RPT-49956, *Completion Report for the 241-C Tank Farm, C-104 Angle Direct Push Characterization.*
RPP-RPT-50581, *Completion Report for the 241-C Tank Farm, C-101 Angle Direct Push Characterization.*
RPP-RPT-51384, *Completion Report for the 241-C Tank Farm C-203 Angle Direct Push Characterization.*

Table 3-3. Top of Units Identified in Hanford Site GeoContacts Database for Selected Groundwater Wells in the Vicinity of Waste Management Area C.

Count	Well ID	Well Name	Ground Surface Elevation (m[1])	Backfill (m[1] bgs)	H1 (m[1] bgs)	H2 (m[1] bgs)	H3 (m[1] bgs)	Basalt (m[1] bgs)	Source
130	A4810	299-E27-12	200.25	N/A	0	10.67	70.1	—	RPP-18290
131	A4811	299-E27-13	200.30	N/A	0	12.19	72.54	—	RPP-18290
132	A4813	299-E27-15	197.82	0	3.05	18.29	70.1	—	RPP-18290
133	C4126	299-E27-20	205.45	N/A	—	0.305[2]	73.15	—	RPP-18290
134	C7571	299-E27-25	186.8	N/A	0	18.29	57.91	74.98	SGW-48722
135	A5897	299-E24-3	213.47	N/A	0	32.61	—	—	RPP-14430
136	A5898	299-E24-4	213.48	N/A	0	21.34	—	—	RPP-14430
137	A4756	299-E24-20	210.12	N/A	0	35.05	83.82	—	RPP-14430
138	C4123	299-E24-22	209.55	N/A	0	32.92	91.44	—	PNNL-14538
139	C4257	299-E24-33	206.03	N/A	0	17.68	76.81	96.01	PNNL-18835
140	A6642	299-E26-6	199.19	N/A	0	18.29	74.07	—	RPP-14430
141	A4805	299-E26-8	189.22	N/A	—	0	41.45	76.20	RPP-14430
142	A6670	299-E27-2	203.09	N/A	0	15.24	77.72	—	RPP-14430
143	A6671	299-E27-3	208.65	N/A	0	10.67	77.72	106.38	RPP-14430

[1] Hanford Site GeoContacts Database reports units in feet since that is what is measured in the field while logging. However, borehole locations are reported in the metric system. To keep all units consistent, the depth below ground surface has been converted to metric; please see Hanford Site GeoContacts Database for depth units in feet. To convert these units to feet, multiply by 3.2808.

[2] The top of the H2 unit identified here was not used in the model due to misidentifying this surface; nearby well 299-E27-23 has the top of this unit at 8.69 m.

m bgs = meters below ground surface
N/A = Not applicable

References:
PNNL-14538, *Borehole Data Package for RCRA Wells 299-E25-93 and 299-E24-22 at Single-Shell Tank Waste Management Area A-AX, Hanford Site, Washington*.
PNNL-18835, *Hydrogeology of the Hanford Site Central Plateau—A Status Report for the 200 East Area* (DRAFT).
RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area*.
RPP-18290, *241-C Tank Farm Geologic and Stratigraphic Analysis*.
SGW-48722, *Borehole Summary Report for the ARRA Installation of Five RCRA Groundwater Monitoring Wells in the 200 Areas, FY 2010*.

The Hanford Site GeoContacts Database is maintained and updated via the CH2M HILL Plateau Remediation Company Environmental Program and Strategic Planning – Risk and Data Integration Task. Contact for authorized access is provided by William Webber at William_D_Webber@rl.gov.

Table 3-4. Measured Elevation of Water Table for Selected Wells in Vicinity of Waste Management Area C.

Well ID	Well Name	Date Measured	Hydraulic Head (m)
A4810	299-E27-12	Average June 2013	121.7985
A4811	299-E27-13	Average June 2013	121.7350
A4812	299-E27-14	Average June 2013	121.7950
A4813	299-E27-15	Average June 2013	121.8000
A4816	299-E27-7	Average June 2013	121.7900
C4124	299-E27-22	Average June 2013	121.8340
C4125	299-E27-4	Average June 2013	121.8190
C4127	299-E27-21	Average June 2013	121.7880
C4190	299-E27-23	Average June 2013	121.8220
C5852	299-E27-155	Average June 2013	121.6820
C7570	299-E27-24	Average June 2013	121.7620
C7571	299-E27-25	Average June 2013	121.6510
A4756	299-E24-20	Average June 2013	121.8100
C4123	299-E24-22	Average June 2013	121.7850
C4257	299-E24-33	Average June 2013	121.7799
A4805	299-E26-8	Average June 2013	121.7800

Table 3-2 presents interpreted tops of the same geologic units from the slant direct pushes which were developed after the completion of Letter Report FS-NW-LT-5367 (see Appendix A). Information for the top of the units came from the direct push completion reports identified in the table that include:

- RPP-32130, *Summary of Direct Push Exploration at 241-C-152 Diversion Box in 241-C Tank Farm*
- RPP-RPT-49956, *Completion Report for the 241-C Tank Farm, C-104 Angle Direct Push Characterization*
- RPP-RPT-50581, *Completion Report for the 241-C Tank Farm, C-101 Angle Direct Push Characterization*, and
- RPP-RPT-51384, *Completion Report for the 241-C Tank Farm C-203 Angle Direct Push Characterization*.

Table 3-2 provides the actual location for the top of the unit given in State Plane Coordinates along with its elevation in NAVD88, taking into account that the direct pushes were slant holes,

rather than simply vertical pushes with a depth below ground surface reported. Table 3-2 also includes the azimuth with north being 0 degrees, the dip (from ground surface), and the length of pipe to reach the contact.

Table 3-3 provides a summary of the top of the units identified in groundwater wells in the immediate vicinity of WMA C and selected groundwater wells outside of WMA C based on the Hanford Site GeoContacts Database. As noted in the Hanford Site GeoContacts Database and Table 3-3, information for these wells was taken from the following sources.

- PNNL-14538, *Borehole Data Package for RCRA Wells 299-E25-93 and 299-E24-22 at Single-Shell Tank Waste Management Area A-AX, Hanford Site, Washington*
- PNNL-18835, *Hydrogeology of the Hanford Site Central Plateau—A Status Report for the 200 East Area* (DRAFT)
- RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area*
- RPP-18290, *241-C Tank Farm Geologic and Stratigraphic Analysis*
- SGW-48722, *Borehole Summary Report for the ARRA Installation of Five RCRA Groundwater Monitoring Wells in the 200 Areas, FY 2010*.

Interpretations provided in the Hanford Site GeoContacts Database does not break the H2 unit into three separate facies as delineated in the other interpretations provided in Tables 3-1 and 3-2. The top of the H2 unit is defined as the top of H2 sand unit; the subunits H2 gravel and H2 silt are located below the H2 sand unit.

Table 3-4 provides the elevation for the water table for the groundwater monitoring wells in June 2013 which allows the depiction of the unconfined aquifer in the geologic model.

3.2 ALTERNATIVE GEOLOGIC MODEL II OF WASTE MANAGEMENT AREA C (*NEZ PERCE INTERPRETATION*)

In addition to the Alternative Geologic Model I of the WMA C area developed by WRPS and its site contractor support staff, a second geologic model (Alternative Geologic Model II) was developed using an evaluation of dry well, direct push, borehole, and groundwater well data by technical staff from the Nez Perce Tribe. This data is summarized in Table 3-5. No modifications were made to this data and it was used exactly as given to create the model in the vicinity of WMA C. However, because of the need to expand the geologic model and to include the water table into the model, the data provided by the Nez Perce was supplemented with data from the last 10 lines of Table 3-3 and all data provided in Table 3-4 to develop this second model.

Table 3-5. Top of Units Identified in Selected Boreholes by the Nez Perce Tribe. (6 sheets)

Borehole	Easting (m)	Northing (m)	Reference Elevation (m)	Backfill[1] (m)	H1[2] (m)	H2 Sand[2] (m)	H2 Coarse Gravelly Sand[2] (m)	H2 Silt[2] (m)	H3[2] (m)	Top of Basalt[3] (m)
299-E27-12	575054.14	136583.53	202.548	pinch	1.01	14.33	52.43	unknown	71.32	short
299-E27-13	575064.92	136489.23	204.918	pinch	0.91	13.72	55.78	unknown	72.54	short
299-E27-14	575217.34	136498.24	199.75	pinch	3.05	28.04	50.29	69.8	71.93	short
299-E27-15	575095.26	136630.36	200.024	pinch	0.85	21.34	48.16	unknown	74.68	short
299-E27-21	575145.03	136407.21	204.995	pinch	0	18.59	54.86	73.15	74.07	100.7
299-E27-22	575185.10	136685.33	192.604	pinch	1.83	24.38	46.63	69	69.19	81.69
299-E27-23	575069.46	136452.23	205.661	pinch	3.66	17.98	55.47	71.93	74.98	short
299-E27-4	575032.02	136497.92	204.685	pinch	6.71	15.85	55.78	70.1	72.54	short
299-E27-56	575205.49	136575.84	197.654	0	9.75	short	short	short	short	short
299-E27-54	575204.73	136519.89	199.848	pinch	0	26.82	short	short	short	short
299-E27-55	575148.53	136491.33	200.433	0	11.58	17.68	short	short	short	short
299-E27-53	575093.53	136598.34	198.753	pinch	0	15.85	short	short	short	short
299-E27-121	575023.60	136540.40	203.2	0	3.66	11.28	short	short	short	short
299-E27-124	575108.30	136635.10	198.45	pinch	1.52	short	short	short	short	short
299-E27-120	575029.70	136519.00	202.3	pinch	0	10.67	short	short	short	short
299-E27-122	575063.30	136540.50	201.7	pinch	0	10.06	short	short	short	short
299-E27-60	575171.21	136512.48	198.115	0	11.43	21.95	short	short	short	short
299-E27-59	575161.23	136490.94	198.505	0	11.58	20.12	short	short	short	short
299-E27-58	575148.09	136503.90	198.395	0	11.58	18.59	short	short	short	short
299-E27-61	575157.78	136516.99	198.263	0	11.58	20.42	short	short	short	short
299-E27-74	575209.79	136559.49	197.698	0	13.11	25.3	short	short	short	short

Table 3-5. Top of Units Identified in Selected Boreholes by the Nez Perce Tribe. (6 sheets)

Borehole	Easting (m)	Northing (m)	Reference Elevation (m)	Backfill[1] (m)	H1[2] (m)	H2 Sand[2] (m)	H2 Coarse Gravelly Sand[2] (m)	H2 Silt[2] (m)	H3[2] (m)	Top of Basalt[3] (m)
299-E27-75	575218.10	136547.36	197.602	0	13.11	unknown	short	short	short	short
299-E27-76	575210.56	136534.82	197.825	0	12.8	25.6	short	short	short	short
299-E27-77	575195.21	136536.27	197.903	0	12.19	23.16	short	short	short	short
299-E27-78	575190.40	136547.28	197.903	0	12.5	22.86	short	short	short	short
299-E27-115	575145.64	136537.42	198.28	0	11.58	short	short	short	short	short
299-E27-67	575149.32	136536.74	198.234	0	11.89	19.51	short	short	short	short
299-E27-116	575149.65	136533.88	198.219	0	11.43	short	short	short	short	short
299-E27-79	575153.52	136525.59	198.201	0	11.43	18.9	short	short	short	short
299-E27-80	575146.15	136512.57	198.345	0	11.58	17.98	short	short	short	short
299-E27-66	575127.66	136516.09	198.949	0	11.89	16.15	short	short	short	short
299-E27-65	575137.30	136539.29	198.386	0	11.89	17.98	short	short	short	short
299-E27-70	575172.44	136557.04	197.972	0	11.58	22.25	short	short	short	short
299-E27-81	575174.95	136547.15	198.024	0	11.58	22.56	short	short	short	short
299-E27-69	575171.00	136536.01	198.037	0	11.89	22.25	short	short	short	short
299-E27-82	575161.04	136532.57	198.081	0	11.58	20.42	short	short	short	short
299-E27-119	575153.36	136532.82	198.272	0	11.89	short	short	short	short	short
299-E27-117	575149.14	136540.21	198.176	0	11.58	short	short	short	short	short
299-E27-83	575146.59	136547.07	198.203	0	11.58	19.81	short	short	short	short
299-E27-68	575149.34	136557.05	198.088	0	12.19	21.95	short	short	short	short
299-E27-72	575192.54	136579.60	197.644	0	12.19	23.77	short	short	short	short
299-E27-84	575197.02	136569.11	197.649	0	12.19	24.38	short	short	short	short

Table 3-5. Top of Units Identified in Selected Boreholes by the Nez Perce Tribe. (6 sheets)

Borehole	Easting (m)	Northing (m)	Reference Elevation (m)	Backfill[1] (m)	H1[2] (m)	H2 Sand[2] (m)	H2 Coarse Gravelly Sand[2] (m)	H2 Silt[2] (m)	H3[2] (m)	Top of Basalt[3] (m)
299-E27-73	575191.29	136558.32	197.894	0	13.11	24.38	short	short	short	short
299-E27-85	575168.81	136568.82	197.979	0	11.89	22.56	short	short	short	short
299-E27-71	575172.08	136578.29	197.808	0	12.5	22.56	short	short	short	short
299-E27-86	575181.88	136582.49	197.548	0	12.8	23.16	short	short	short	short
299-E27-87	575124.36	136562.33	198.17	0	11.58	18.29	short	short	short	short
299-E27-88	575133.11	136553.97	198.153	0	12.19	18.29	short	short	short	short
299-E27-89	575124.53	136535.64	198.78	0	12.19	15.85	short	short	short	short
299-E27-90	575112.77	136533.58	198.728	0	11.58	14.33	short	short	short	short
299-E27-91	575104.87	136541.30	198.59	0	11.58	13.72	short	short	short	short
299-E27-92	575103.90	136552.56	198.351	0	11.58	13.72	short	short	short	short
299-E27-93	575111.81	136558.37	198.264	0	11.58	15.24	short	short	short	short
299-E27-94	575150.01	136578.83	197.951	0	11.58	22.86	short	short	short	short
299-E27-51	575155.58	136568.87	197.954	0	11.58	short	short	short	short	short
299-E27-95	575139.66	136582.99	197.983	0	11.58	21.95	short	short	short	short
299-E27-96	575165.41	136604.20	197.663	0	13.72	22.86	short	short	short	short
299-E27-97	575174.07	136596.52	197.763	0	12.8	22.86	short	short	short	short
299-E27-98	575161.12	136576.18	197.958	0	11.58	21.95	short	short	short	short
299-E27-135	575156.15	136578.34	198.458	0	12.5	22.25	short	short	short	short
299-E27-99	575145.59	136596.86	197.845	0	12.8	22.86	short	short	short	short
299-E27-100	575154.40	136603.30	197.708	0	12.5	24.38	short	short	short	short
299-E27-101	575099.89	136583.02	198.208	0	11.58	15.24	short	short	short	short

Table 3-5. Top of Units Identified in Selected Boreholes by the Nez Perce Tribe. (6 sheets)

Borehole	Easting (m)	Northing (m)	Reference Elevation (m)	Backfill[1] (m)	H1[2] (m)	H2 Sand[2] (m)	H2 Coarse Gravelly Sand[2] (m)	H2 Silt[2] (m)	H3[2] (m)	Top of Basalt[3] (m)
299-E27-102	575110.27	136572.60	198.178	0	11.43	17.07	short	short	short	short
299-E27-103	575082.74	136566.89	199.312	0	11.58	13.11	short	short	short	short
299-E27-104	575087.04	136579.65	198.553	0	11.43	13.11	short	short	short	short
299-E27-63	575126.35	136600.47	197.951	0	11.58	21.03	short	short	short	short
299-E27-105	575127.30	136578.53	198.154	0	11.89	20.42	short	short	short	short
299-E27-64	575117.88	136576.36	198.167	0	12.65	18.9	short	short	short	short
299-E27-62	575104.05	136590.06	198.147	0	11.58	15.54	short	short	short	short
299-E27-106	575110.04	136602.67	198.081	0	11.58	18.29	short	short	short	short
299-E27-107	575144.63	136625.96	197.65	0	13.11	24.08	short	short	short	short
299-E27-108	575153.50	136616.43	197.589	0	13.11	24.08	short	short	short	short
299-E27-109	575124.87	136612.06	197.949	0	12.19	20.73	short	short	short	short
299-E27-125	575142.34	136624.71	197.704	0	12.8	23.77	short	short	short	short
C4297	575151.20	136534.60	198.229	0	11.89	19.51	48.77	short	short	short
299-E27-7	575220.59	136619.40	194.536	unknown	unknown	unknown	unknown	unknown	unknown	85.5
299-E27-155	575030.00	136450.00	206	pinch	0.3	19.81	54.25	70.1	70.41	102.41
C4401	575030.50	136546.60	202.75	pinch	0	14.33	short	short	short	short
C4403	575021.90	136544.40	203.05	pinch	0	14.33	short	short	short	short
C4405	575015.50	136537.90	203.26	pinch	0	short	short	short	short	short
C4407	575023.00	136530.40	203.23	pinch	0	14.02	short	short	short	short
C4409	575027.30	136528.20	203.04	pinch	0	short	short	short	short	short
C4411	575032.70	136520.60	203.2	pinch	0	14.02	short	short	short	short

Table 3-5. Top of Units Identified in Selected Boreholes by the Nez Perce Tribe. (6 sheets)

Borehole	Easting (m)	Northing (m)	Reference Elevation (m)	Backfill[1] (m)	H1[2] (m)	H2 Sand[2] (m)	H2 Coarse Gravelly Sand[2] (m)	H2 Silt[2] (m)	H3[2] (m)	Top of Basalt[3] (m)
C4413	575036.30	136520.00	203.17	pinch	0	short	short	short	short	short
C4415	575042.40	136521.70	203.06	pinch	0	15.85	short	short	short	short
C4417	575044.60	136521.70	203.04	pinch	0	15.85	short	short	short	short
C4419	575050.00	136527.10	202.64	pinch	0	14.33	short	short	short	short
C4421	575052.10	136527.00	202.59	pinch	0	14.63	short	short	short	short
C4425	575058.60	136529.20	202.49	pinch	0	short	short	short	short	short
C4427	575061.90	136541.10	201.61	pinch	0	short	short	short	short	short
C4429	575060.80	136533.60	202.03	pinch	0	14.33	short	short	short	short
C4431	575068.80	136537.20	201.71	pinch	0	11.58	short	short	short	short
C4433	575055.40	136539.00	201.89	pinch	0	short	short	short	short	short
C4435	575053.10	136543.20	201.74	pinch	0	short	short	short	short	short
C4437	575048.70	136549.60	201.86	pinch	0	12.8	short	short	short	short
C4439	575046.60	136551.70	201.96	pinch	0	short	short	short	short	short
C4447	575055.20	136547.50	201.54	pinch	0	short	short	short	short	short
C5943	575044.10	136476.60	205.4	pinch	0	14.94	short	short	short	short
C5947	575058.10	136479.00	205	pinch	0	16.15	56.08	short	short	short
C5951	575060.10	136473.40	205.13	pinch	0	16.15	short	short	short	short
C5953	575046.90	136466.80	205.6	pinch	0	18.9	short	short	short	short
C5955	575054.40	136468.30	205.42	pinch	0	15.24	short	short	short	short
C5957	575058.40	136463.50	205.66	pinch	0	14.94	short	short	short	short
C5959	575048.90	136457.80	205.85	pinch	0	17.68	short	short	short	short

Table 3-5. Top of Units Identified in Selected Boreholes by the Nez Perce Tribe. (6 sheets)

Borehole	Easting (m)	Northing (m)	Reference Elevation (m)	Backfill[1] (m)	H1[2] (m)	H2 Sand[2] (m)	H2 Coarse Gravelly Sand[2] (m)	H2 Silt[2] (m)	H3[2] (m)	Top of Basalt[3] (m)
C5961	575047.80	136448.90	206.75	pinch	0	17.68	short	short	short	short
C5963	575062.90	136454.40	205.65	pinch	0	16.46	short	short	short	short
C6391	575115.20	136474.30	203.51	pinch	0	16.15	short	short	short	short
C6393	575119.70	136465.80	203.72	pinch	0	15.85	53.04	short	short	short
C6395	575110.60	136469.70	203.65	pinch	0	14.63	short	short	short	short
C6397	575125.40	136482.40	203.07	pinch	0	17.37	short	short	short	short
C6399	575130.10	136478.00	203.03	pinch	0	17.98	54.86	short	short	short
C6403	575116.00	136473.70	203.3	pinch	0	unknown	short	short	short	short
C6405	575117.70	136487.80	203.11	pinch	0	16.76	54.56	short	short	short
C7465	575211.40	136559.00	197.67	0	13.72	24.99	50.29	short	short	short
C7467	575222.60	136563.00	197.49	0	13.72	23.47	48.77	short	short	short
C7669	575188.70	136548.00	197.795	0	12.19	23.77	50.29	short	short	short
C7667	575110.70	136632.30	198.101	0	4.57	19.2	47.85	short	short	short
C7471	575240.60	136588.70	194.983	pinch	1.83	23.47	48.77	short	short	short
C7469	575153.20	136537.60	198.198	0	unknown	short	short	short	short	short

Waste Management Area C Geology
Unit tops are depths in meters below ground surface

[1] "pinch" in the Backfill column indicates a small amount of backfill was present.

[2] "short" in any formation column means the total depth of the borehole ended before reaching this unit.

[3] Top of Basalt was projected at two of the locations (E27-7 and E27-21). These projections enabled the generation of a basalt surface using Environmental Visualization System.

It should be noted that previous interpretations of the geologic strata within WMA C did not break out the H2 sands into three separate facies. However, both the Energy*Solutions* and the Nez Perce interpretations identified evidence that supported the delineation of the three facies within the H2 sands that will be carried forward into the geologic model. Also, the unconfined aquifer is wholly contained within the undifferentiated H3/Cold Creek/Ringold unit in the vicinity of WMA C. The June 2013 water measurements at the groundwater wells were used to create the water table surface and provided a basis for dividing the undifferentiated H3/Cold Creek/Ringold unit into two separate layers; one associated with the vadose zone and one associated with the unconfined aquifer. Furthermore, the Nez Perce description of the H2 unit (see e-mail from S. Sobczyk to M. P. Bergeron, "WMA C geology" [Sobczyk, S., 2014-03-10]) includes the following:

> *In addition to the three layers in the Hanford H2, … there are numerous, discontinuous, low permeability laminations/lenses in the particularly in the upper portion of the H2 unit. These "lenses" parallel the overall dip of the H2, which is ~3% dip to the northeast.*

3.3 REFERENCE POINT ELEVATIONS

It should also be noted that a review of the data used in the Nez Perce and WRPS interpretations identified differences in the reference datum for a few selected boreholes and wells. The reference datum becomes important when locating a surface in three-dimensional (3-D) space. The geologic picks are made from geologic and geophysical logs that are measured as depth below ground surface. Care must be used when extracting the elevation from the Hanford Site Well Information Data Lookup (WIDL) because the reference elevation in WIDL is usually top of casing. For groundwater wells the top of casing often extends above ground surface; frequently two to four feet above ground surface. Another measurement in WIDL is Disc_Z which is the elevation at ground surface at the location of the well. For the groundwater wells, the hierarchy for choosing the elevation reference point is given below:

1) Use Disc_Z elevation, if available in WIDL

2) If Disc_Z elevation is not available, use the value in the Hanford Site GeoContacts Database

3) If neither value is available, use the interpolated value from the LIDAR flyover which reports the ground surface elevation.

For the dry wells within WMA C, the top of casing is either at ground surface or a few inches above ground surface. A Disc_Z elevation was only reported for 12 of the 71 dry wells and the difference between top of casing and the Disc_Z was less than a couple of inches for those dry wells. Therefore, the top of the casing was used as the reference point for ground surface. For the direct push, a Global Positioning System was used to locate the elevation at ground surface and that elevation is reported in the borehole completion reports for the direct push.

Table 3-6 lists the ground surface elevations at each well site. Also included in the table is the ground surface elevation interpolated from the LIDAR data at the well location. The ground surface elevation at the reference point for all wells used in the alternative geologic models is in excellent agreement with the LIDAR data, with only four locations showing a difference of more than one foot (shown in bold in Table 3-6). When there is a discrepancy between the reference point elevation and the LIDAR, it appears to be related to sharp increase/decrease in topographic gradient. The ground surface reference point elevations were used to calculate the locations of the different top of geologic layers, because these elevations were confirmed against the LIDAR data. The elevations in Table 3-1, Table 3-3 and Table 3-5 were not used as the reference point elevations. The elevation for the top of the units was calculated by subtracting the depth below ground surface given in Tables 3-1, 3-3, and 3-5 from the reference point elevations given in Table 3-6. For the slant boreholes, the elevation and State Plane Coordinates for the top of an identified unit were calculated by the azimuth, the dip, and distance down the pipe run from a reference point elevation and State Plane Coordinates given in Table 3-2.

Table 3-6. Reference Point Elevations for the Alternative Geologic Models. (5 sheets)

TFName	Well Name	Reference Point	Reference Point Elevation (m)	LIDAR Elevation at Reference Point (m)	Difference (m)	Difference (ft)
299-E27-4	299-E27-4	Disc_Z	204.685	204.644	0.041	0.13
299-E27-7	299-E27-7	LIDAR	194.495	194.495	0.000	0.00
299-E27-12	299-E27-12	Disc_Z	201.542	201.486	0.056	0.18
299-E27-13	299-E27-13	Disc_Z	204.088	204.215	-0.127	-0.42
299-E27-14	299-E27-14	Disc_Z	200.839	200.861	-0.022	-0.07
299-E27-15	299-E27-15	Disc_Z	199.160	199.083	0.077	0.25
299-E27-20	299-E27-20	Disc_Z	205.447	205.476	-0.029	-0.09
299-E27-21	299-E27-21	Disc_Z	204.993	204.860	0.133	0.44
299-E27-22	299-E27-22	Disc_Z	192.600	192.530	0.070	0.23
299-E27-23	299-E27-23	Disc_Z	205.659	205.618	0.041	0.13
299-E27-24	299-E27-24	Disc_Z	202.841	202.660	0.181	0.59
299-E27-155	299-E27-155	Disc_Z	207.680	207.580	0.100	0.33
30-00-01	299-E27-56	TOC	197.654	197.647	0.007	0.02
30-00-03	**299-E27-54**	**TOC**	**199.848**	**199.086**	**0.762**	**2.50**
30-00-06	299-E27-55	TOC	200.433	200.240	0.193	0.63
30-00-09	299-E27-57	TOC	200.659	200.573	0.086	0.28
30-00-10	299-E27-53	TOC	198.753	198.682	0.071	0.23
30-00-11	299-E27-121	TOC	203.240	203.204	0.036	0.12
30-00-12	299-E27-52	TOC	197.712	197.721	-0.009	-0.03

Table 3-6. Reference Point Elevations for the Alternative Geologic Models. (5 sheets)

TFName	Well Name	Reference Point	Reference Point Elevation (m)	LIDAR Elevation at Reference Point (m)	Difference (m)	Difference (ft)
30-00-13	299-E27-124	TOC	198.319	198.350	-0.031	-0.10
30-00-22	299-E27-120	TOC	203.278	203.276	0.002	0.01
30-00-24	299-E27-122	TOC	201.604	201.592	0.011	0.04
30-01-01	299-E27-60	TOC	198.115	198.101	0.014	0.05
30-01-06	299-E27-59	TOC	198.505	198.493	0.012	0.04
30-01-09	299-E27-58	TOC	198.395	198.409	-0.014	-0.05
30-01-12	299-E27-61	TOC	198.263	198.222	0.041	0.14
30-03-01	299-E27-74	TOC	197.698	197.723	-0.025	-0.08
30-03-03	299-E27-75	TOC	197.602	197.678	-0.076	-0.25
30-03-05	299-E27-76	TOC	197.825	197.814	0.011	0.04
30-03-07	299-E27-77	TOC	197.903	197.899	0.004	0.01
30-03-09	299-E27-78	TOC	197.903	197.840	0.063	0.21
30-04-01	299-E27-115	TOC	198.280	198.287	-0.007	-0.02
30-04-02	299-E27-67	TOC	198.234	198.199	0.035	0.11
30-04-03	299-E27-116	TOC	198.219	198.203	0.016	0.05
30-04-04	299-E27-79	TOC	198.201	198.177	0.024	0.08
30-04-05	299-E27-80	TOC	198.345	198.337	0.008	0.03
30-04-08	299-E27-66	TOC	198.949	199.042	-0.093	-0.30
30-04-12	299-E27-65	TOC	198.386	198.432	-0.046	-0.15
30-05-02	299-E27-70	TOC	197.972	197.977	-0.005	-0.02
30-05-03	299-E27-81	TOC	198.024	198.016	0.008	0.03
30-05-04	299-E27-69	TOC	198.037	198.069	-0.032	-0.11
30-05-05	299-E27-82	TOC	198.081	198.119	-0.038	-0.12
30-05-06	299-E27-119	TOC	198.272	198.217	0.055	0.18
30-05-07	299-E27-118	TOC	198.191	198.184	0.007	0.02
30-05-08	299-E27-117	TOC	198.176	198.151	0.025	0.08
30-05-09	299-E27-83	TOC	198.203	198.173	0.030	0.10
30-05-10	299-E27-68	TOC	198.088	198.099	-0.011	-0.03
30-06-02	299-E27-72	TOC	197.644	197.701	-0.057	-0.19
30-06-03	299-E27-84	TOC	197.649	197.712	-0.063	-0.21
30-06-04	299-E27-73	TOC	197.894	197.920	-0.026	-0.08

Table 3-6. Reference Point Elevations for the Alternative Geologic Models. (5 sheets)

TFName	Well Name	Reference Point	Reference Point Elevation (m)	LIDAR Elevation at Reference Point (m)	Difference (m)	Difference (ft)
30-06-09	299-E27-85	TOC	197.979	197.998	-0.019	-0.06
30-06-10	299-E27-71	TOC	197.808	197.837	-0.029	-0.10
30-06-12	299-E27-86	TOC	197.581	197.668	-0.087	-0.29
30-07-01	299-E27-87	TOC	198.170	198.160	0.010	0.03
30-07-02	299-E27-88	TOC	198.153	198.147	0.006	0.02
30-07-05	299-E27-89	TOC	198.780	198.762	0.018	0.06
30-07-07	299-E27-90	TOC	198.728	198.793	-0.065	-0.21
30-07-08	299-E27-91	TOC	198.590	198.563	0.027	0.09
30-07-10	299-E27-92	TOC	198.351	198.474	-0.123	-0.40
30-07-11	299-E27-93	TOC	198.264	198.229	0.035	0.12
30-08-02	299-E27-94	TOC	197.951	197.914	0.037	0.12
30-08-03	299-E27-51	TOC	197.954	197.951	0.003	0.01
30-08-12	299-E27-95	TOC	197.983	198.000	-0.017	-0.06
30-09-01	299-E27-96	TOC	197.663	197.548	0.115	0.38
30-09-02	299-E27-97	TOC	197.763	197.744	0.019	0.06
30-09-06	299-E27-98	TOC	197.958	198.036	-0.078	-0.26
30-09-07	**299-E27-135**	**TOC**	**198.458**	**198.156**	**0.302**	**0.99**
30-09-10	299-E27-99	TOC	197.845	197.864	-0.019	-0.06
30-09-11	299-E27-100	TOC	197.708	197.721	-0.012	-0.04
30-10-01	299-E27-101	TOC	198.208	198.202	0.006	0.02
30-10-02	299-E27-102	TOC	198.178	198.153	0.025	0.08
30-10-09	299-E27-103	TOC	199.312	199.333	-0.021	-0.07
30-10-11	299-E27-104	TOC	198.553	198.632	-0.079	-0.26
30-11-01	299-E27-63	TOC	197.951	197.945	0.006	0.02
30-11-05	299-E27-105	TOC	198.154	198.173	-0.019	-0.06
30-11-06	299-E27-64	TOC	198.167	198.085	0.082	0.27
30-11-09	299-E27-62	TOC	198.147	198.121	0.026	0.09
30-11-11	299-E27-106	TOC	198.081	198.118	-0.037	-0.12
30-12-01	299-E27-107	TOC	197.650	197.633	0.017	0.05
30-12-03	299-E27-108	TOC	197.589	197.561	0.028	0.09
30-12-09	299-E27-109	TOC	197.949	197.901	0.048	0.16

Table 3-6. Reference Point Elevations for the Alternative Geologic Models. (5 sheets)

TFName	Well Name	Reference Point	Reference Point Elevation (m)	LIDAR Elevation at Reference Point (m)	Difference (m)	Difference (ft)
30-12-13	299-E27-125	TOC	197.704	197.685	0.019	0.06
C4297	C4297	LIDAR	198.156	198.156	0.000	0.00
C4401	C4401	Ground Surface	202.758	202.746	0.012	0.04
C4403	C4403	Ground Surface	203.049	203.068	-0.019	-0.06
C4405	C4405	Ground Surface	203.258	203.358	-0.100	-0.33
C4407	C4407	Ground Surface	203.229	203.189	0.040	0.13
C4409	C4409	Ground Surface	203.037	203.064	-0.027	-0.09
C4411	C4411	Ground Surface	203.195	203.189	0.006	0.02
C4413	C4413	Ground Surface	203.165	203.201	-0.036	-0.12
C4415	C4415	Ground Surface	203.059	203.046	0.013	0.04
C4417	C4417	Ground Surface	203.035	203.067	-0.032	-0.10
C4419	C4419	Ground Surface	202.635	202.677	-0.042	-0.14
C4421	C4421	Ground Surface	202.586	202.601	-0.015	-0.05
C4425	C4425	Ground Surface	202.486	202.383	0.103	0.34
C4427	C4427	Ground Surface	201.608	201.599	0.009	0.03
C4429	C4429	Ground Surface	202.025	202.045	-0.019	-0.06
C4431	C4431	Ground Surface	201.709	201.689	0.020	0.07
C4433	C4433	Ground Surface	201.890	201.908	-0.018	-0.06
C4435	C4435	Ground Surface	201.738	201.790	-0.052	-0.17
C4437	C4437	Ground Surface	201.860	201.892	-0.032	-0.10
C4439	C4439	Ground Surface	201.960	201.965	-0.005	-0.02
C4447	C4447	Ground Surface	201.542	201.569	-0.027	-0.09
C5943	C5943	Ground Surface	205.404	205.315	0.089	0.29
C5947	C5947	Ground Surface	204.996	204.944	0.052	0.17
C5951	C5951	Ground Surface	205.126	205.120	0.006	0.02
C5953	C5953	Ground Surface	205.600	205.658	-0.058	-0.19
C5955	C5955	Ground Surface	205.421	205.429	-0.008	-0.03
C5957	C5957	Ground Surface	205.659	205.472	0.187	0.61
C5959	C5959	Ground Surface	205.848	205.833	0.015	0.05
C5961	C5961	Ground Surface	206.745	206.754	-0.009	-0.03
C5963	C5963	Ground Surface	205.652	205.643	0.009	0.03

Table 3-6. Reference Point Elevations for the Alternative Geologic Models. (5 sheets)

TFName	Well Name	Reference Point	Reference Point Elevation (m)	LIDAR Elevation at Reference Point (m)	Difference (m)	Difference (ft)
C6391	C6391	Ground Surface	203.510	203.534	-0.024	-0.08
C6393	C6393	Ground Surface	203.722	203.711	0.011	0.04
C6395	C6395	Ground Surface	203.653	203.628	0.025	0.08
C6397	C6397	Ground Surface	203.072	203.126	-0.054	-0.18
C6399	C6399	Ground Surface	203.028	203.073	-0.045	-0.15
C6403	C6403	Ground Surface	203.302	203.511	-0.209	-0.69
C6405	C6405	Ground Surface	203.113	203.123	-0.010	-0.03
C7465	C7465	Ground Surface	197.669	197.759	-0.090	-0.29
C7467	C7467	Ground Surface	197.492	197.613	-0.121	-0.40
C7469	C7469	Ground Surface	198.198	198.157	0.041	0.14
C7471	C7471	Ground Surface	195.023	195.037	-0.014	-0.05
C7667	C7667	Ground Surface	198.145	198.149	-0.004	-0.01
C7669	C7669	Ground Surface	197.795	197.825	-0.030	-0.10
299-E24-3	299-E24-3	TOPs DB	213.460	213.502	-0.042	-0.14
299-E24-4	299-E24-4	TOPs DB	213.030	213.102	-0.072	-0.24
299-E24-20	299-E24-20	TOPs DB	210.110	209.930	0.180	0.59
299-E24-22	299-E24-22	TOPs DB	209.550	209.469	0.081	0.27
299-E24-33	299-E24-33	TOPs DB	206.030	206.024	0.006	0.02
299-E26-6	**299-E26-6**	**TOPs DB**	**199.040**	**199.506**	**-0.466**	**-1.53**
299-E26-8	299-E26-8	TOPs DB	189.210	189.224	-0.014	-0.05
299-E27-2	**299-E27-2**	**TOPs DB**	**203.390**	**204.062**	**-0.672**	**-2.21**
299-E27-3	299-E27-3	TOPs DB	208.900	208.882	0.018	0.06
299-E27-25	299-E27-25	TOPS DB	186.800	186.604	0.196	0.64

LIDAR = Laser Imaging, Detection and Ranging
TOC = Top of Casing
TOPs DB = Hanford Site GeoContacts Database, maintained and updated via the CH2M HILL Plateau Remediation Company Environmental Program and Strategic Planning – Risk and Data Integration Task. Contact for authorized access is provided by William Webber at William_D_Webber@rl.gov.

4.0 ACCESS® DATABASE FOR TOP OF UNITS IN THE REGION OF WASTE MANAGEMENT AREA C

The previous section described and summarized the raw data used to delineate the top of each geologic unit in the region within and around WMA C. The data in Tables 3-1 through 3-5 are provided in the same format and units as the original reports. The data in those tables were imported directly into an Access® database and manually reformatted to create several tables which could then be easily queried to create output that can be read by various plotting programs to create geologic models of the region surrounding WMA C. The reformat step also included the standardization of units. This chapter describes that Access® database and the queries used to output the data into a Tecplot® input file.

4.1 ACCESS® DATA TABLES

Tables 3-1 through 3-6 were imported directly into the Access® database named WMAC_GeoMod.accdb. These tables in Access® are named rawData_tbl-3-1 through rawData_tbl_3-6 and correspond to Tables 3-1 through 3-6 in the previous chapter. In these tables, a number of table fields contained both numeric data and character data. In Access®, it is not possible to have numeric data mixed with character data. Therefore, for those fields the data was imported as character data with the numbers being converted to character data. This was done to ensure no data was lost during the importation process. Since these tables are given in the previous chapter, they will not be discussed in this section. They were imported in order to easily trace back any specific part of the datasets to its source.

However, the data in those tables were manually formatted to create the following tables.

1) ***tblGeoTopsSorted*** contains the top of the units for the vertical dry wells, groundwater wells, and direct pushes, along with the top of the unconfined aquifer from the groundwater wells. The data in this table is reformatted from Tables 3-1, 3-3, 3-4 and 3-5 in order to allow Access® database queries. All depth units from the original tables have been converted to feet in this table.

2) ***tblSlantGeoTops*** contains the top of the units for the slant direct pushes. None of these direct pushes reached the water table; the data in this table came from Table 3-2.

In addition to these two tables, three tables were built in Excel®[4] and then imported directly into the Access® database. These tables are as follows.

1) ***tblUnits*** provides a geologic unit identifier number, geologic unit name, and a description.

2) ***tblWMAC_wells*** contains location information and well type for the groundwater wells, dry wells, and direct pushes used in the alternative geologic models.

[4] Excel® is a registered trademark of Microsoft Corporation in the U.S. and other countries.

3) ***tblTecplot*** is an output table designed to easily import the geologic tops information into Tecplot®.

The newly created tables allow the user to quickly query for the tops of the units and to include additional location information in order to plot the data in 3-D space. Tables 4-1 through Table 4-5 provide the fields plus a short description of those fields in each of the newly created tables.

Table 4-1. Data Fields for Access® Table *tblGeoTopsSorted*.

Database Field	Data Type	Size	Description
SortOrder	Number	Long Integer	Sort order based on the Well Type and Well Number; nearby Groundwater Wells come first in Well Number order, followed by Dry Wells/TFName, followed by Direct Push/Well_ID, followed by Groundwater Wells/Well Name outside the vicinity of Waste Management Area C.
TFName	Text	Char(25)	Tank farm name (e.g., 30-05-07: 30 = tank farm C, 05 = tank C-105, 07 = 7 o'clock position around tank); if no TFName, uses Well Name, if no Well Name uses Well_ID.
Top	Number	Double	Depth below reference elevation (usually ground surface) at which the top of the unit is located.
Bottom	Number	Double	Depth below reference elevation (usually ground surface) at which the bottom of the unit is located or the total depth drilled.
Unit_ID	Number	Double	Number assigned to a particular unit. It starts at 1 for basalt and continues upward to land surface which is 9. If the total depth drilled lands within a unit, this is indicated when Unit_ID = Unit_ID- 0.5.
UnitName	Text	Char(20)	Name of the unit; if the name ends with "_TD" it means the total depth drilled lands within that unit.
Description	Text	Char(255)	Additional notes about that particular record for top of unit.
Source	Text	Char(255)	Source of information for particular data point.
Comments	Text	Char(255)	Any additional comments either for the well or for record.
DepthUnits	Text	Char(10)	Measuring units in this particular table are feet.
WELL_NAME	Text	Char(25)	Actual Hanford Well Name, or Well_ID if it does not have a Well Name (i.e., direct pushes do not have Well Names).
WellDepthID	Number	Long Integer	Sorting number to ensure the top of units for each individual well/direct push are sorted from ground surface.

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Table 4-2. Data Fields for Access® Table *tblSlantGeoTops*.

Database Field	Data Type	Size	Description
SortIndex	Number	Integer	Sorting number to ensure the top of units for a particular well/direct push are sorted from ground surface to depth.
SortOrder	Number	Long Integer	SortOrder is based on the Well_ID
WELL_NAME	Text	Char(25)	Actual Hanford Well Name, or Well_ID if it does not have a Well Name (i.e., direct pushes do not have Well Names).
TFName	Text	Char(25)	Tank farm name (e.g., 30-05-07: 30 = tank farm C, 05 = tank C-105, 07 = 7 o'clock position around tank); if no TFName, uses Well Name, if no Well Name uses Well_ID.
Easting	Number	Double	State Plane Coordinates in meters for location of top of unit.
Northing	Number	Double	State Plane Coordinates in meters for location of top of unit.
Elevation	Number	Double	NAVD88 for elevation of top of unit in meters.
Unit_ID	Number	Double	Number assigned to a particular unit. It starts at 1 for basalt and continues upward to land surface which is 9. If the total depth drilled lands within a unit, this is indicated when Unit_ID = Unit_ID - 0.5.
UnitName	Text	Char(20)	Name of the unit; if the name ends with "_TD" it means the total depth drilled lands within that unit.
Azimuth	Number	Double	Azimuth in degrees to reach location of the top of the unit from the starting direct push location. Zero or 360 is due north (in degrees).
Dip	Number	Double	Dip to reach location from the starting direct push location. Dip is measured from the vertical in degrees since boreholes are vertical; use 90 - dip to get the dip from land surface.
Pipe Run	Number	Double	Pipe run in meters from surface location directly to the XYZ point. It is the hypotenuse of the triangle formed from the starting point to the XYZ point in this record.
Source	Text	Char(255)	Report which contains the geophysical and geologic logs.

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Table 4-3. Data Fields for Access® Table *tblGeoUnits*.

Database Field	Data Type	Size	Description
Unit_ID	Number	Double	Number assigned to a particular unit. It starts at 1 for basalt and continues upward to land surface which is 9. If the total depth drilled lands within a unit, this is indicated when Unit_ID = Unit_ID - 0.5.
UnitName	Text	Char(20)	Name of the unit; if the name ends with "_TD" it means the total depth drilled lands within that unit.
Description	Text	Char(255)	Describes the unit.

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Table 4-4. Data Fields for Access® Table *tblWMAC_wells*.

Database Field	Data Type	Size	Description
SortOrder	Number	Long Integer	Sort order based on the Well Type and Well Number; nearby Groundwater Wells first in Well Number order, followed by Dry Wells/TFName, followed by Direct Push/Well_ID, followed by Groundwater Wells/Well Name outside the vicinity of Waste Management Area C.
SortWellName	Text	Char(25)	Sort based on WELL_NAME; all 299-E wells ending numbers are now 3 digits (e.g., well 299-E27-7 becomes 299-E27-007, and 299-E27-14 becomes 299-E27-014).
WELL_ID	Text	Char(10)	Hanford Well_ID is usually a single character followed by four digits.
WELL_NAME	Text	Char(25)	Actual Hanford Well Name, or Well_ID if it does not have a Well Name (i.e., direct pushes do not have Well Names).
TFName	Text	Char(25)	Tank farm name (e.g., 30-05-07: 30 = tank farm C, 05 = tank C-105, 07 = 7 o'clock position around tank); if no TFName, uses Well Name, if no Well Name uses Well_ID.
WasteSite_Location	Text	Char(30)	Closest waste site; e.g., C-105 or UPR-82.
WorkPlanName	Text	Char(30)	Name used in the work plan; A, B, C, etc.
WELL_TYPE	Text	Char(30)	Well Type→ Groundwater Well, Vadose Well, Deep Characterization, Boring.
SAMP SITE_ID	Text	Char(10)	Same as WELL_ID.
EASTING	Number	Double	State Plane Easting (m).
NORTHING	Number	Double	State Plane Northing (m).
ELEVATION	Number	Double	NAVD88 Elevation (m).
Well Depth	Number	Double	Total Depth of the Well in meters.
CompletionReport	Text	Char(50)	Not all direct pushes are in Well Information and Document Lookup; if not, a completion report that publishes the Easting, Northing and Elevation is given in this field.
AngleDirectPush	Yes/No	Boolean	Yes if angle Direct Push, No if vertical Direct Push.
WellUse	Text	Char(20)	Well use monitoring, characterization, logging, etc.

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Table 4-5. Data Fields for Access® Table *tblTecplot*.

Database Field	Data Type	Size	Description
KeepSort	AutoNumber	Long Integer	Autonumber field which is used to ensure the sort on appending data to this table is correct.
SortOrder	Number	Long Integer	Sort order based on the Well Type and Well Number, nearby Groundwater Wells come first in Well Number order, followed by Dry Wells/TFName, followed by Direct Push/Well_ID, followed by Groundwater Wells/Well Name outside the vicinity of Waste Management Area C.
UnitName	Text	Char(20)	Name of the unit; if the name ends with "_TD" it means the total depth drilled lands within that unit.
Source	Text	Char(255)	Source for the geologic information found in this table.
WorkPlanName	Text	Char(30)	Name used in the work plan; A, B, C, etc.
WELL_NAME	Text	Char(25)	Actual Hanford Well Name or Well_ID if it does not have a Well Name (i.e., direct pushes do not have well names).
TFName	Text	Char(25)	Tank farm name (e.g., 30-05-07: 30 = tank farm C, 05 = tank C-105, 07 = 7 o'clock position around tank); if no TFName, uses Well Name, if no Well Name uses Well_ID.
Blank	Text	Char(1)	Blank Column used in Excel® to create the final Tecplot® data file.
EASTING	Number	Double	State Plane Easting (m).
NORTHING	Number	Double	State Plane Northing (m).
Elevation	Number	Double	NAVD88 Elevation (m).
Unit_ID	Number	Single	Number assigned to a particular unit. It starts at 1 for basalt and continues upward to land surface which is 9. If the total depth drilled lands within a unit, this is indicated when Unit_ID = Unit_ID - 0.5.

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Excel® is a registered trademark of Microsoft Corporation in the U.S. and other countries.
Tecplot® is a registered trademark of Tecplot, Inc., 3535 Factoria Blvd. SE, Bellevue, Washington.

4.2 ACCESS® DATA QUERIES

Once the top of the units information and the associated location information for each groundwater well, dry well, and direct push were reformatted into tables (4-1 through 4-5) that could be easily extracted for other programs, a set of database queries was constructed to retrieve them in a certain order and format. These queries are used to place the data into an Excel® file in which only a few modifications had to be made in order to import the data into Tecplot®. This section describes those queries.

A decision was made to build the table ***tblTecplot*** using a specified sort in order to quickly find data within Tecplot®. The following provides the sorting in the table ***tblTecplot***.

1) WRPS Geologic Model Data (These data are used in development of Alternative Geologic Model I)
    a. Groundwater Well sorted by Well Name (299-E27-4 – 299-E27-155)
        i. Sorted by Depth below Reference Point (Table 3-6)
    b. Tank Farm Dry Wells sorted by tank farm name (30-00-01 – 30-12-13)
        i. Sorted by Depth below Reference Point (Table 3-6)
    c. Deep Characterization Borehole (C4297)
        i. Sorted by Depth below Reference Point (Table 3-6)
    d. Direct Push sorted by Well ID (C4401 – C7469)
        i. Sorted by Depth below Reference Point (Table 3-6)

2) Nez Perce Geologic Model Data (These data are used in development of Alternative Geologic Model II)
    a. Groundwater Well sorted by Well Name (299-E27-4 – 299-E27-155)
        i. Sorted by Depth below Reference Point (Table 3-6)
    b. Tank Farm Dry Wells sorted by tank farm name (30-00-01 – 30-12-13)
        i. Sorted by Depth below Reference Point (Table 3-6)
    c. Deep Characterization Borehole (C4297)
        i. Sorted by Depth below Reference Point (Table 3-6)
    d. Direct Push sorted by Well ID (C4401 – C7469)
        i. Sorted by Depth below Reference Point (Table 3-6)

3) Groundwater Wells outside the vicinity of WMA C sorted by Well Name (299-E24-03)
    a. Sorted by Depth below Reference Point (Table 3-6).

The groundwater wells outside the vicinity of WMA C are used by both alternative geologic models. Table 4-6 lists the queries used to build the table ***tblTecplot*** and provides a description of these queries.

The queries in Table 4-6 should be run in the order they are listed. Query 1 deletes all records in ***tblTecplot***; queries 2 through 5 extract the data from the appropriate tables for the WRPS Model (Alternative Geologic Model I) and append this data into ***tblTecplot***. Query 6 extracts the data set for the Nez Perce Model (Alternative Geologic Model II) and appends it to ***tblTecplot***, while query 7 extracts the data for the groundwater wells outside the vicinity of WMA and appends this data into ***tblTecplot***. Once the complete data set (***tblTecplot***) has been assembled, the user can either export it to an Excel® spreadsheet or copy it to an Excel® spreadsheet where a minor modification needs to be made to create a Tecplot®-compatible data file. In addition to this table, query 8 is run to extract all the unique XY locations (in State Plane Coordinates). The purpose of extracting all unique XY locations is to include them in the triangular mesh that Tecplot® generates. The top of formations within the mesh become exact at those locations during the kriging process. Once query 8 is run, copy and paste the Easting and Northing columns into a text editor such as NotePad, NotePad++, or TextPad and add the Tecplot® header below. Once the header has been added, save the file for later use.

Table 4-6. Description of Access® Queries to Build Table *tblTecplot*.

Number	Query	Description
1	0_qryDeleteRecordsInTecplotTable	This query is used to delete all records in the table ***tblTecplot***; it keeps the field names.
2	1_qryTecplotAppend0	This query links tables ***tblGeoTopsSorted*** and ***tblWMAC_wells*** through the data field TFName and appends all records related to groundwater wells, dry wells, direct push up to direct push C4447 down (i.e., SortOrder < 124) to the ***tblTecplot*** table; the next direct push is a slant direct push which requires separate query.
3	2_qryTecplotAppend1stSlant	This query links tables ***tblSlantGeoTops*** and ***tblWMAC_wells*** through the data field TFName and appends all records related to the first set of direct pushes (i.e., C5104 to C5109 [123< SortOrder < 150]) to the ***tblTecplot*** table. The next direct push is a vertical direct push which requires separate query.
4	3_qryTecplotAppendAfterSlant	This query links tables ***tblGeoTopsSorted*** and ***tblWMAC_wells*** through the data field TFName and appends all records related to vertical direct pushes from C5942 to 7669 (i.e., 129< SortOrder < 193) to the ***tblTecplot*** table. The next direct push is a slant direct push which requires separate query.
5	4_qryTecplotAppend2ndSlant	This query links tables ***tblSlantGeoTops*** and ***tblWMAC_wells*** through the data field TFName and appends all records related to the first set of direct pushes (i.e., C8099 to C8105 [150< SortOrder < 193]) to the ***tblTecplot*** table. The next query retrieves the Nez Perce data.
6	5_qryTecplotAppendNezPerce	This query links tables ***tblGeoTopsSorted*** and ***tblWMAC_wells*** through the data field TFName and appends all records related to groundwater wells, dry wells, and direct push from the Nez Perce dataset to ***tblTecplot*** table. It does this by collecting all records in ***tblGeoTopsSorted*** that begin with "St*".
7	6_qryTecplotAppendOutside	This query links tables ***tblGeoTopsSorted*** and ***tblWMAC_wells*** through the data field TFName and appends all records related to groundwater wells outside the vicinity of WMA C to ***tblTecplot*** table. All the wells within the vicinity of WMA C are within 250 ft of the WMA C fenceline; wells outside the vicinity of WMA C are greater than 350 ft from the WMA C fenceline.
8	7_qryXYlocations	This query uses the table ***tblTecplot*** with the Access Totals Function (∑) group to get a listing of each unique XY location in State Plane Coordinates. These coordinates will be used in the mesh building operations.

WMA = waste management area

Access® is a registered trademark of Microsoft Corporation in the U.S. and other countries.

Tecplot® Header:

Variables = “Easting (m)”, “Northing (m)”
Zone T= “Top of Units XY Locations”
DT = (DOUBLE, DOUBLE)

4.3 EXCEL® SPREADSHEET TO TECPLOT®

Once the user exports or copies the ***tblTecplot*** file to Excel®, the following changes need to be made. In the first row, navigate to column “H”, replace the word ‘Blank’ with the following: ‘Variables = "Easting (m)", "Northing (m)", "Elevation (m)", "UnitID"’; include the double quotes but not the single quotes. In the next four columns (I through L), clear the column headings. Next in row 2 of column “H”, type the following formula:

```
=IF(G2<>G1,CONCATENATE("Zone T=",CHAR(34),G2,CHAR(34)),"")
```

Next, either copy the formula to all rows of column “H” or use the fill down Excel® function. This creates a Tecplot® zone header information for each groundwater well, dry well, and direct push. The next step is to copy columns “H” through “L” into a text editor and then save it with .dat suffix. For the sake of this exercise, call it WellsTecplot.dat. The data file can then be read into Tecplot® to begin making the alternative geologic models which are described in the next chapter.

The data in Access® ***tblTecplot*** is given in Table 4-7 and was used to create Alternative Conceptual Model I. Alternative Conceptual Model II was created by replacing the stratigraphic contacts in Table 4-7 by the stratigraphic contacts in Table 4-8 for the same wells. The stratigraphic contacts of Table 4-8 were provided by Dr. Stanley Sobczyk of the Environmental Restoration & Waste Management Program of the Nez Perce Tribe. Stratigraphic picks in the wells of Alternative Conceptual Model I that were not evaluated by Dr. Sobczyk remained the same for Alternative Conceptual Model II. Alternative Conceptual Model II also includes subdividing the Hanford H2 unit into three subunits, an upper sand unit, a middle coarse sand/gravely unit, and a lower silt unit.

Table 4-7. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model I (Meters above Mean Sea Level). (5 sheets)

Well Name	Data Source	Elevation	Total Drilled Depth Elevation	Backfill/ Eolian Sand	Top Hanford H1 Unit	Top Hanford H2 Unit	Top of H3/CCu/Ru	Top of Basalt
299-E27-4	FS-NW-LT-5367	204.69	110.88	—	204.69	188.68	132.45	—
299-E27-7	FS-NW-LT-5367	194.50	108.85	194.50	182.00	169.50	—	—
299-E27-12	RPP-18290	201.54	119.25	—	201.54	190.87	131.44	—
299-E27-13	RPP-18290	204.09	119.99	—	204.09	191.90	131.55	—
299-E27-14	FS-NW-LT-5367	200.84	119.52	—	200.84	173.56	128.45	—
299-E27-15	RPP-18290	199.16	119.15	199.16	196.11	180.87	129.06	—
299-E27-20	RPP-18290	205.45	120.56	—	205.45	—	132.30	—
299-E27-21	FS-NW-LT-5367	204.99	110.86	—	204.99	186.40	121.78	—
299-E27-22	FS-NW-LT-5367/ PNNL-14656 Top of Basalt	192.60	110.88	—	192.60	169.13	122.19	110.91
299-E27-23	FS-NW-LT-5367	205.66	110.88	—	205.66	196.97	131.44	—
299-E27-24	FS-NW-LT-5367	202.84	105.98	—	202.84	184.25	128.77	—
299-E27-25	SGW-48722	186.80	111.21	—	186.80	168.51	128.89	111.82
299-E27-51	FS-NW-LT-5367	197.95	152.23	197.95	186.68	—	—	—
299-E27-52	FS-NW-LT-5367	197.71	151.99	197.71	—	173.63	—	—
299-E27-53	FS-NW-LT-5367	198.75	153.03	198.75	N/D	183.21	—	—
299-E27-54	FS-NW-LT-5367	199.85	152.60	199.85	N/D	173.18	—	—
299-E27-55	FS-NW-LT-5367	200.43	153.49	200.43	—	177.88	—	—
299-E27-56	RPP-18290	197.65	153.46	197.65	N/D	177.54	—	—
299-E27-57	FS-NW-LT-5367	200.66	154.94	200.66	—	188.16	—	—
299-E27-58	FS-NW-LT-5367	198.40	167.92	198.40	186.66	180.26	—	—
299-E27-59	FS-NW-LT-5367	198.51	168.03	198.51	186.77	178.24	—	—
299-E27-60	FS-NW-LT-5367	198.12	167.64	198.12	186.69	176.32	—	—
299-E27-61	FS-NW-LT-5367	198.26	167.78	198.26	186.68	177.84	—	—
299-E27-62	FS-NW-LT-5367	198.15	167.67	198.15	186.72	182.60	—	—
299-E27-63	FS-NW-LT-5367	197.95	167.47	197.95	186.37	176.92	—	—
299-E27-64	FS-NW-LT-5367	198.17	167.69	198.17	186.74	179.12	—	—
299-E27-65	FS-NW-LT-5367	198.39	157.24	198.39	186.74	180.40	—	—
299-E27-66	FS-NW-LT-5367	198.95	154.75	198.95	187.67	183.10	—	—
299-E27-67	FS-NW-LT-5367	198.23	158.61	198.23	186.35	178.73	—	—
299-E27-68	FS-NW-LT-5367	198.09	156.94	198.09	186.66	175.84	—	—

Table 4-7. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model I (Meters above Mean Sea Level). (5 sheets)

Well Name	Data Source	Elevation	Total Drilled Depth Elevation	Backfill/ Eolian Sand	Top Hanford H1 Unit	Top Hanford H2 Unit	Top of H3/CCu/Ru	Top of Basalt
299-E27-69	FS-NW-LT-5367	198.04	161.46	198.04	186.15	176.09	—	—
299-E27-70	FS-NW-LT-5367	197.97	158.35	197.97	186.54	175.42	—	—
299-E27-71	FS-NW-LT-5367	197.81	158.18	197.81	185.16	174.95	—	—
299-E27-72	FS-NW-LT-5367	197.64	159.54	197.64	185.60	173.87	—	—
299-E27-73	FS-NW-LT-5367	197.89	158.27	197.89	186.31	173.81	—	—
299-E27-74	FS-NW-LT-5367	197.70	167.22	197.70	184.59	172.55	—	—
299-E27-75	FS-NW-LT-5367	197.60	167.12	197.60	184.50	171.85	—	—
299-E27-76	FS-NW-LT-5367	197.83	167.35	197.83	186.09	172.53	—	—
299-E27-77	FS-NW-LT-5367	197.90	167.42	197.90	185.86	173.98	—	—
299-E27-78	FS-NW-LT-5367	197.90	167.42	197.90	186.47	175.04	—	—
299-E27-79	FS-NW-LT-5367	198.20	167.72	198.20	186.92	179.46	—	—
299-E27-80	FS-NW-LT-5367	198.35	167.87	198.35	186.76	180.36	—	—
299-E27-81	FS-NW-LT-5367	198.02	167.54	198.02	186.59	175.47	—	—
299-E27-82	FS-NW-LT-5367	198.08	167.60	198.08	186.65	177.66	—	—
299-E27-83	FS-NW-LT-5367	198.20	167.72	198.20	186.77	178.54	—	—
299-E27-84	FS-NW-LT-5367	197.65	167.17	197.65	185.91	173.11	—	—
299-E27-85	FS-NW-LT-5367	197.98	167.50	197.98	186.09	175.27	—	—
299-E27-86	FS-NW-LT-5367	197.58	167.10	197.58	186.15	174.26	—	—
299-E27-87	FS-NW-LT-5367	198.17	167.69	198.17	186.74	179.88	—	—
299-E27-88	FS-NW-LT-5367	198.15	167.67	198.15	186.57	180.02	—	—
299-E27-89	FS-NW-LT-5367	198.78	168.30	198.78	186.74	182.78	—	—
299-E27-90	FS-NW-LT-5367	198.73	168.25	198.73	186.99	184.40	—	—
299-E27-91	FS-NW-LT-5367	198.59	168.11	198.59	186.86	185.03	—	—
299-E27-92	FS-NW-LT-5367	198.35	167.87	198.35	186.62	184.64	—	—
299-E27-93	FS-NW-LT-5367	198.26	167.78	198.26	186.83	183.18	—	—
299-E27-94	FS-NW-LT-5367	197.95	167.47	197.95	186.44	175.32	—	—
299-E27-95	FS-NW-LT-5367	197.98	167.50	197.98	186.55	176.34	—	—
299-E27-96	FS-NW-LT-5367	197.66	167.18	197.66	186.08	174.88	—	—
299-E27-97	FS-NW-LT-5367	197.76	167.28	197.76	186.03	174.90	—	—
299-E27-98	FS-NW-LT-5367	197.96	167.48	197.96	186.30	176.09	—	—

Table 4-7. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model I (Meters above Mean Sea Level). (5 sheets)

Well Name	Data Source	Elevation	Total Drilled Depth Elevation	Backfill/ Eolian Sand	Top Hanford H1 Unit	Top Hanford H2 Unit	Top of H3/CCu/Ru	Top of Basalt
299-E27-99	FS-NW-LT-5367	197.85	167.37	197.85	185.81	175.29	—	—
299-E27-100	FS-NW-LT-5367	197.71	167.23	197.71	185.21	173.63	—	—
299-E27-101	FS-NW-LT-5367	198.21	167.73	198.21	186.63	183.27	—	—
299-E27-102	FS-NW-LT-5367	198.18	167.70	198.18	186.60	181.26	—	—
299-E27-103	FS-NW-LT-5367	199.31	168.83	199.31	187.27	186.66	—	—
299-E27-104	FS-NW-LT-5367	198.55	168.07	198.55	186.97	185.45	—	—
299-E27-105	FS-NW-LT-5367	198.15	167.67	198.15	186.57	177.28	—	—
299-E27-106	FS-NW-LT-5367	198.08	167.60	198.08	186.50	179.79	—	—
299-E27-107	FS-NW-LT-5367	197.65	167.17	197.65	184.54	172.81	—	—
299-E27-108	FS-NW-LT-5367	197.59	167.11	197.59	185.40	173.66	—	—
299-E27-109	FS-NW-LT-5367	197.95	167.47	197.95	186.21	176.92	—	—
299-E27-115	FS-NW-LT-5367	198.28	183.04	198.28	186.70	—	—	—
299-E27-116	FS-NW-LT-5367	198.22	182.98	198.22	186.94	—	—	—
299-E27-117	FS-NW-LT-5367	198.18	182.94	198.18	186.59	—	—	—
299-E27-118	FS-NW-LT-5367	198.19	176.86	198.19	—	—	—	—
299-E27-119	FS-NW-LT-5367	198.27	179.98	198.27	186.38	—	—	—
299-E27-120	FS-NW-LT-5367	203.28	184.99	203.28	—	195.66	—	—
299-E27-121	FS-NW-LT-5367	203.24	184.95	203.24	—	196.23	—	—
299-E27-122	FS-NW-LT-5367	201.60	183.32	201.60	—	191.55	—	—
299-E27-124	FS-NW-LT-5367	198.32	180.03	198.32	196.79	—	—	—
299-E27-125	FS-NW-LT-5367	197.70	158.08	197.70	185.82	174.08	—	—
299-E27-135	FS-NW-LT-5367	198.46	160.36	198.46	185.96	176.21	—	—
299-E27-155	FS-NW-LT-5367/ SGW-37834 Top of Basalt	207.68	104.05	—	207.68	186.95	121.73	105.27
C4297	FS-NW-LT-5367	198.16	138.54	198.16	185.96	178.95	—	—
C4401	FS-NW-LT-5367	202.76	184.47	202.76	198.40[a]	196.36	—	—
C4403	FS-NW-LT-5367	203.05	185.13	203.05	201.07[a]	196.95	—	—
C4405	FS-NW-LT-5367	203.26	193.66	203.26	201.30[a]	197.47	—	—
C4407	FS-NW-LT-5367	203.23	185.26	203.23	198.89[a]	196.68	—	—
C4409	FS-NW-LT-5367	203.04	193.59	203.04	198.83[a]	195.87	—	—

Table 4-7. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model I (Meters above Mean Sea Level). (5 sheets)

Well Name	Data Source	Elevation	Total Drilled Depth Elevation	Backfill/ Eolian Sand	Top Hanford H1 Unit	Top Hanford H2 Unit	Top of H3/CCu/Ru	Top of Basalt
C4411	FS-NW-LT-5367	203.20	183.35	203.20	198.89[a]	196.03	—	—
C4413	FS-NW-LT-5367	203.17	193.82	203.17	198.81[a]	195.55	—	—
C4415	FS-NW-LT-5367	203.06	185.35	203.06	198.66[a]	194.52	—	—
C4417	FS-NW-LT-5367	203.04	185.33	203.04	198.61[a]	194.35	—	—
C4419	FS-NW-LT-5367	202.64	185.02	202.64	198.40[a]	193.49	—	—
C4421	FS-NW-LT-5367	202.59	184.77	202.59	198.36[a]	193.29	—	—
C4425	FS-NW-LT-5367	202.49	193.04	202.49	198.21[a]	—	—	—
C4427	FS-NW-LT-5367	201.61	191.73	201.61	197.88[a]	194.90	—	—
C4429	FS-NW-LT-5367	202.03	184.26	202.03	198.06[a]	192.12	—	—
C4431	FS-NW-LT-5367	201.71	183.76	201.71	198.22[a]	190.58	—	—
C4433	FS-NW-LT-5367	201.89	192.01	201.89	198.06[a]	—	—	—
C4435	FS-NW-LT-5367	201.74	191.07	201.74	198.02[a]	191.98	—	—
C4437	FS-NW-LT-5367	201.86	183.91	201.86	197.98[a]	193.17	—	—
C4439	FS-NW-LT-5367	201.96	192.21	201.96	197.98[a]	192.97	—	—
C4447	FS-NW-LT-5367	201.54	192.40	201.54	197.89[a]	—	—	—
C5104	RPP-32130, p19	201.74	178.36	201.74	197.96[a]	193.71	—	—
C5105	RPP-32130, p19	201.74	188.21	201.74	198.00[a]	193.31	—	—
C5106	RPP-32130, p19	203.00	179.28	203.00	198.58[a]	194.08	—	—
C5107	RPP-32130, p19	203.00	189.89	203.00	198.58[a]	195.08	—	—
C5108	RPP-32130, p19	203.22	185.08	203.22	198.85[a]	194.91	—	—
C5109	RPP-32130, p19	203.22	193.02	203.22	198.83[a]	194.53	—	—
C5943	FS-NW-LT-5367	205.40	173.70	—	205.40	198.09	—	—
C5947	FS-NW-LT-5367	205.00	143.27	—	205.00	196.77	—	—
C5951	FS-NW-LT-5367	205.13	173.43	—	205.13	196.74	—	—
C5953	FS-NW-LT-5367	205.60	173.90	—	205.60	197.83	—	—
C5955	FS-NW-LT-5367	205.42	173.72	—	205.42	197.80	—	—
C5957	FS-NW-LT-5367	205.66	161.77	—	205.66	197.73	—	—
C5959	FS-NW-LT-5367	205.85	174.15	—	205.85	198.84	—	—
C5961	FS-NW-LT-5367	206.75	175.05	—	206.75	199.58	—	—

Table 4-7. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model I (Meters above Mean Sea Level). (5 sheets)

Well Name	Data Source	Elevation	Total Drilled Depth Elevation	Backfill/ Eolian Sand	Top Hanford H1 Unit	Top Hanford H2 Unit	Top of H3/CCu/Ru	Top of Basalt
C5963	FS-NW-LT-5367	205.65	173.95	—	205.65	197.88	—	—
C6391	FS-NW-LT-5367	203.51	156.27	—	203.51	187.36	—	—
C6393	FS-NW-LT-5367	203.72	130.57	—	203.72	187.72	—	—
C6395	FS-NW-LT-5367	203.65	156.41	—	203.65	189.33	—	—
C6397	FS-NW-LT-5367	203.07	155.83	—	203.07	186.00	—	—
C6399	FS-NW-LT-5367	203.03	129.88	—	203.03	184.89	—	—
C6405	FS-NW-LT-5367	203.11	129.96	—	203.11	186.20	—	—
C7465	FS-NW-LT-5367	197.67	136.10	197.67	184.11	172.98	—	—
C7467	FS-NW-LT-5367	197.49	144.46	197.49	183.78	174.02	—	—
C7471	FS-NW-LT-5367	195.02	126.44	195.02	182.83	171.55	—	—
C7667	FS-NW-LT-5367	198.15	129.57	198.15	185.65	176.20	—	—
C7669	FS-NW-LT-5367	197.80	129.22	197.80	185.30	173.87	—	—
C8099	RPP-RPT-49956	202.47	139.15	202.47	192.70[a]	182.45	—	—
C8101	RPP-RPT-50581	202.39	158.36	202.39	191.57	184.84	—	—
C8103	RPP-RPT-50581	198.05	152.78	198.05	186.48	176.21	—	—
C8105	RPP-RPT-51384	193.65	171.08	193.65	181.43	171.87	—	—
299-E24-3	RPP-14430	213.46	111.96	—	213.46	180.85	—	—
299-E24-4	RPP-14430	213.03	112.45	213.03	204.20[b]	191.69	—	—
299-E24-20	RPP-14430	210.11	117.45	—	210.11	175.06	126.29	—
299-E24-22	PNL-14538	209.55	108.97	—	209.55	176.63	118.11	—
299-E24-33	PNNL-18835	206.03	109.90	—	206.03	188.35	129.22	110.02
299-E26-6	RPP-14430	199.04	110.65	199.04	194.20[b]	180.75	124.97	—
299-E26-8	RPP-14430	189.21	67.29	189.21	—	186.20[b]	147.76	113.01
299-E27-2	RPP-14430	203.39	108.29	—	203.39	188.15	125.67	—
299-E27-3	RPP-14430	208.90	99.17	—	208.90	198.23	131.18	102.52

[a] Interpolated from bottom of backfill surface.

[b] First unit was identified below eolian sand, Alternative conceptual model did not include eolian sand and land surface was used for the top of the unit.

N/D = Non determinable

Table 4-8. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model II[a] (Meters above Mean Sea Level). (5 sheets)

Well Name	Elevation	Elevation at Bottom of Well	Backfill	Top of Hanford H1 Unit	Top of Hanford H2 Upper Sand Unit	Top of Hanford H2 Middle Coarse Sand/ Gravely Unit	Top of Hanford H2 Lower Silt Unit	Top of H3/CCu/Ru	Top of Basalt
299-E27-4	204.69	110.88	204.69	197.98	188.84	148.91	134.58	132.14	—
299-E27-7	194.50	108.85	—	—	—	—	—	—	109.00
299-E27-12	201.54	119.25	201.54	200.54	187.22	149.12	—	130.22	—
299-E27-13	204.09	119.99	204.09	203.17	190.37	148.31	—	131.55	—
299-E27-14	200.84	119.52	200.84	197.79	172.80	150.55	131.04	128.91	—
299-E27-15	199.16	119.15	199.16	198.31	177.82	151.00	—	124.48	—
299-E27-21	204.99	110.86	204.99	—	186.40	150.13	131.84	130.93	104.29
299-E27-22	192.60	110.88	192.60	190.77	168.22	145.97	123.59	123.41	110.91
299-E27-23	205.66	110.88	205.66	202.00	187.68	150.19	133.73	130.68	—
299-E27-155	207.68	104.05	207.68	207.38	187.87	153.43	137.58	137.27	105.27
299-E27-51	197.95	152.23	197.95	186.37	—	—	—	—	—
299-E27-53	198.75	153.03	198.75	—	182.90	—	—	—	—
299-E27-54	199.85	152.60	199.85	—	173.03	—	—	—	—
299-E27-55	200.43	153.49	200.43	188.85	182.75	—	—	—	—
299-E27-56	197.65	153.46	197.65	187.90	—	—	—	—	—
299-E27-58	198.40	167.92	198.40	186.81	179.80	—	—	—	—
299-E27-59	198.51	168.03	198.51	186.92	178.39	—	—	—	—
299-E27-60	198.12	167.64	198.12	186.69	176.17	—	—	—	—
299-E27-61	198.26	167.78	198.26	186.68	177.84	—	—	—	—
299-E27-62	198.15	167.67	198.15	186.56	182.60	—	—	—	—
299-E27-63	197.95	167.47	197.95	186.37	176.92	—	—	—	—
299-E27-64	198.17	167.69	198.17	185.52	179.27	—	—	—	—
299-E27-65	198.39	157.24	198.39	186.50	180.40	—	—	—	—
299-E27-66	198.95	154.75	198.95	187.06	182.79	—	—	—	—
299-E27-67	198.23	158.61	198.23	186.35	178.73	—	—	—	—
299-E27-68	198.09	156.94	198.09	185.90	176.14	—	—	—	—
299-E27-69	198.04	161.46	198.04	186.15	175.79	—	—	—	—

Table 4-8. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model II[a] (Meters above Mean Sea Level). (5 sheets)

Well Name	Elevation	Elevation at Bottom of Well	Backfill	Top of Hanford H1 Unit	Top of Hanford H2 Upper Sand Unit	Top of Hanford H2 Middle Coarse Sand/ Gravely Unit	Top of Hanford H2 Lower Silt Unit	Top of H3/CCu/Ru	Top of Basalt
299-E27-70	197.97	158.35	197.97	186.39	175.72	—	—	—	—
299-E27-71	197.81	158.18	197.81	185.31	175.25	—	—	—	—
299-E27-72	197.64	159.54	197.64	185.45	173.87	—	—	—	—
299-E27-73	197.89	158.27	197.89	184.79	173.51	—	—	—	—
299-E27-74	197.70	167.22	197.70	184.59	172.40	—	—	—	—
299-E27-75	197.60	167.12	197.60	184.50	—	—	—	—	—
299-E27-76	197.83	167.35	197.83	185.02	172.22	—	—	—	—
299-E27-77	197.90	167.42	197.90	185.71	174.74	—	—	—	—
299-E27-78	197.90	167.42	197.90	185.41	175.04	—	—	—	—
299-E27-79	198.20	167.72	198.20	186.77	179.30	—	—	—	—
299-E27-80	198.35	167.87	198.35	186.76	180.36	—	—	—	—
299-E27-81	198.02	167.54	198.02	186.44	175.47	—	—	—	—
299-E27-82	198.08	167.60	198.08	186.50	177.66	—	—	—	—
299-E27-83	198.20	167.72	198.20	186.62	178.39	—	—	—	—
299-E27-84	197.65	167.17	197.65	185.46	173.27	—	—	—	—
299-E27-85	197.98	167.50	197.98	186.09	175.42	—	—	—	—
299-E27-86	197.58	167.10	197.58	184.78	174.42	—	—	—	—
299-E27-87	198.17	167.69	198.17	186.59	179.88	—	—	—	—
299-E27-88	198.15	167.67	198.15	185.96	179.87	—	—	—	—
299-E27-89	198.78	168.30	198.78	186.59	182.93	—	—	—	—
299-E27-90	198.73	168.25	198.73	187.15	184.40	—	—	—	—
299-E27-91	198.59	168.11	198.59	187.01	184.87	—	—	—	—
299-E27-92	198.35	167.87	198.35	186.77	184.64	—	—	—	—
299-E27-93	198.26	167.78	198.26	186.68	183.02	—	—	—	—
299-E27-94	197.95	167.47	197.95	186.37	175.09	—	—	—	—
299-E27-95	197.98	167.50	197.98	186.40	176.04	—	—	—	—
299-E27-96	197.66	167.18	197.66	183.95	174.80	—	—	—	—

Table 4-8. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model II[a] (Meters above Mean Sea Level). (5 sheets)

Well Name	Elevation	Elevation at Bottom of Well	Backfill	Top of Hanford H1 Unit	Top of Hanford H2 Upper Sand Unit	Top of Hanford H2 Middle Coarse Sand/ Gravely Unit	Top of Hanford H2 Lower Silt Unit	Top of H3/CCu/Ru	Top of Basalt
299-E27-97	197.76	167.28	197.76	184.96	174.90	—	—	—	—
299-E27-98	197.96	167.48	197.96	186.38	176.01	—	—	—	—
299-E27-99	197.85	167.37	197.85	185.04	174.99	—	—	—	—
299-E27-100	197.71	167.23	197.71	185.21	173.32	—	—	—	—
299-E27-101	198.21	167.73	198.21	186.63	182.97	—	—	—	—
299-E27-102	198.18	167.70	198.18	186.75	181.11	—	—	—	—
299-E27-103	199.31	168.83	199.31	187.73	186.21	—	—	—	—
299-E27-104	198.55	168.07	198.55	187.12	185.45	—	—	—	—
299-E27-105	198.15	167.67	198.15	186.27	177.73	—	—	—	—
299-E27-106	198.08	167.60	198.08	186.50	179.79	—	—	—	—
299-E27-107	197.65	167.17	197.65	184.54	173.57	—	—	—	—
299-E27-108	197.59	167.11	197.59	184.48	173.51	—	—	—	—
299-E27-109	197.95	167.47	197.95	185.76	177.22	—	—	—	—
299-E27-115	198.28	183.04	198.28	186.70	—	—	—	—	—
299-E27-116	198.22	182.98	198.22	186.79	—	—	—	—	—
299-E27-117	198.18	182.94	198.18	186.59	—	—	—	—	—
299-E27-119	198.27	179.98	198.27	186.38	—	—	—	—	—
299-E27-120	203.28	184.99	—	203.28	192.61	—	—	—	—
299-E27-121	203.24	184.95	203.24	199.58	191.96	—	—	—	—
299-E27-122	201.60	183.32	—	201.60	191.55	—	—	—	—
299-E27-124	198.32	180.03	198.32	196.79	—	—	—	—	—
299-E27-125	197.70	158.08	197.70	184.90	173.93	—	—	—	—
299-E27-135	198.46	160.36	198.46	185.96	176.21	—	—	—	—
C4297	198.16	138.54	198.16	186.27	178.65	149.39	—	—	—
C4401	202.76	184.47	202.76	198.40[b]	188.43	—	—	—	—
C4403	203.05	185.13	203.05	201.07[b]	188.72	—	—	—	—

Table 4-8. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model II[a] (Meters above Mean Sea Level). (5 sheets)

Well Name	Elevation	Elevation at Bottom of Well	Backfill	Top of Hanford H1 Unit	Top of Hanford H2 Upper Sand Unit	Top of Hanford H2 Middle Coarse Sand/ Gravely Unit	Top of Hanford H2 Lower Silt Unit	Top of H3/CCu/Ru	Top of Basalt
C4405	203.26	193.66	203.26	201.30[b]	—	—	—	—	—
C4407	203.23	185.26	203.23	198.89[b]	189.21	—	—	—	—
C4409	203.04	193.59	203.04	198.83[b]	—	—	—	—	—
C4411	203.20	183.35	203.20	198.89[b]	189.17	—	—	—	—
C4413	203.17	193.82	203.17	198.81[b]	—	—	—	—	—
C4415	203.06	185.35	203.06	198.66[b]	187.21	—	—	—	—
C4417	203.04	185.33	203.04	198.61[b]	187.19	—	—	—	—
C4419	202.64	185.02	202.64	198.40[b]	188.31	—	—	—	—
C4421	202.59	184.77	202.59	198.36[b]	187.96	—	—	—	—
C4425	202.49	193.04	202.49	198.21[b]	—	—	—	—	—
C4427	201.61	191.73	201.61	197.88[b]	—	—	—	—	—
C4429	202.03	184.26	202.03	198.06[b]	187.70	—	—	—	—
C4431	201.71	183.76	201.71	198.22[b]	190.13	—	—	—	—
C4433	201.89	192.01	201.89	198.06[b]	—	—	—	—	—
C4435	201.74	191.07	201.74	198.02[b]	—	—	—	—	—
C4437	201.86	183.91	201.86	197.98[b]	189.06	—	—	—	—
C4439	201.96	192.21	201.96	197.98[b]	—	—	—	—	—
C4447	201.54	192.40	201.54	197.89[b]	—	—	—	—	—
C5943	205.40	173.70	—	205.40	190.47	—	—	—	—
C5947	205.00	143.27	—	205.00	188.84	148.91	—	—	—
C5951	205.13	173.43	—	205.13	188.97	—	—	—	—
C5953	205.60	173.90	—	205.60	186.70	—	—	—	—
C5955	205.42	173.72	—	205.42	190.18	—	—	—	—
C5957	205.66	161.77	—	205.66	190.72	—	—	—	—
C5959	205.85	174.15	—	205.85	188.17	—	—	—	—

Table 4-8. Elevation of Stratigraphic Contacts used in the Alternative Conceptual Model II[a] (Meters above Mean Sea Level). (5 sheets)

Well Name	Elevation	Elevation at Bottom of Well	Backfill	Top of Hanford H1 Unit	Top of Hanford H2 Upper Sand Unit	Top of Hanford H2 Middle Coarse Sand/ Gravely Unit	Top of Hanford H2 Lower Silt Unit	Top of H3/CCu/Ru	Top of Basalt
C5961	206.75	175.05	—	206.75	189.07	—	—	—	—
C5963	205.65	173.95	—	205.65	189.19	—	—	—	—
C6391	203.51	156.27	—	203.51	187.36	—	—	—	—
C6393	203.72	130.57	—	203.72	187.87	150.69	—	—	—
C6395	203.65	156.41	—	203.65	189.02	—	—	—	—
C6397	203.07	155.83	—	203.07	185.70	—	—	—	—
C6399	203.03	129.88	—	203.03	185.04	148.16	—	—	—
C6403	203.30	—	—	203.30	—	—	—	—	—
C6405	203.11	129.96	—	203.11	186.35	148.55	—	—	—
C7465	197.67	136.10	197.67	183.95	172.68	147.38	—	—	—
C7467	197.49	144.46	197.49	183.78	174.02	148.72	—	—	—
C7469	198.20	—	—	—	—	—	—	—	—
C7471	195.02	126.44	195.02	193.19	171.55	146.26	—	—	—
C7667	198.15	129.57	198.15	193.57	178.94	150.29	—	—	—
C7669	197.80	129.22	197.80	185.60	174.02	147.50	—	—	—

[a] Source of data in this table is from Sobczyk, S., 2014-03-10, “WMA C geology” (e-mail to M. P. Bergeron, Washington River Protection Solutions, LLC), Environmental Restoration & Waste Management Program, Nez Perce Tribe, Lapwai, Idaho. Table 3-5 provides the same data as measured by depth below ground surface

[b] Interpolated from bottom of backfill surface.

5.0 BUILDING THE ALTERNATIVE GEOLOGIC MODELS IN TECPLOT®

Once the tops of each unit from the boreholes are known, it is possible to turn that one-dimensional data into a 3-D surface representing the top of each unit. This section describes the process by which these 3-D surfaces are generated from the borehole data. In this example, the kriging algorithm provided in Tecplot® is used to generate the surfaces onto a triangular mesh. Other software packages (LeapFrog3D®, EVS®, Surfer®, etc.)[5] could also be used to generate these surfaces.

It should be noted that the greater the number of boreholes in which the top of the unit is identified, the less uncertainty exists in locating that surface in 3-D space. For example, at WMA C there are a large number of boreholes (direct pushes, dry wells, groundwater wells, and characterization boreholes) in which the top of the H2 Sand unit has been identified and the location of this surface within WMA C is better known. However, the location of other surfaces is less well known as one goes deeper into the vadose zone because a large number of boreholes are shallow and do not intercept the different deeper underlying units. This also occurs as one moves away from WMA C, because there are fewer boreholes. Nevertheless, there is a need to expand the area to ensure that the vadose zone/groundwater models developed have boundary locations far enough away from the area of interest (i.e., the areas containing the SSTs, diversion boxes, and CR-Vault) that the simulated conditions at the boundaries are not affecting the results of the modeling. Kriging does this by taking an average over the surface and trends in areas where little or no data exists. There is an inherent assumption that the surfaces created for each unit are essentially correct. However, that assumption needs to be evaluated through sensitivity and uncertainty analysis of alternative vadose zone/groundwater models.

5.1 BUILDING THE MESH

After turning the ***tblTecplot*** table into a Tecplot® data file, it is time to build a Tecplot® triangular mesh. The mesh is used to create a surface representing the tops of each individual unit. The surface is created by using the kriging algorithm in Tecplot® to interpolate the location for the top of the unit onto the mesh created in this step. Since WMA C is at an approximate 45 degree angle to true north, the mesh was also angled at 45 degrees to keep the grid spacing (i.e., the distance between individual data points in the mesh) and memory usage to a minimum.

The design of the mesh needs to ensure that it can incorporate a Subsurface Transport Over Multiple Phases (STOMP©)[6] model with boundaries at least 100 m from the WMA to ensure that DOE O 435.1, *Radioactive Waste Management* requirements are met. A decision was made to make the mesh at least 150 m from the WMA C fence line. Furthermore, if there were nearby wells away from the vicinity of WMA C that have geologic data, the mesh should be expanded

[5] The LeapFrog Hydro® visualization software is a registered trademark of ARANZ Geo Limited, Christchurch, New Zealand (see http://www.leapfrog3d.com/products/leapfrog-hydro).
Environmental Visualization System (EVS) is a product of C Tech Development Corporation, Henderson, Nevada.
Surfer® is a registered trademark of Golden Software, Golden, Colorado.

[6] Subsurface Transport Over Multiple Phases (STOMP) is copyrighted by Battelle Memorial Institute, 1996.

to include those wells. All the wells in ***tblTecplot*** were plotted. Once they were plotted, the following observations and decisions were made:

1) No nearby wells were identified outside the vicinity of WMA C to the west, southwest, and northwest; therefore, the boundary of the mesh to the northwest of the area would extend ~180 m in that direction

2) A nearby well to the north (299-E26-8) led to the boundary to the northeast being set to ~270 m from the WMA C fence line

3) A nearby well to the east (299-E24-20) led to the boundary to the southeast being set to ~340 m from the WMA C fence line

4) A nearby well to the south (299-E24-3) led to the boundary to the southwest being set to ~270 m from the WMA C fence line

5) A large density of data points, representing groundwater wells, dry wells, and direct pushes, are located between wells 299-E27-155 (to the southwest of WMA C), 299-E27-22 (to the north of WMA C), 299-E27-15 (to the northwest of WMA C) and 299-E27-24 (to the southeast of WMA C); in this region the grid spacing in this area was set to 2 m, and the mesh outside of this area was set to 10 m.

This section describes the process used to create the interpolation mesh. The same mesh will be used for each top of unit. The mesh can be exported directly into LeapFrog Hydro®. The steps to create the mesh are listed below.

1) Open Tecplot®, go to Data/Create Zone; when the create zone dialog comes up, enter the following in the input boxes: I = 73, J = 79, K=1, XMin = 0, XMax = 720, YMin = 0, YMax = 780. The mesh begins as a rectangular mesh with 10-m grid spacing and is Zone 1 [Figure 5-1(a), red grid].

2) Next cut a hole in it by using IJK Blanking; do this by going to Plot/Blank/IJK Blanking, select Interior and IJK Ranges using Index Value, set I-Min to 16, set I-Max to 43, set J-Min to 21 and J-Max to 56. This will be the area containing 2-m grid spacing [Figure 5-1(b)].

Figure 5-1(a). Grid with 10-meter Spacing between Nodes.

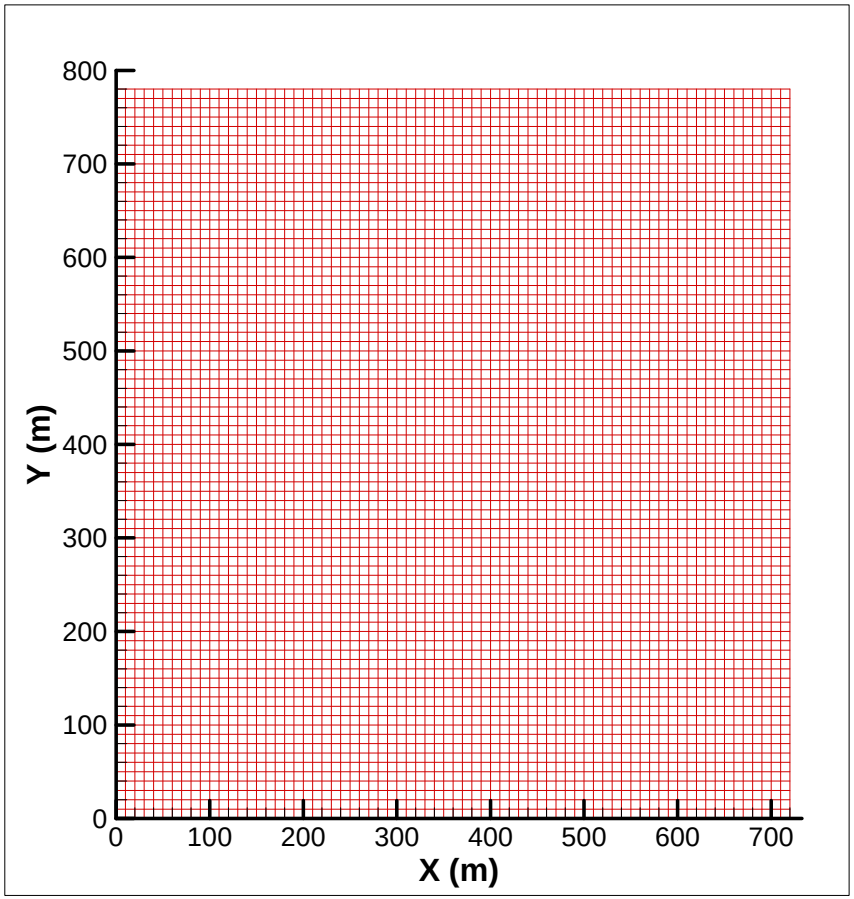
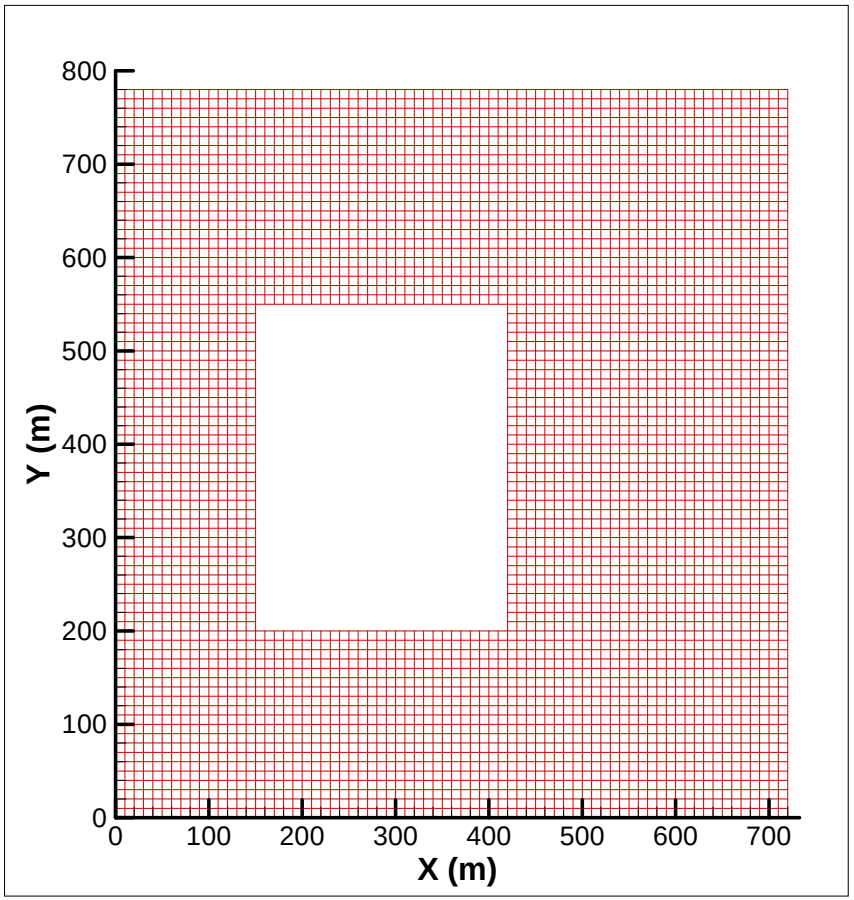


Figure 5-1(b). Subarea with 2-meter Spacing between Nodes.



3) Create a subgrid from Zone 1 by going to Data/Extract Subzone and setting the following: I-Index Start to 17 and I-Index End to 42, J-Index Start to 22 and J-Index End to 55, the skip I and J remain at 1 [Figure 5-2(a)]. The subzone is Zone 2 and will be refined to have a 2-m grid spacing.

4) The step from 10 m to 2 m is too great, so four 1-D subgrids are extracted along each boundary. These subzones' mesh will be refined to a 5-m grid. They are Zones 3 to 6, respectively. The indices for these extractions are given below:

    a. West Boundary → I-Index Start and End = 16; J-Index Start = 21; End is 56 (Blue)

    b. East Boundary → I-Index Start and End = 43; J-Index Start = 21; End is 56 (Cyan)

    c. South Boundary → I-Index Start = 16; End = 43; J-Index Start and End is 21 (Brown)

    d. North Boundary → I-Index Start = 16; End = 43; J-Index Start and End is 56 (Magenta).

5) Following the creation of these zones, they must be moved into position by adding 5 to the X-Variable for Zone 3 (West), subtracting 5 from the X-Variable for Zone 4 (East), adding 5 to the Y-Variable for Zone 5 (South), and subtracting 5 from the Y-Variable for Zone 6 (North). This is done by going to the Data Alteration menu and writing the appropriate equation (e.g., X = X+5 and selecting Zone 3) [Figure 5-2(b)].

6) Once the 10-m nodal spacing grids given in steps 2 to 5 are added to and moved into place, the grid spacing needs to be refined to 2-m spacing for the green grid given in step 2 and 5-m spacing for the boundary grids. Load the RefineZone add-on and then from the TecGeo menu, select RefineZone; in the dialog box that comes up, select Zone and enter 5 into the zone refinement dialog boxes. That will create Zone 7 with 2-m grid spacing [Figure 5-3(a)]; repeat the process for Zones 3 through 6, but instead of entering 5 for the zone refinement, enter 2 for 5-m grid spacing [Figure 5-3(b)]. Now delete Zones 2 through 7, and save the data file as an ASCII data file.

7) Edit the ASCII data file in a text editor and change all occurrences of "single" to "double". This is done because by translating the mesh to the location of WMA C, six more significant digits are added to the mesh to incorporate the State Plane Coordinates.

Figure 5-2(a). Grid to be Refined to 2-meter Node Spacing.

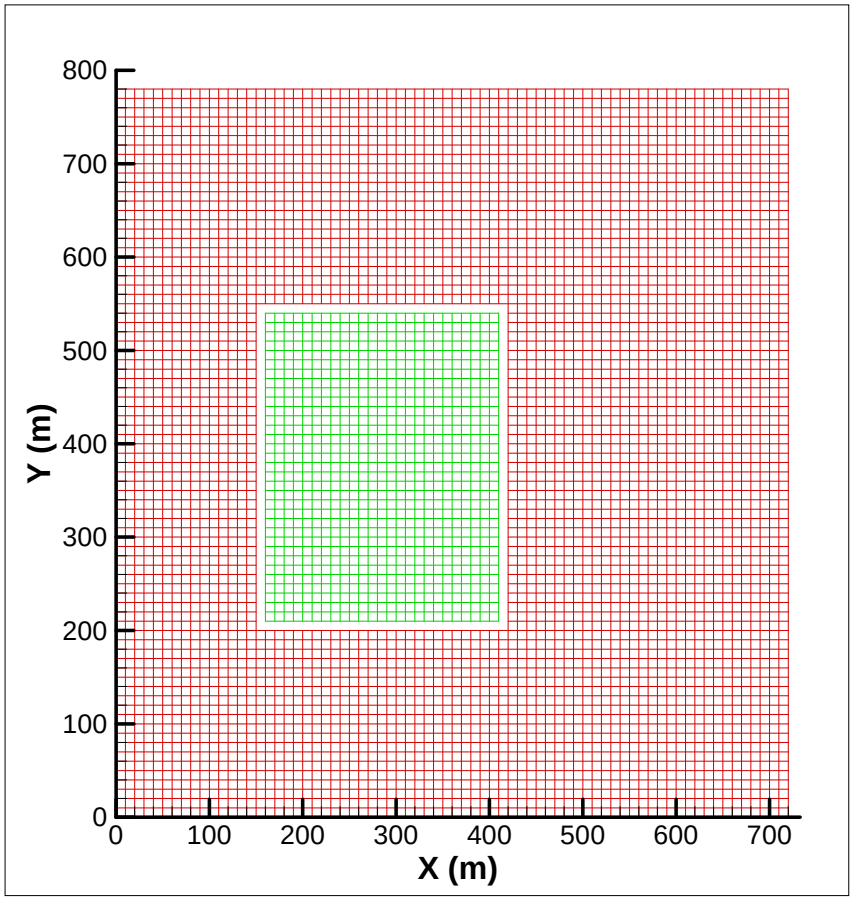


Figure 5-2(b). Interior Boundaries with 5-meter Grid Spacing.

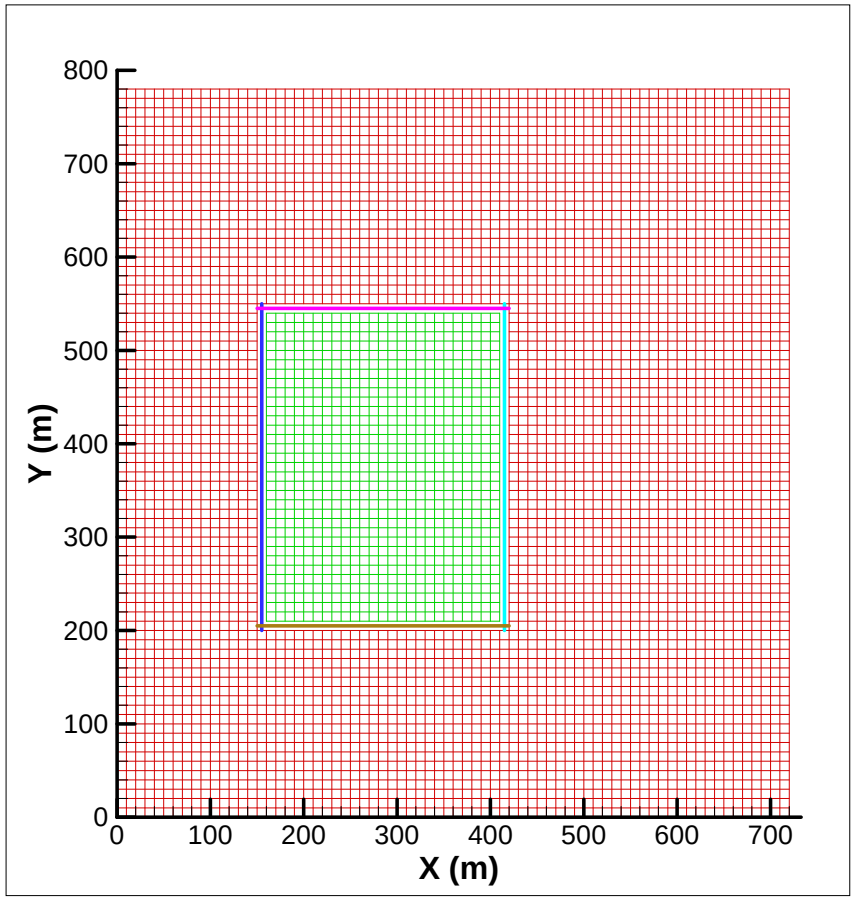


Figure 5-3(a). Southwest Corner of Interior Grid Refined to 2-meter Node Spacing.

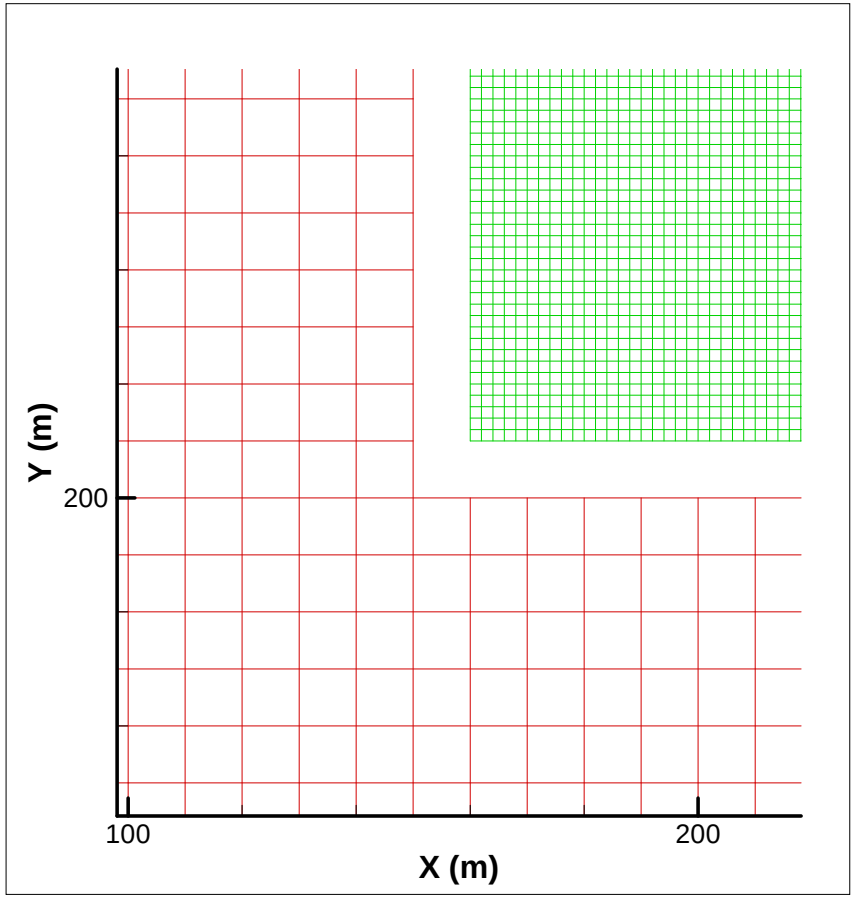
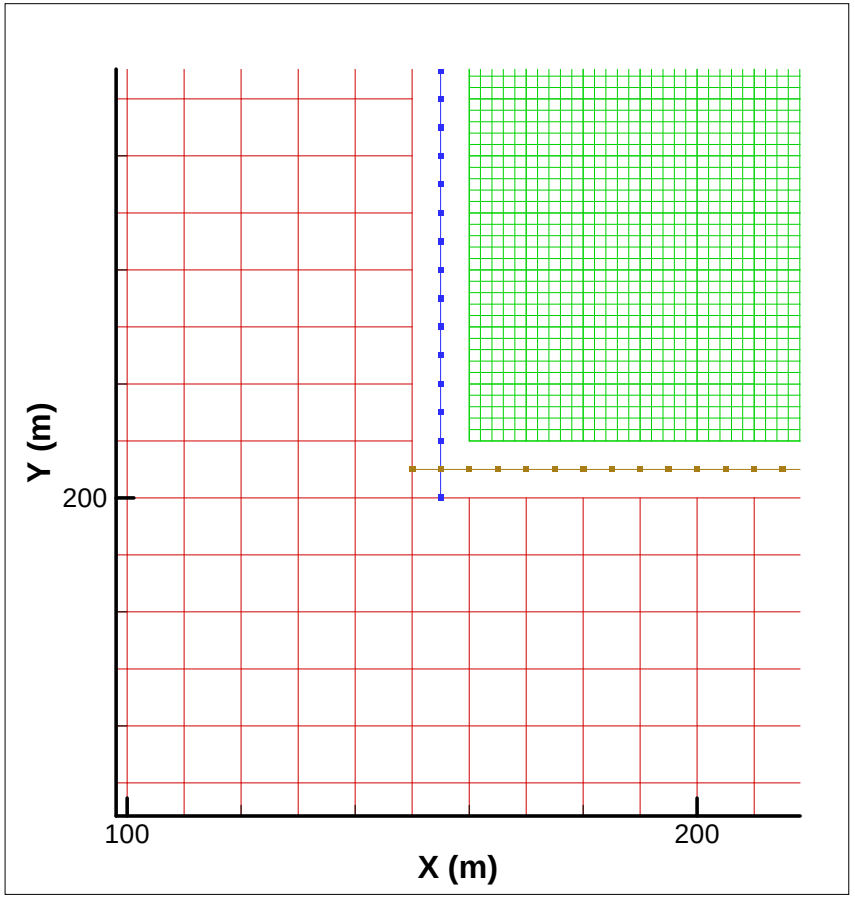


Figure 5-3(b). Interior Boundaries Refined with 5-meter Node Spacing Shown in Southwest Corner of Interior Grid.



8) Read the ASCII data file back into Tecplot® to rotate the mesh -45 degrees and translate it into position. To rotate the mesh, select "Data/2D Rotate…", select -45 for angle of rotation, enter 0 for X- and Y-Origen, and select all zones [Figure 5-4(a)].

9) To translate the grids into position at WMA C, select "Data/Alter Equation…" and type the equations (a) and (b) into the "Equation(s)" box, select all zones and click on the "Compute" box. The go to "Data/Data Set Info" and change the name of the X variable to "Easting (m)" and the Y variable to "Northing (m)". The result is shown in Figure 5-4(b).

    a. X = X + 574667
    b. Y = Y + 136453

10) Now read in the file created from query 8 given in Table 4-6 and in the instructions following that table. That file contains the Easting and Northing of all wells containing the geologic information. These are shown in blue on Figure 5-5(a).

11) It is now possible to create final mesh by triangulating on all data points and nodes shown in Figure 5-5(a). First go to Plot/Blank/IJK Blanking, select Interior and IJK Ranges using Index Value, set I-Min to 17, set I-Max to 42, set J-Min to 22, and J-Max to 55. Then go to "Data/Triangulate", select all zones and set keep factor to 0.05. The final mesh is shown in Figure 5-5(b).

Once the triangular mesh is created, save the mesh to be read into Tecplot® for the interpolation of top of units. It should also be noted that by adding the XY locations of the groundwater wells, dry wells, and direct pushes to the triangularization step and using the kriging algorithm in Tecplot®, the top of the unit at that location will be exact (i.e., what was observed in the well). If this step is not included, the top of the unit would not be exact because a grid node is not located at the well. Distortion of the mesh at the well locations can be seen if this document is being read as a Portable Document Format (PDF)[7] file, and the reader can zoom into an area in which a well is located.

5.2 INTERPOLATION OF TOP OF UNIT INFORMATION ONTO THE MESH

The next step in the process is to build the model to interpolate the tops of the units onto the mesh built in the previous chapter. Two of the top of the units do not come from the Access® database. These units are the top of the backfill, and the top of the H1 unit. The top of the backfill is nothing more than land surface, while the top of the H1 is land surface, except over the top of the backfill. For all other units, the top of the unit comes from the Tecplot® data file created in Section 4.3. The following subsections describe how each of the top of the units is created and interpolated onto the mesh created in the previous subsections.

[7] Portable Document Format (PDF) is an open standard for electronic document exchange maintained by the International Organization for Standardization and invented by Adobe Systems, Inc., San Jose, California.

Figure 5-4(a). Rotated Grids.

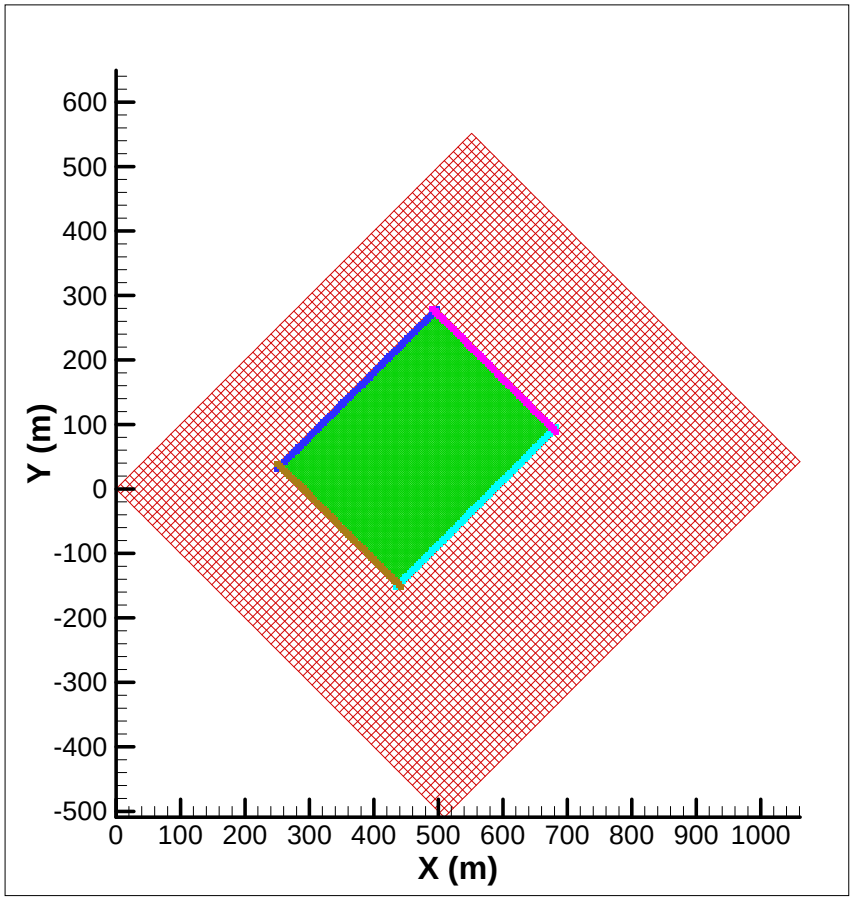


Figure 5-4(b). Rotated Grids Translated to State Plane Coordinates.

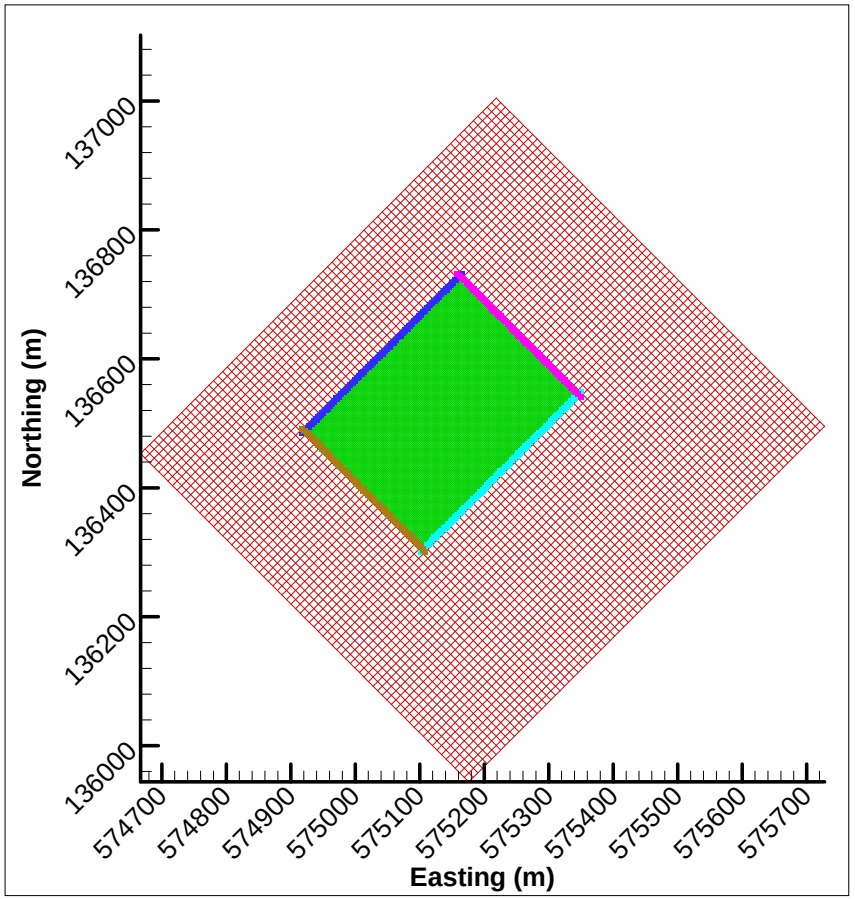


Figure 5-5(a). Rotated Grids with Added Locations of Groundwater Wells, Dry Wells, and Direct Pushes.

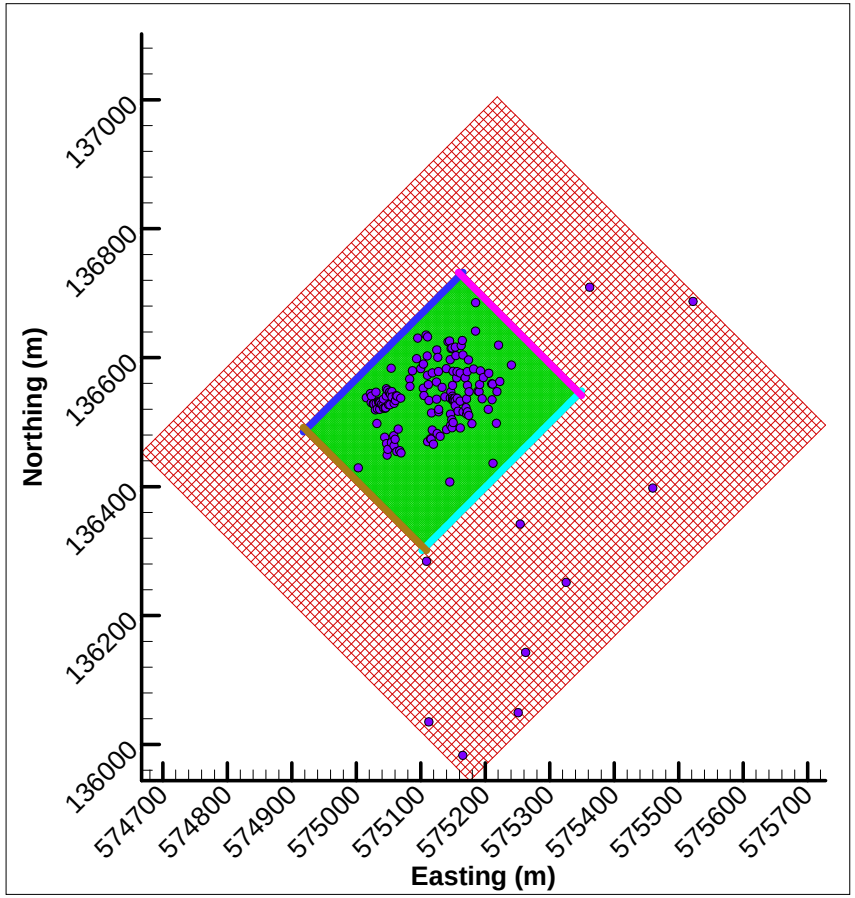
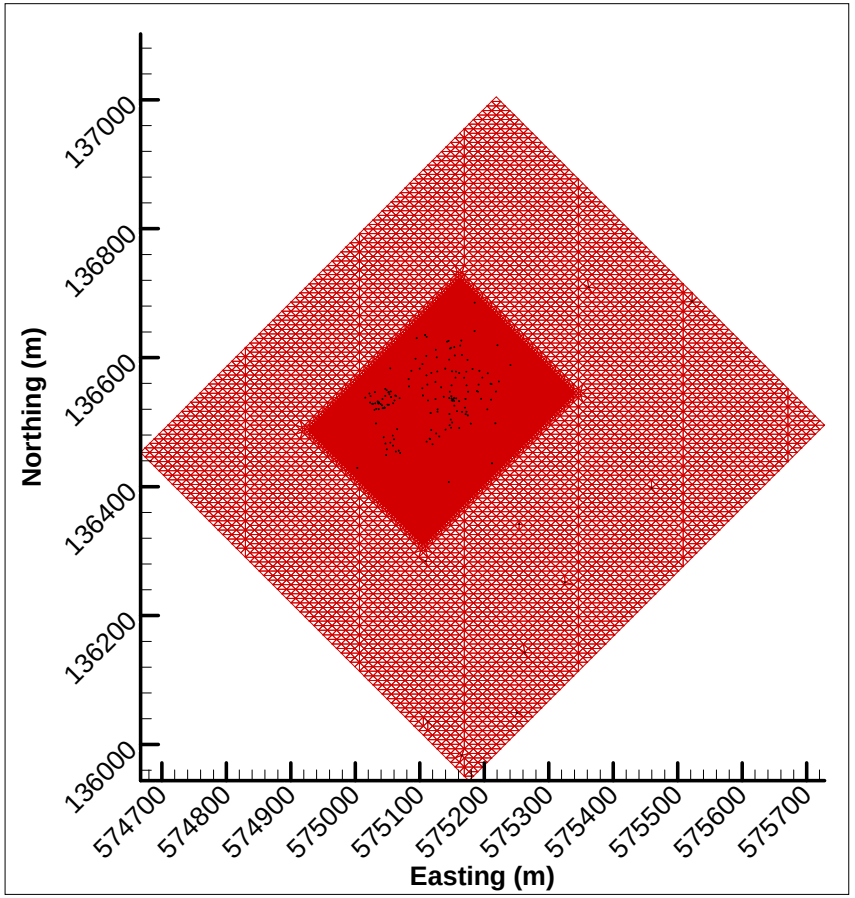


Figure 5-5(b). Rotated Grids with Final Triangular Mesh to be Used for the Interpolation for the Top of Units.



5.2.1 Land Surface

The topography of the land surface is created by the LIDAR coverage collected in 2008 by the Site and is available through Mission Support Alliance Site contractor. A LIDAR shapes coverage is available in a PDF format with the Site broken into numbered rectangular shapes, with each shape representing a region on the Site. For the WMA C area, the rectangular shapes that cover WMA C are numbers 107, 108, 129, and 130. Each of these shapes is in an ASCII data file that consists of three columns: an easting, a northing, and an elevation. The easting and northing are in State Plane Coordinates, while the elevation is NAVD88. The shape file names are Ground000107.xyz, Ground000108.xyz, Ground000129.xyz, and Ground000130.xyz. Each of these files is edited to include the following Tecplot® header placed at the top of the file:

Variables = “Easting (m)”, “Northing (m)”, “Elevation (m)”
Zone T= “Ground000107”
DT = (DOUBLE DOUBLE SINGLE).

After editing the files to include the header, open them in Tecplot®; use multiple file dialog and have the filter set to “*.*” since they do not have a normal Tecplot® extension. After the files are read into Tecplot®, choose 2D Cartesian from the plot style menu, one zone style menu, go to scatter tab, select all zone, and set symbol type to point, choose color as multi and select C1. Next read in the triangulation mesh, created in the previous section. You will get an error message because that mesh does not have an elevation variable; ignore it. The white areas within the flooded region are buildings. Go to Plot/2D Order and select by zones. Click on Zone Style Button, turn off the mesh for Zones 1 through 4, turn on the mesh for Zone 5 and turn off the scatter layer for Zone 5. The plot you should see is given in Figure 5-6(a). Go to “Data/Alter Specify Equations…” type {UnitID} = 0 in the equation box, select all zones, then calculate. Now type {UnitID} = 9 and select Zone 5, then calculate. Go to “Data/Interpolate/Linear”, select Triangulation zone for source zone, select UnitID for variable, select Destination Zone “Ground000107”, Select Do Not Change for Outside Points. This is used to blank all LIDAR data points outside of the triangular mesh. Repeat this step for Zones 2 through 4.

Then go to “Plot/Blanking/Value Blanking/” and turn on value blanking, blank entire cell when primary value is blanked, make constraint 1 active, choose UnitID for blanking variable, set “is equal to” constant and set value to 0. Figure 5-6(b) shows the result of implementing value blanking. Next go to Data/Interpolate/Kriging, select Zones 1 to 4; select only Elevation as the variable; set Zone 5 (i.e., triangulated mesh) as the destination zone, set the range to be 0.3 (default value), set the zero value to be 0 (default value); set the drift to be linear (default value), and the point selection to be octant (default value) with the number of points to be 8 (default value). To find out what these selections actually do, please read the Tecplot® User’s manual. Next hit the “Compute” button to create a mesh with the land surface elevations. It will take it some time to perform this calculation.

Figure 5-6(a). Laser Imaging, Detection and Ranging Data as Scatter Symbols Colored to Elevation along with the Triangular Mesh.

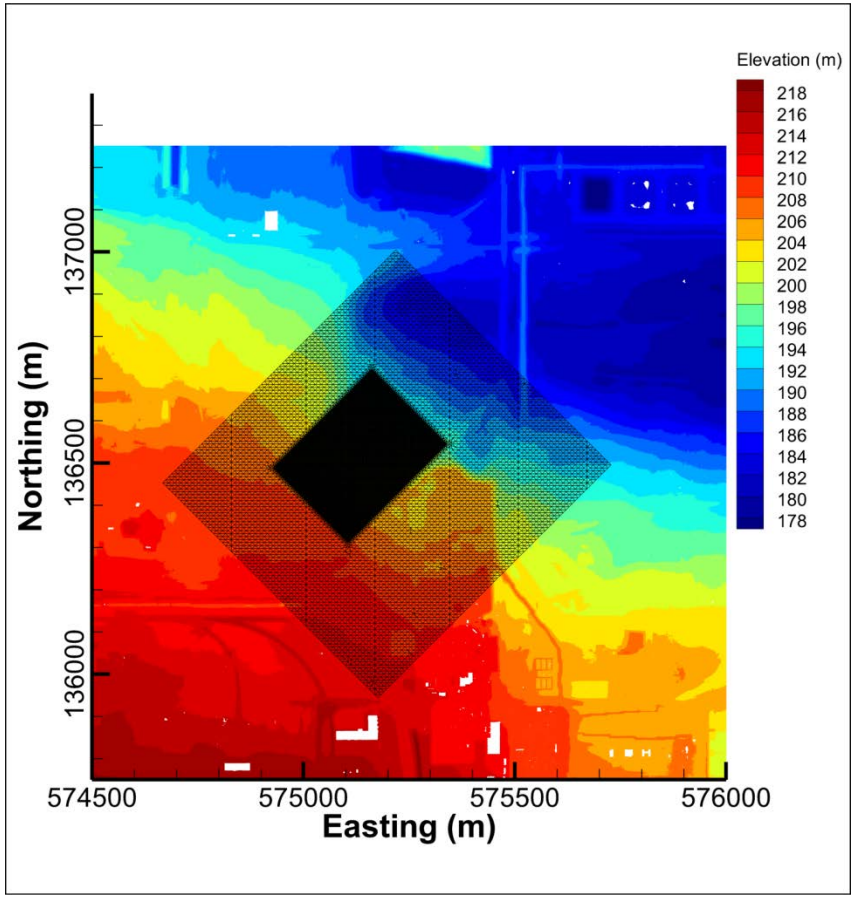


Figure 5-6(b). Laser Imaging, Detection and Ranging Data as Scatter Symbols Colored to Elevation along with the Triangular Mesh Blanked Outside of Triangular Mesh.

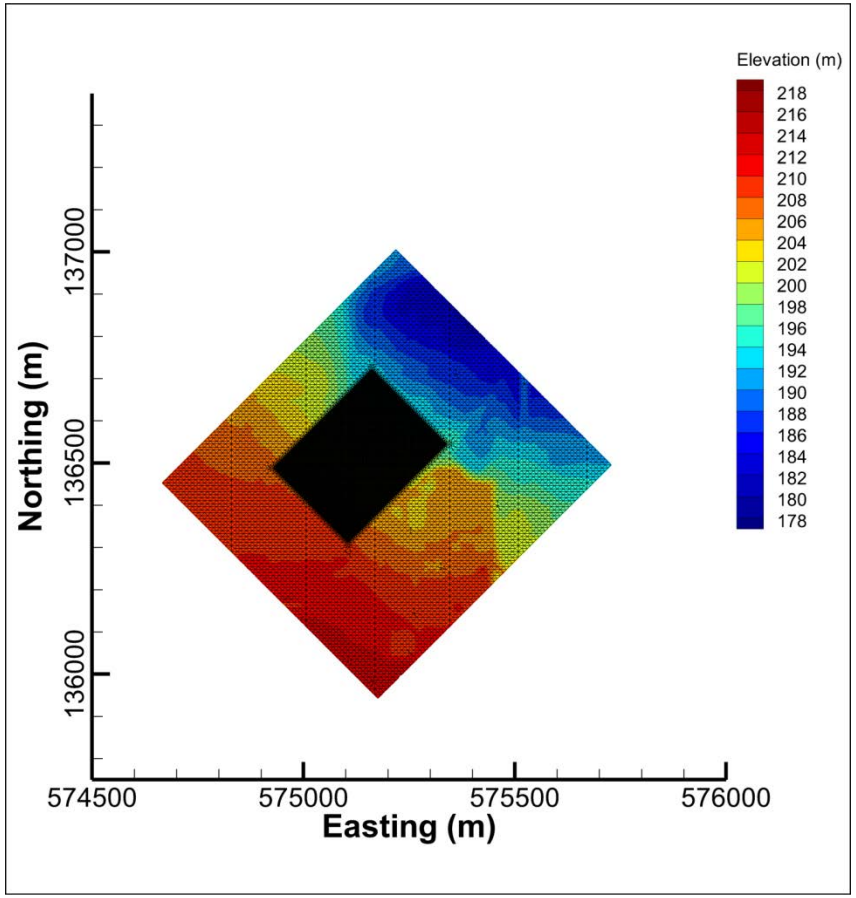


Figure 5-7(a) shows the contour lines from the triangular mesh which represent the elevation at ground surface, while the flooded contours are still the scatter data points from the LIDAR data. This figure shows the difference between the two after kriging. Land surface with a Z-exaggeration of 5 is shown in Figure 5-7(b). The WMA C fence line has been added to this figure along with the contour lines. Note that the area around WMA C shows much finer detail; this is due to the 2-m grid space for the interior of the triangular mesh. The detail in the area of the 10-m grid is missing and only the general pattern of the topography is shown.

5.2.2 Backfill

The bottom of the backfill at WMA C as a mesh was put together a number of years ago through the use of engineered drawings which show the bottom elevation (W-72742, *Hanford Engineer Works 20'-0" Dia. Storage Tanks Arrangement Bldg# 241-T, 241-U, 241-B, 241-C*) of the base of the tanks in NGVD29 and pictures of the construction of the tanks in 1943 shown in WRPS-45154-VA, *Engineered System #1: Recharge and Waste Release within Engineered System in Waste Management Area C*. The process to build this mesh is similar to the description given in Section 5.1 and will not be repeated here. That backfill mesh will be used to create both the land surface over the tank farm and the top of the H1 unit. The backfill surface is given in Figure 5-8(a) along with the contour lines showing elevation in NAVD 88.

Read in the backfillbottom.plt file. Next open the Zone Style dialog, turn on scatter and turn off mesh for the zone Backfill Bottom. Go to “Data/Create Zone/Duplicate” and duplicate the triangular mesh which contains the land surface elevation two times. Now go to “Data/Data Set Info” and when the data set menu appears, click on the first copy of the triangular mesh; rename it “Land Surface” and name the second copy of the mesh “Top of H1”. Then go to “Data/Interpolate/Linear” and select the zone title Backfill Bottom as the source zone, elevation as the only variable, and Top of H1 for destination zone; select “Do Not Change” for outside points; then hit the “Compute” button. The result is shown in Figure 5-8(b).

To get land surface over the backfill area, go to “Data/Alter/Specify Equations…”; select all zones and type the following equation:

```
{Thickness} = 1
```

Then click on the “Compute” button. Select the zone named “Land Surface” only and then type the following equation:

```
{Thickness} = v3 – v3[n], where n is the number on the zone name “Top of H1”
```

Figure 5-7(a). Laser Imaging, Detection and Ranging Data as Scatter Symbols Colored to Elevation along with the Contour Lines from the Triangular Mesh after the Kriging Interpolation.

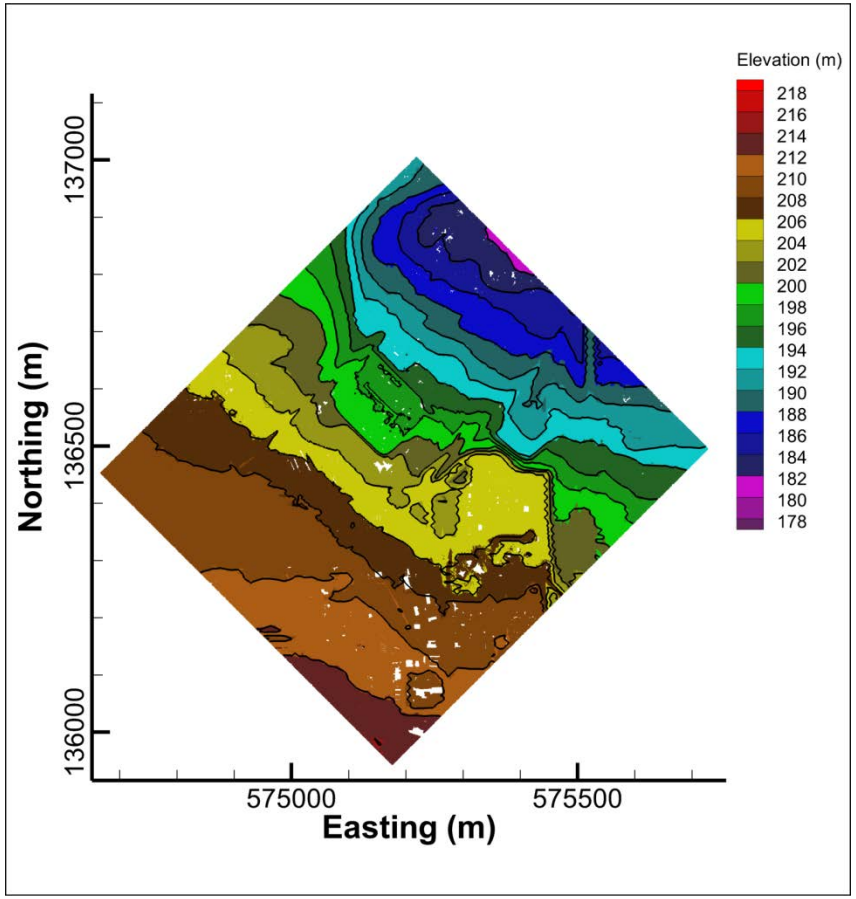


Figure 5-7(b). Land Surface with the Z-Exaggerated 5 to 1 over the Horizontal Distance.

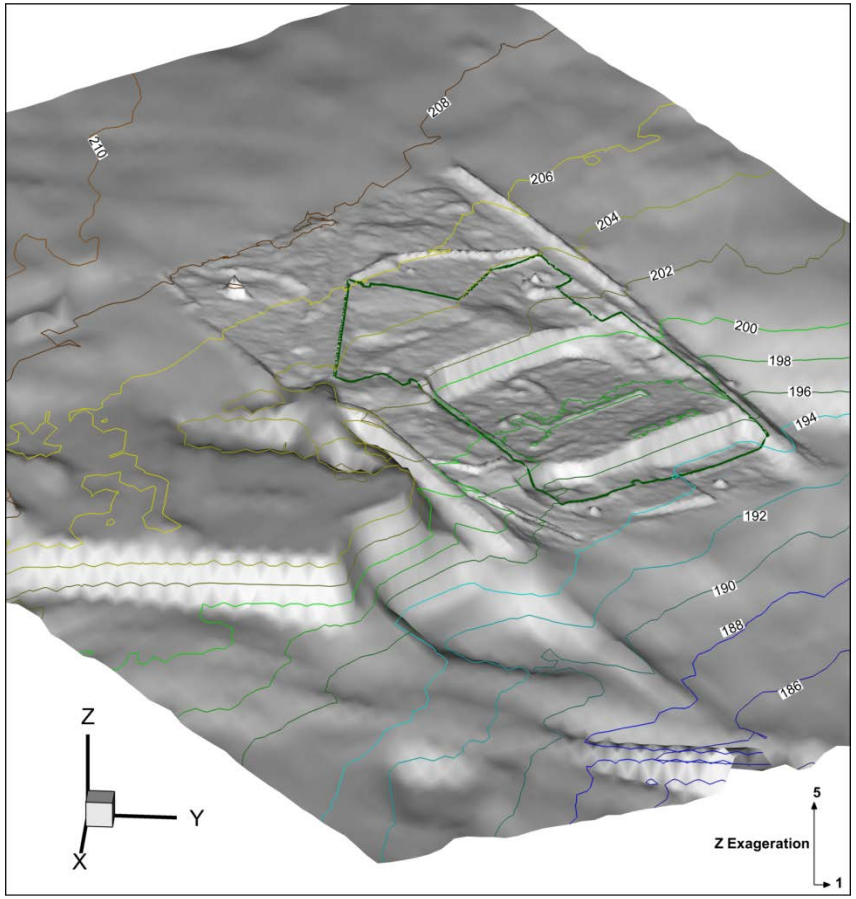


Figure 5-8(a). Bottom of Backfill Surface.

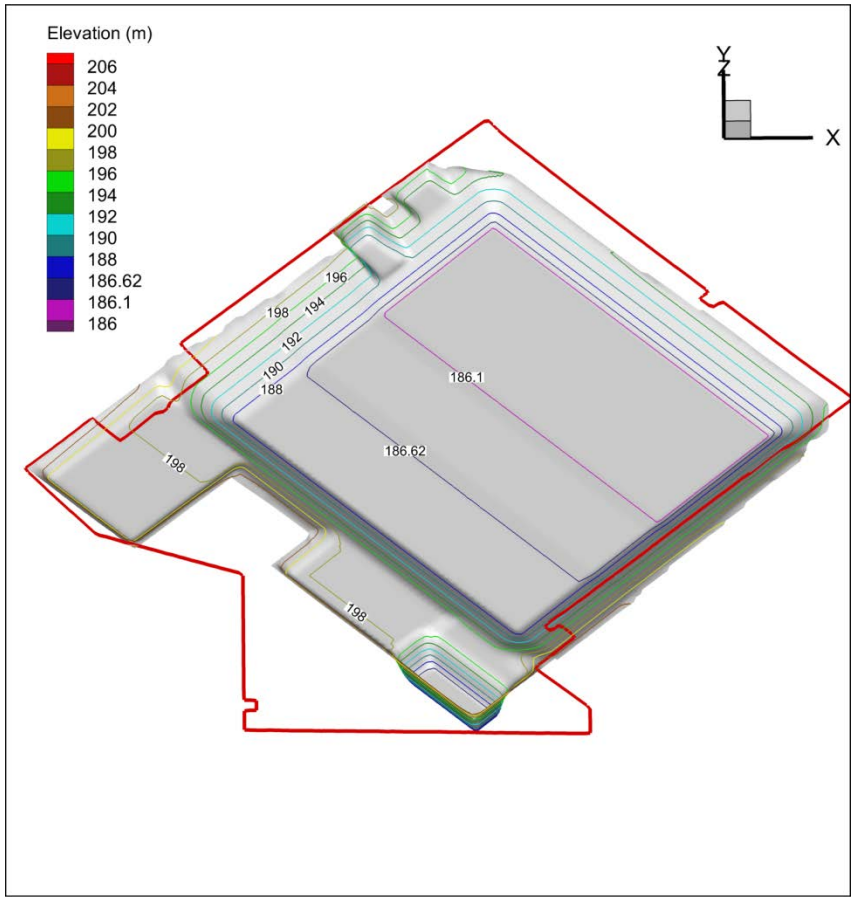
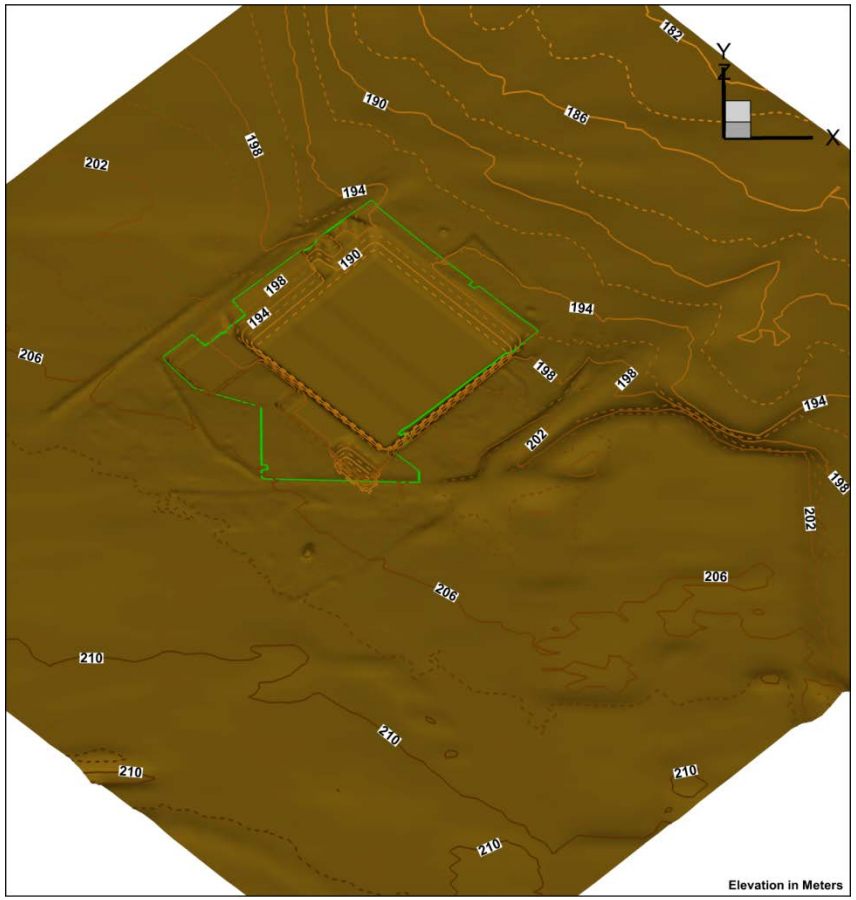


Figure 5-8(b). Bottom of Backfill Linearly Interpolated onto Triangular Mesh.



This equation will subtract the elevation given in the zone named “Top of H1” from the zone named “Land Surface”; where the elevations coincide, the value for variable thickness will be zero (Note: There may be a few values with a thickness less than zero, and that is caused by the linear interpolation of the BackfillBottom zone because the mesh spacing there is 1 m). After calculating thickness, go to “Plot/Blanking/Value Blanking”; choose “Include Value Blanking”, choose “All corners are blanked”; select Constraint 8 and turn active; select “Thickness” variable, when it is less than or equal to 0. The result is shown in Figure 5-9(a).

5.2.3 Top of Units through to Unconfined Aquifer

The mesh used for the “Top of H1” will now be used to create the top of each unit down to and including the water table or top of the confined aquifer. The process used is the same for each of these units. However, before starting the process, the mesh representing each unit must be prepared. The same process can be used to create the Nez Perce model, only using the well data the Nez Perce have interpreted that these are Tecplot® Zones 133 through 253 plus the outside wells (Zones 254 through 263) in the WellsTecplot.dat file.

5.2.3.1 Mesh Preparation. This is accomplished by duplicating the mesh representing Top of H1 and renaming the duplicated mesh, and making sure the mesh has the same UnitID as that in the WellsTecplot.dat file created in Section 4.3. Follow these steps.

1) Go to “Data/Alter/Specify Equations…”, select zone named “Backfill Landsurface”, type {UnitID} = 8 into the equation(s) box and click on the “Compute” button.

2) Go to “Data/Alter/Specify Equations…”, select zone named “Top of H1 Unit”, type {UnitID} = 7 into the equation(s) box and click on the “Compute” button.

3) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Top of H2 Sand”; go to “Data/Alter/Specify Equations…”, select the zone named “Top of H2 Sand Unit”, type {UnitID} = 6 into the equation(s) box and click on the “Compute” button.

4) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Top of H2 Coarse Gravelly Sand”; go to “Data/Alter/Specify Equations…”, select the zone named “Top of H2 Coarse Gravelly Sand”, type {UnitID} = 5 into the equation(s) box and click on the “Compute” button.

5) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Top of H2 Silt”; go to “Data/Alter/Specify Equations…”, select the zone named “Top of H2 Silt”, type {UnitID} = 4 into the equation(s) box and click on the “Compute” button.

6) Repeat step 5 but rename it to “Top of H2 Silt Pinch”.

7) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Top of H3/CC_U/RF”; go to “Data/Alter/Specify Equations…”, select the zone named “Top of H3/CC_U/RF”, type {UnitID} = 3 into the equation(s) box and click on the “Compute” button.

8) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Water Table”; go to “Data/Alter/Specify Equations…”, select the zone named “Water Table”, type {UnitID} = 2 into the equation(s) box and click on the “Compute” button.

9) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Top of Basalt”; go to “Data/Alter/Specify Equations…”, select the zone named “Top of Basalt”, type {UnitID} = 1 into the equation(s) box and click on the “Compute” button.

10) Go to “Data/Create Zone/Duplicate”, select zone named “Top of H1 Unit”, click on “Create Button”, go to “Data/Data Set Info”, select last zone in list and change the name to “Bottom of Model”; go to “Data/Alter/Specify Equations…”, select the zone named “Bottom of Model”, type {UnitID} = 1 into the equation(s) box and click on the “Compute” button. Select the same zone again and type V3 = 90 into the equation box and click on the “Compute” button. This zone is set at constant elevation of 90 m.

After completing steps 1 through 10, save the zones named “Backfill Landsurface – Bottom of Model” into a Tecplot® binary file. Go to “File/Write Data File/”, then select the zones and all variables and write the file out to GeoModelMesh.plt.

5.2.3.2 Kriging. This section describes the kriging process to calculate the top of units H2 through to the water table. This begins by first reading in the file WellsTecplot.dat created in Section 4.3. Once it is read into Tecplot®, the thickness variable needs to be set to 1.0. Do this by going to “Data/Alter/Specify Equations…”; enter {Thickness} = 1 for all Well zones and then hit the “Compute” button. The contours for the variable UnitID are set to be between 1.5 to 7.5 with an interval as 1; use the Bands tab on the contour dialog to set the colors. The scatter layer is set to 1.0 for size, black outline, with it filled to the color to which the contour is set. Next read in the file GeoModelMesh.plt into the existing data set by adding it. Turn off the scatter symbols and the mesh for this layer, but turn on contours.

After the file is read, it is now set up to do the kriging; before kriging the blanking variable has to be set. Make sure your plot is set to two-dimensional (2-D) mode. Kriging on elevation is not allowed in 3-D mode. Next, the kriging algorithm only uses data points that are not blanked. Go to “Plot/Blanking/Value Blanking”; choose “Include Value Blanking”, choose “primary corner is blanked”; select Constraint 1 and turn active; select “UnitID”, when it is not equal to X (see below for values to use for X). This will turn off all data points in the plot not equal to a user-specified number. The following describes the kriging process for each top of the unit.

H2 Sand Unit	To krig the top of the H2 Sand Unit onto the mesh called Top of H2 Sand Unit, set the X value for blanking constraint 1 to be 6, then go to "Data/Interpolate/Kriging", select the first set of wells from 299-E27-4 (Zone 1) to C8105 (Zone 133) and the outside wells 299-E24-3 (Zone 254) to 299-E27-25 (Zone 263); select variable Elevation (m) only, select Destination Zone "Top of H2 unit (Zone 266)"; set Range to 0.3; set Zero Value to be 0, set Drift to Linear, select Point Selection to All, then click on "Compute" button. After examining the results in 3-D, four wells (299-E27-7, 299-E27-20, C8101, 299-E26-8) did not align with other nearby wells and were removed from the zones for kriging. The kriging was then repeated without those wells. The results for this top of unit after repeating the kriging are shown in Figure 5-9(b) including the elevation contour lines. The ball symbols on the plot are the data points for the top of the H2 Sand Unit.
H2 Coarse Gravelly Sand	To krig the top of the H2 Coarse Gravelly Sand onto the mesh called Top of H2 Coarse Gravelly Sand, set the X value for blanking constraint 1 to be 5, then go to "Data/Interpolate/Kriging", select the same wells used for the H2 Sand Unit. The results of the kriging for this top of unit are shown in Figure 5-10(a). The ball symbols on the plot are the data points for the top of the H2 Coarse Gravelly Sand. Wells 299-E27-7 and 299-E27-14 were removed due to inconsistency with other wells (i.e., bull's-eye effects).
H2 Silt	To krig the top of the H2 Silt onto the mesh called Top of H2 Silt, set the X value for blanking constraint 1 to be 4, then go to "Data/Interpolate/Kriging", select the same wells used for the H2 Unit. After examining the results of the kriging effort and then comparing it against the Nez Perce alternative model complete with discussions with Mr. Kent Reynolds of Energy*Solutions*, Inc. and Dr. Stan Sobcyzk of the Nez Perce, a decision was made to use the surface generated by the geologic picks for the top of this unit from the Nez Perce. Using the Nez Perce picks for this unit also maintains the overall dip of the geologic layers to the northeast. The results of the kriging for this top of unit are shown in Figure 5-10(b). The ball symbols on the plot are the data points for the top of the H2 Silt.
H3	To krig the top of the H3/CC_U/RF Unit onto the mesh called Top of H3/CC_U/RF, set the X value for blanking constraint 1 to be 3, then go to "Data/Interpolate/Kriging", select the same wells used for the H2 Unit. After examining the results in 3-D, two wells (299-E24-22 and 299-E26-8, shown as red symbols) did not align with other nearby wells and were removed from the zones for kriging. The kriging was then repeated without those wells. Following the examination of the second kriging and comparing it to the surface created by the Nez Perce, a decision was made in consultation with Mr. Reynolds and Dr. Sobczyk to use the geologic picks from the Nez Perce for wells 299-E27-21 and 299-E27-155. The kriging was repeated after these changes. The results for this top of unit after these changes are shown in Figure 5-11(a). Nez Perce geologic picks are shown as yellow symbols on this figure. The ball symbols on the plot are the data points for the top of the H3/CC_U/RF Unit.

Water Table To krig the Water Table onto the mesh called Water Table, set the X value for blanking constraint 1 to be 2, then go to "Data/Interpolate/Kriging", select the same wells used for the H2 Unit. After examining the kriging results for all groundwater wells, wells 299-E27-13, 299-E27-24, 299-E27-25, and 299-E27-155 seemed to create bull's-eyes in the water table surface and were removed as data points in the kriging operation. The remaining groundwater wells were krigged again to come up with the water table surface shown in Figure 5-11(b). The ball symbols on the plot are the data points for the June 2013 water table in the vicinity of WMA C.

5.2.4 Top of the Basalt

Few wells reach the top of the basalt in the vicinity of WMA C. The top of the basalt was taken from a regional 200 East Area geologic model developed in the LeapFrog Hydro® geologic modeling data package. The top of the basalt was exported from LeapFrog Hydro® in two files (tob 200e_pt.asc, tob 200e_tr.asc). The first file contains the X, Y, Z of each data point, while the second file contains the connectivity array. Remove the header information from each file (i.e., the first seven lines). After removing the header, there are four columns of numbers.

Copy the columns in the _pt.asc file into Excel® using the text import wizard with a space as delimiter. There should be 22,539 points; next, on line 22540 of the Excel® spreadsheet copy the four columns from the _tr.asc. The triangular connectivity follows the XYZ points. There should be 44,474 triangles defined. Remove the first column in the spreadsheet (the first column in both files contains the count of either points or triangles). There should be 67,013 (22,539 + 44,474) rows in the Excel® spreadsheet; copy that data into a text editor and add the Tecplot® header given below, then save the file and read it into the existing Tecplot® data set by adding it. Tecplot® will display a warning about missing variables; ignore it.

Tecplot® Header:

```
Variables = "Easting (m)", "Northing (m)", "Elevation (m)"
Zone T="Top of Basalt LeapFrog"
 STRANDID=0, SOLUTIONTIME=0
 Nodes=22539, Elements=44474, ZONETYPE=FETriangle
 DATAPACKING=Point
 DT=(DOUBLE DOUBLE DOUBLE )
```

Note that Word 2010 may use a different character for the quotes. If the file errors out while reading it, replace the quotation characters.

After reading the LeapFrog Hydro® data into Tecplot®, go to "Data/Alter/Specify Equations…" and select last zone read in the list; it should have a title of "Top of Basalt LeapFrog". Type the following equations into the Equation(s) box:

```
{UnitID} = 1
{Thickness} = 1
```

Figure 5-9(a). Land Surface over the Backfill.

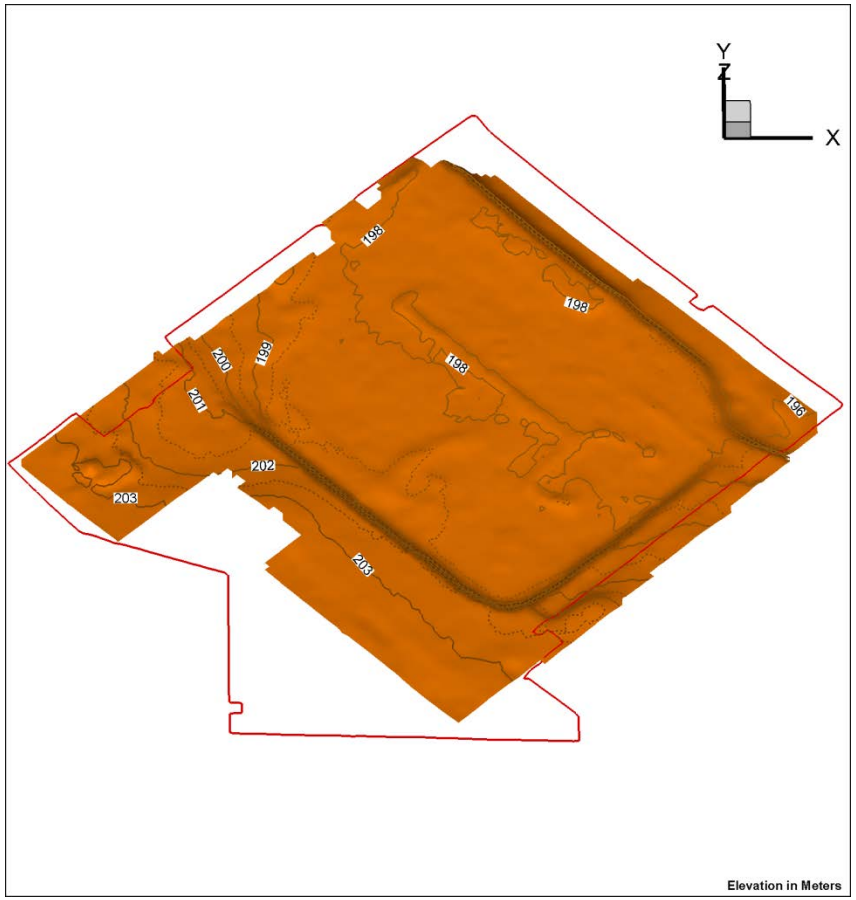


Figure 5-9(b). Kriging Results for the Top of the H2 Sand Unit.

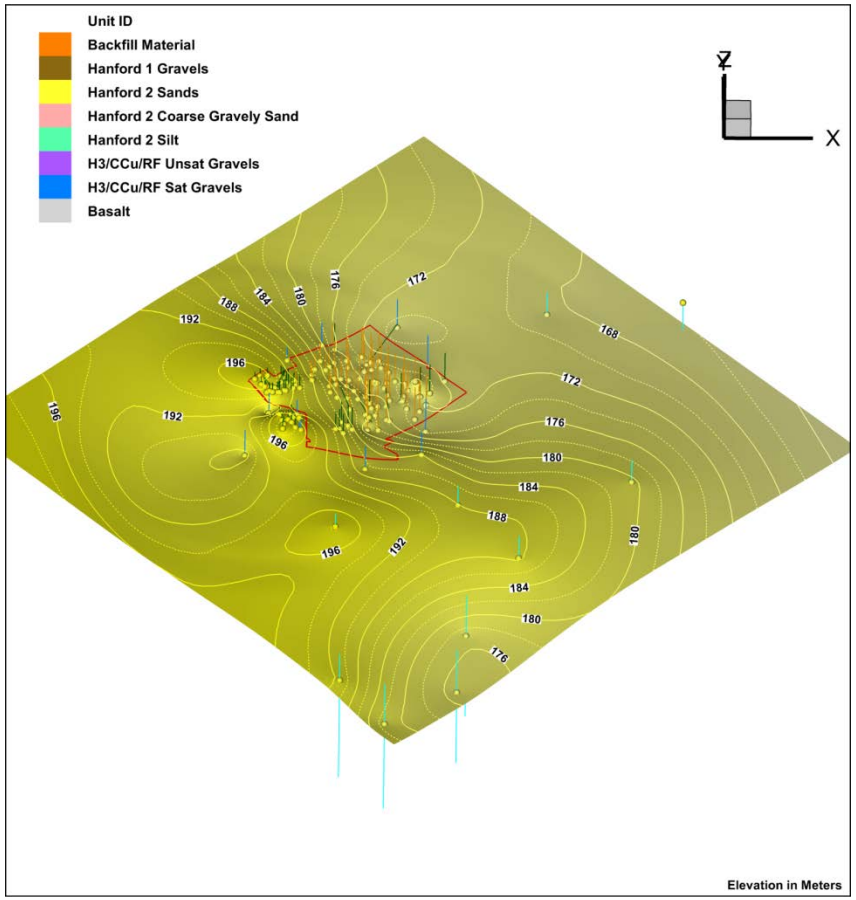


Figure 5-10(a). Kriging Results for the Top of the H2 Coarse Gravelly Sand.

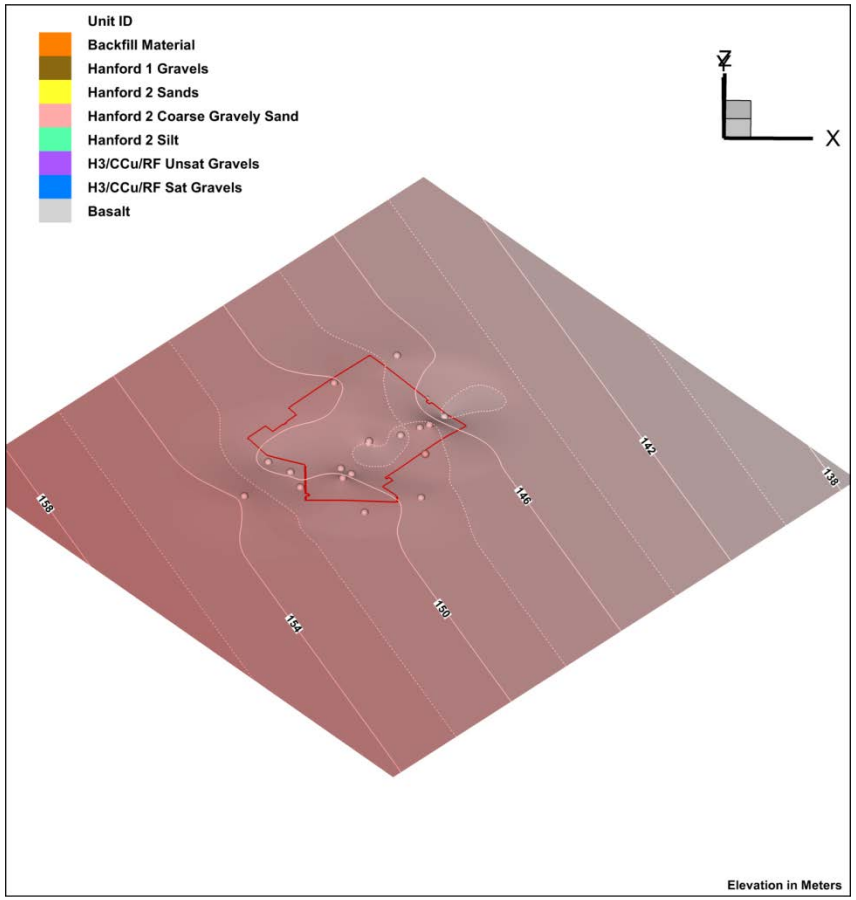


Figure 5-10(b). Kriging Results for the Top of the H2 Silt.

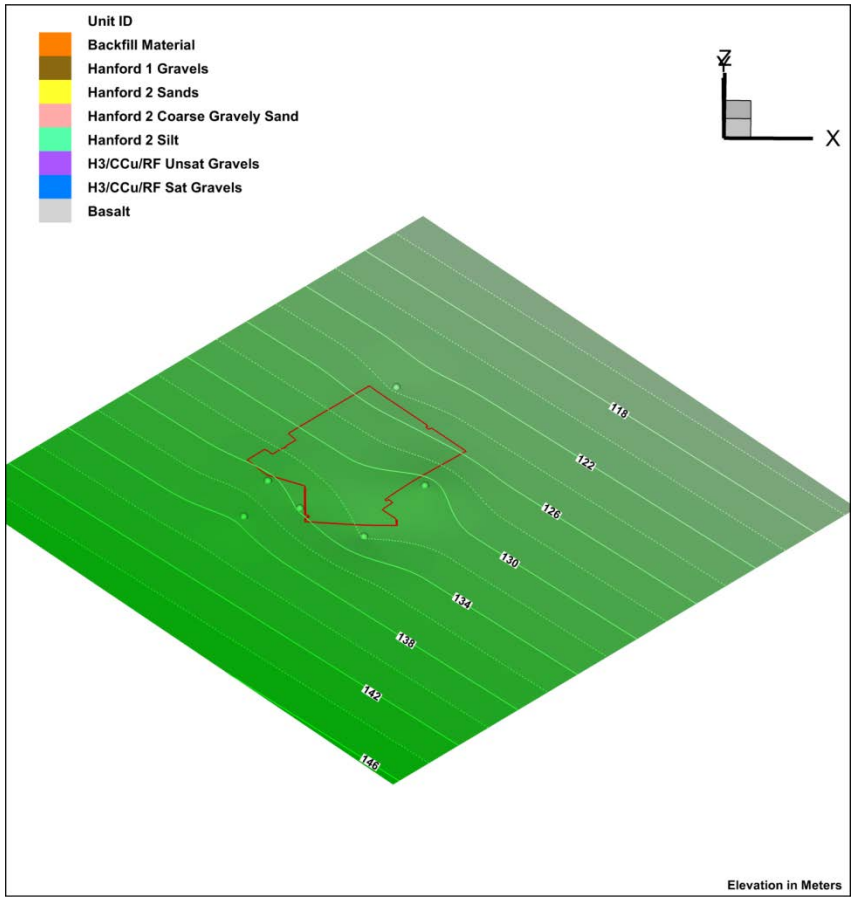


Figure 5-11(a). Kriging Results for the Top of the H3/CC$_U$/RF Unit.

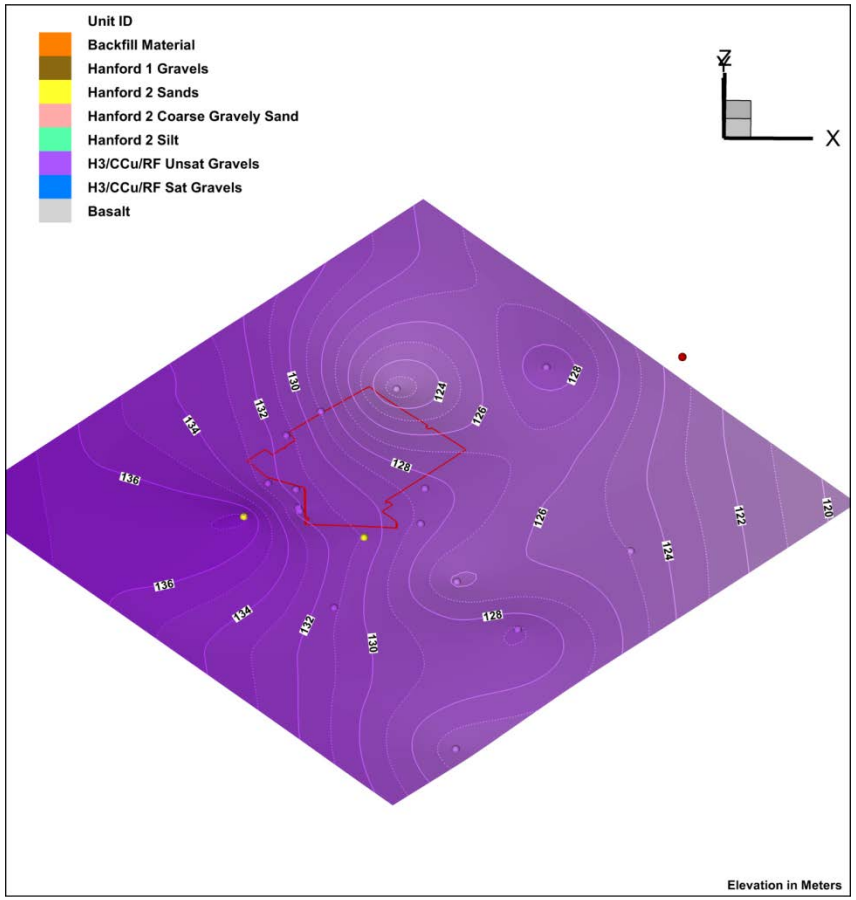
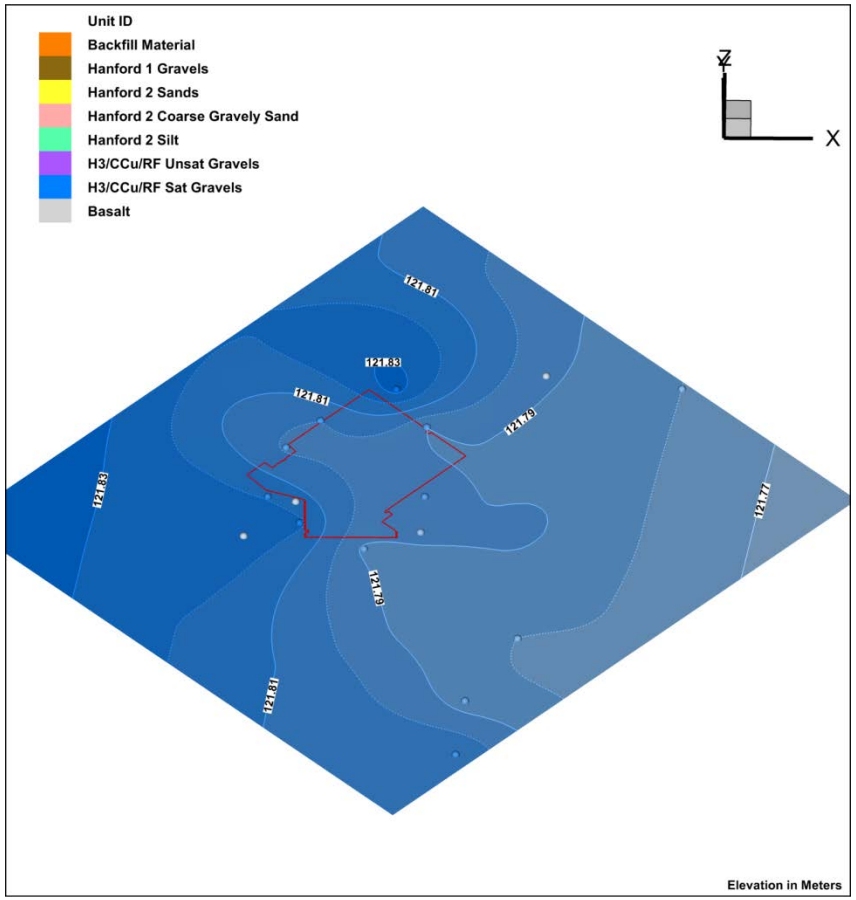


Figure 5-11(b). Kriging Results for the Water Table.



Click on the "Compute" button. Next, set the X value for blanking constraint 1 to be 1, then go to "Data/Interpolate/Linear", select "Top of Basalt LeapFrog" and the destination zone as "Top of the Basalt". Then click on the "Compute" button. Figure 5-12(a) shows the result of the linear interpolation. Delete the zone "Top of the Basalt LeapFrog" (Data/Delete/Zone). All layers are shown in Figure 5-12(b). Each of these layers can easily be exported into a LeapFrog Hydro® compatible file using the ***ToLeapFrog*** developed for Tecplot®.

5.2.5 H2 Silt Pinched

After examining all Top of Unit surfaces, Figure 5-13(a) shows the H2 Silt pinching out. To have geologic model pinching out so the interpolation of material properties to STOMP© is correct, the surface of H2 Silt must match the surface of H3 where the pinchout occurs. To accomplish this, first turn off value blanking for constraint 1, but leave it on for constraint 8 (i.e., thickness less than or equal to 0) and turn on only Top of H2 Silt and Top of H3 zones. Then go to "Data/Alter/Specify Equations…" and select zone titled "Top of H2 Silt Pinch" (in this example, this is Zone 269) and type the following equations into the Equations box:

`V3 = V3[268]`	→ Sets the value for Elevation for Zone 269 to be the same as 268
`V3= MAX(V3,V3[270])`	→ Takes Maximum Elevation between H3 and H2 Silt
`{Thickness}=V3-V3[270]`	→ Calculates the thickness between H2 Silt and H3

What these equations do is to set the Elevation of the H2 Silt below the H3 layer to the same elevation as the H3 layer. It then calculates a thickness for the H2 Silt if the thickness is less than or equal to 0; that portion of the H2 Silt is blanked [Figure 5-13(b)].

5.3 BUILDING THE DIGITAL GEOLOGIC MODEL

After all the tops of the units have been interpolated onto the triangular meshes, a Tecplot® add-on (VolumeZone) can be used to create a 3-D block diagram of the stratigraphy. This add-on will take two 2-D Tecplot® meshes that either have the same number of IJ cells or, if finite element zones have the same number of points and elements, combine them together to make a volume zone. Load the add-on either by including it in the tecplot.add file in the Tecplot® home folder or drag and drop it onto Tecplot® interface. Each stratigraphic layer is put together separately, so to create the volume zone, go to "TecGeo/Create Volume Zone" and a menu comes up. The Z variable should be set to "Elevation (m)"; select the Top Grid (it should be higher in elevation than the Bottom Grid), then select the Bottom Grid. If desired, change the name of the volume zone; if not, click on the button "Create Volume Zone" and a volume zone representing the stratigraphic layer is created. Follow these steps to create each stratigraphic layer in the model.

Backfill — Click on the zone titled "Backfill Landsurface" for Top Grid; next, click on the zone titled "Top of H1" and change title to "Backfill Volume". Then go to "Data/Alter/Specify Equations…", select the "Backfill Volume" zone and type `{UnitID} = 8` in the Equations box, then click on "Compute" button. After putting the volume zone together, the bottom grid will have its old

	UnitID and that needs to be corrected. Since Backfill Landsurface zone has areas with a thickness of 0, those areas will be blanked using constraint 8 with thickness set to 0.
H1	Click on the zone titled "Top of H1" for Top Grid; next, click on the zone titled "Top of H2" and change title to "H1 Volume". Then go to "Data/Alter/Specify Equations…", select the "H1 Volume" zone and type {UnitID} = 7 in the Equations box, then click on "Compute" button.
H2 Sand	Click on the zone titled "Top of H2 Sand" for Top Grid; next, click on the zone titled "Top of H2 Coarse Gravelly Sand" and change title to "H2 Sand Volume". Then go to "Data/Alter/Specify Equations…", select the "H2 Sand Volume" zone and type {UnitID} = 6 in the Equations box, then click on "Compute" button.
H2 Coarse Gravelly Sand	Click on the zone titled "Top of H2 Coarse Gravelly Sand" for Top Grid; next, click on the zone titled "Top of H2 Silt Pinch" and change title to "H2 Coarse Gravelly Sand Volume". Then go to "Data/Alter/Specify Equations…", select the "H2 Coarse Gravelly Sand Volume" zone and type two equations – {UnitID} = 5 and {Thickness} = 1 (because the bottom grid will have thickness of zero in certain regions of its grid) – in the Equations box, then click on "Compute" button.
H2 Silt	Click on the zone titled "Top of H2 Silt Pinch" for Top Grid; next, click on the zone titled "Top of H3/CC_U/RF" and change title to "H2 Silt Volume". Then go to "Data/Alter/Specify Equations…", select the "H2 Silt Volume" zone and type {UnitID} = 4 in the Equations box, then click on "Compute" button.
Undifferentiated H3/CC_U/RF	Click on the zone titled "Top of H3/CC_U/RF" for Top Grid; next, click on the zone titled "Water Table" and change title to "H3/CC_U/RF Vadose Volume". Then go to "Data/Alter/Specify Equations…", select the "H3/CC_U/RF Vadose Volume" zone and type {UnitID} = 3 in the Equations box, then click on "Compute" button.
Undifferentiated H3/CC_U/RF Unconfined Aquifer	Click on the zone titled "Water Table" for Top Grid; next, click on the zone titled "Top of Basalt" and change title to "H3/CC_U/RF Unconfined Aquifer". Then go to "Data/Alter/Specify Equations…", select the "H3/CC_U/RF Unconfined Aquifer" zone and type {UnitID} = 2 in the Equations box, then click on "Compute" button.
Basalt	Click on the zone titled "Top Basalt" for Top Grid; next, click on the zone titled "Bottom of Model" and change title to "Basalt". Then go to "Data/Alter/Specify Equations…", select the "Basalt" zone and type {UnitID} = 1 in the Equations box, then click on "Compute" button.

Figure 5-12(a). Top of Basalt from LeapFrog Hydro® 200 East Area Model.

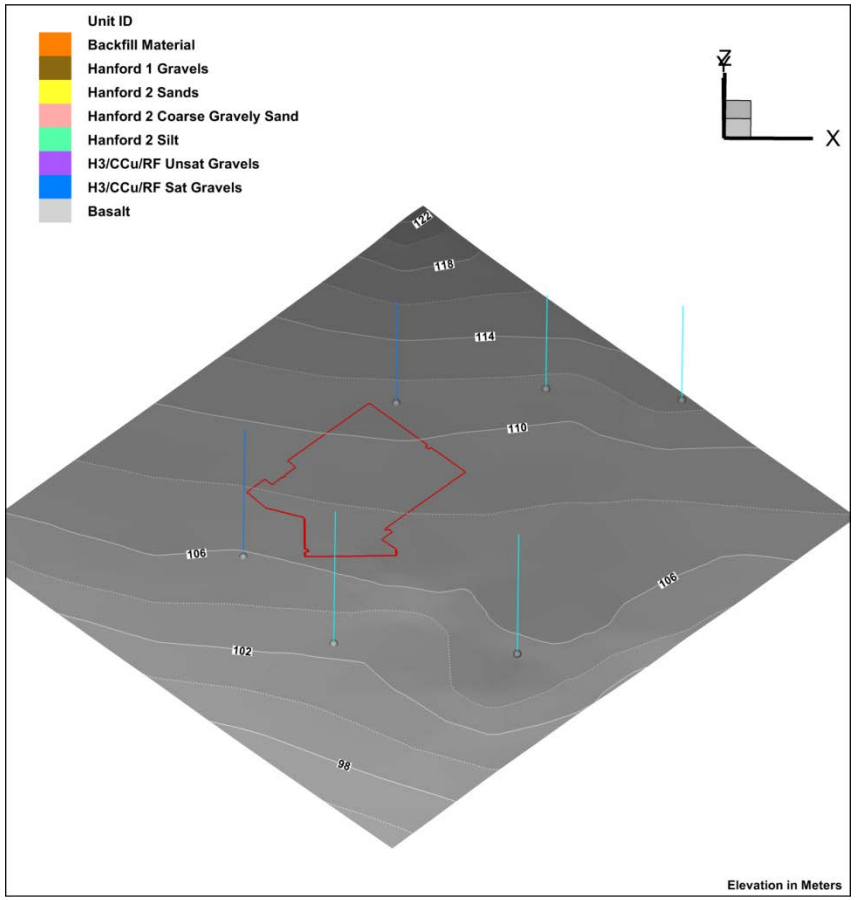
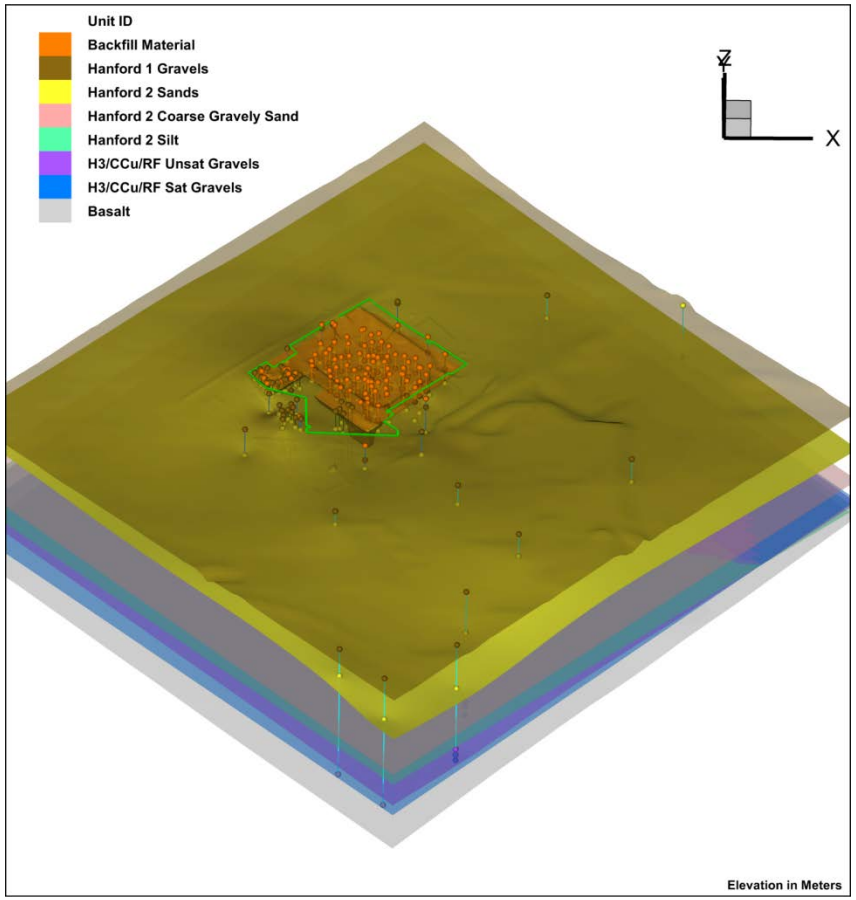


Figure 5-12(b). All Top of Units are Shown.



The LeapFrog Hydro® visualization software is a registered trademark of ARANZ Geo Limited, Christchurch, New Zealand
(see http://www.leapfrog3d.com/products/leapfrog-hydro).

Figure 5-13(a). H2 Silt Pinching out into the H3 Unit.

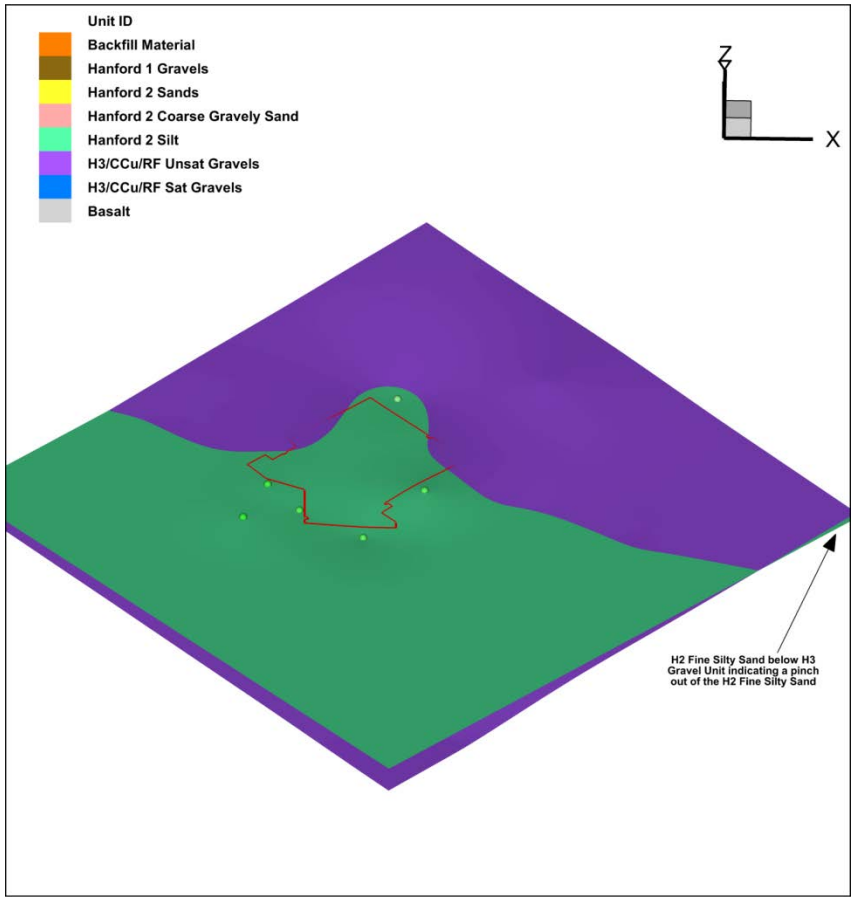


Figure 5-13(b). Removal of H2 Silt underlying the H3 Unit.

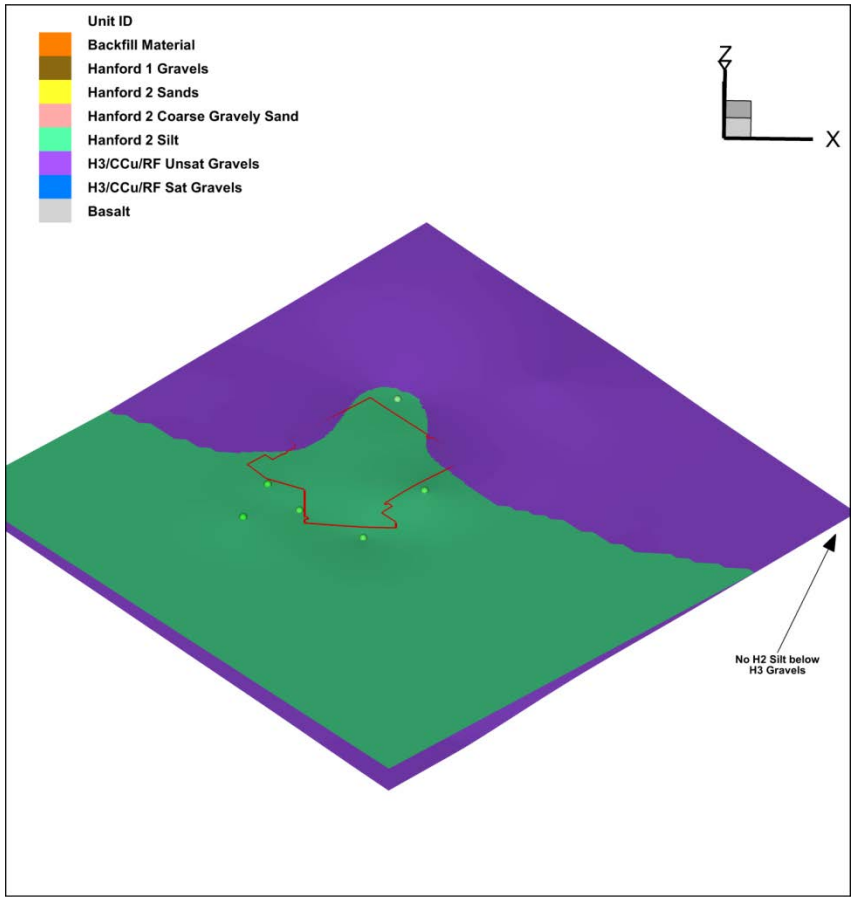


Figure 5-14(a) and Figure 5-14(b) show the different stratigraphic layers in the geologic model. Figure 5-14(a) is a simple block diagram of the geologic model, while Figure 5-14(b) shows the model as transparent with cross-sections.

5.4 USING THE ALTERNATIVE GEOLOGIC MODEL I TO INTERPOLATE STRATIGRAPHY ONTO A SUBSURFACE TRANSPORT OVER MULTIPLE PHASES© MODEL

Once the geologic model is built, it can be used to assign material property values to a STOMP© model. However, for the STOMP© model material properties to display properly, the STOMP© model must be displayed as cell-center data, not cell-centers as node values. In Tecplot®, nodes are located at the intersection of cell interfaces. See Figure 5-15(a) which shows the differences between cell-centers and nodes. In this figure, the nodes are the blue cubes located at the intersection of the cell faces, while the cell-centers are shown as red spheres. Tecplot® cannot interpolate to cell-centers. STOMP© uses cell-centers, but calls them nodes. The reader for STOMP© in Tecplot®, can create a grid based on the cell intersections, which will have a size of (I,J,K) or create a grid based on the cell-centers with a size of (I-1,J-1,K-1). With a grid of cell-centers as nodes, the cell-center is located correctly in XYZ space, but the cells are not displayed correctly [Figure-15(b) green grid block within the nodal volume].

To interpolate the UnitID values as Rock/Soil type values in a STOMP© grid, write out the volume zones built in the previous section, call it *stratigraphy.plt*. Create a new Tecplot® layout and read in the *stratigraphy.plt* file. Now read in a STOMP© nodes-based file (STOMP*cellcenter.plt*) as Tecplot® nodes. In this example, there are (54, 52, 36) cell-centers. The STOMP© cell-center grid is shown within the stratigraphy in Figure 5-16(a). To linearly interpolate in 3-D Mode, follow these steps.

1) Go to “Data/Linear Interpolate…”. Select the source zone(s) named “Backfill Volume”, select UnitID as interpolation variable; select Destination Zone “Stomp Cell-Center”, select Do Not Change Outside Points, click on “Compute” button.

2) Go to “Data/Linear Interpolate…”. Leave everything the same except select “H1 Volume” for the source zone. Then click on “Compute” button.

3) Go to “Data/Linear Interpolate…”. Leave everything the same except select “H2 Volume” for the source zone. Then click on “Compute” button.

4) Go to “Data/Linear Interpolate…”. Leave everything the same except select “H2 Coarse Gravelly Sand Volume” for the source zone. Then click on “Compute” button.

5) Go to “Data/Linear Interpolate…”. Leave everything the same except select “H2 Silt Volume” for the source zone. Then click on “Compute” button.

6) Go to “Data/Linear Interpolate…”. Leave everything the same except select “H3/CC_U/RF Volume” for the source zone. Then click on “Compute” button.

Figure 5-14(a). Alternative Geologic Model I of the Vicinity around Waste Management Area C Z-Exaggeration 2 to 1.

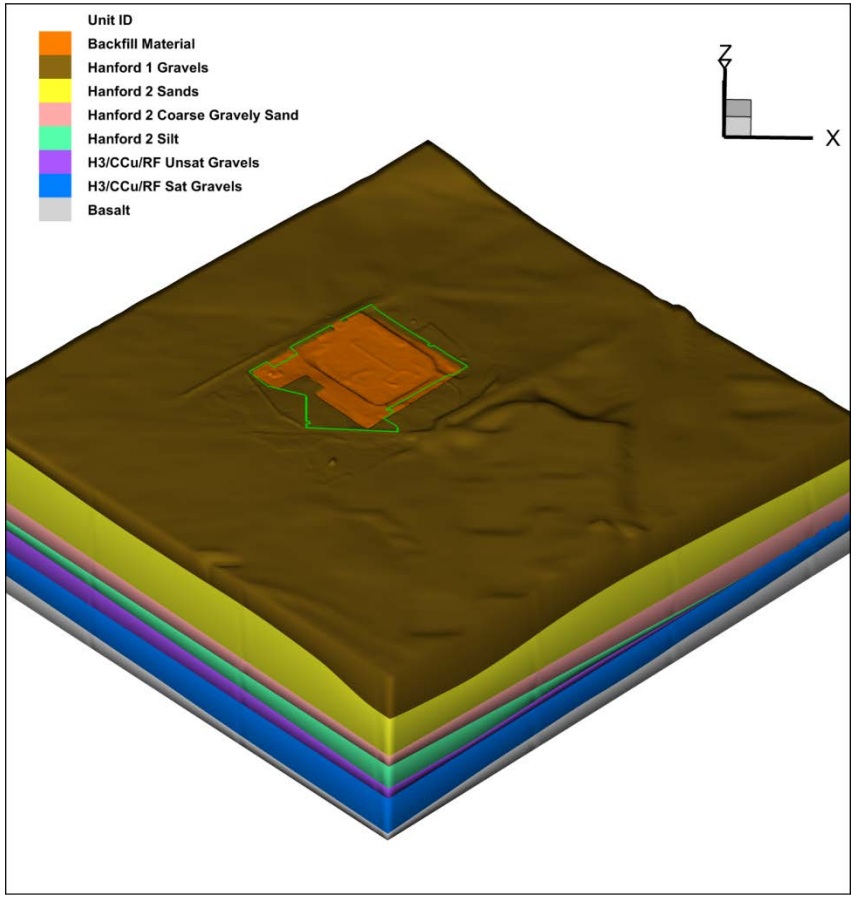


Figure 5-14(b). Alternative Geologic Model I of the Vicinity around Waste Management Area C with Cross-Sections Z-Exaggeration 2 to 1.

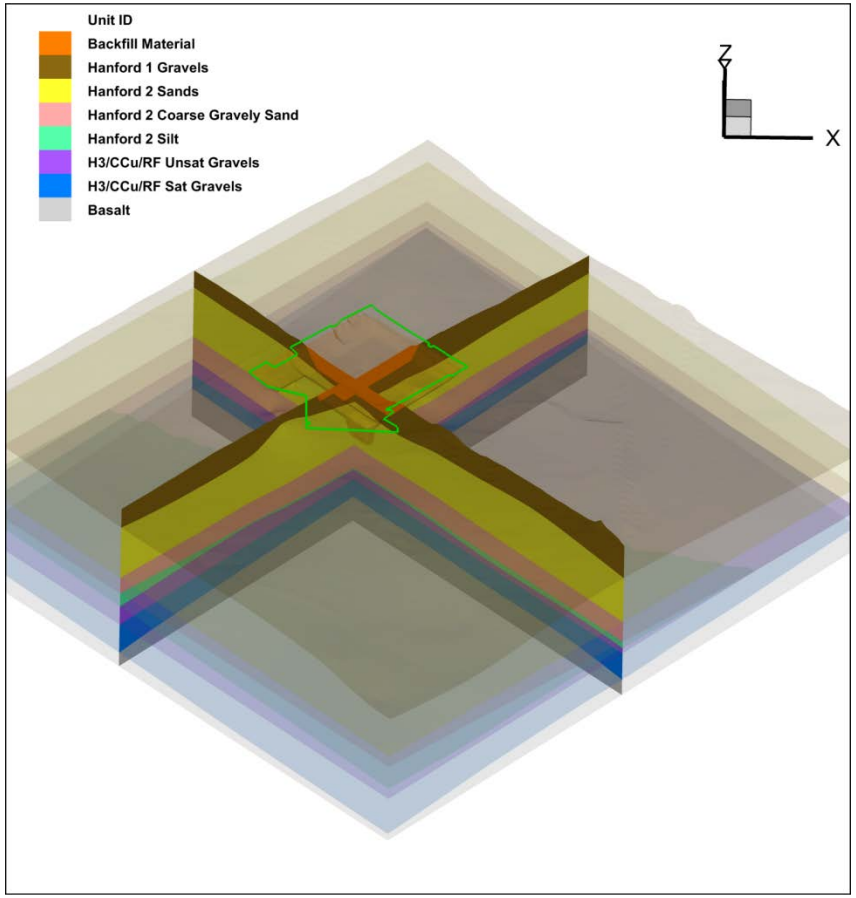


Figure 5-15(a). Node at the Corner and Cell-Centers.

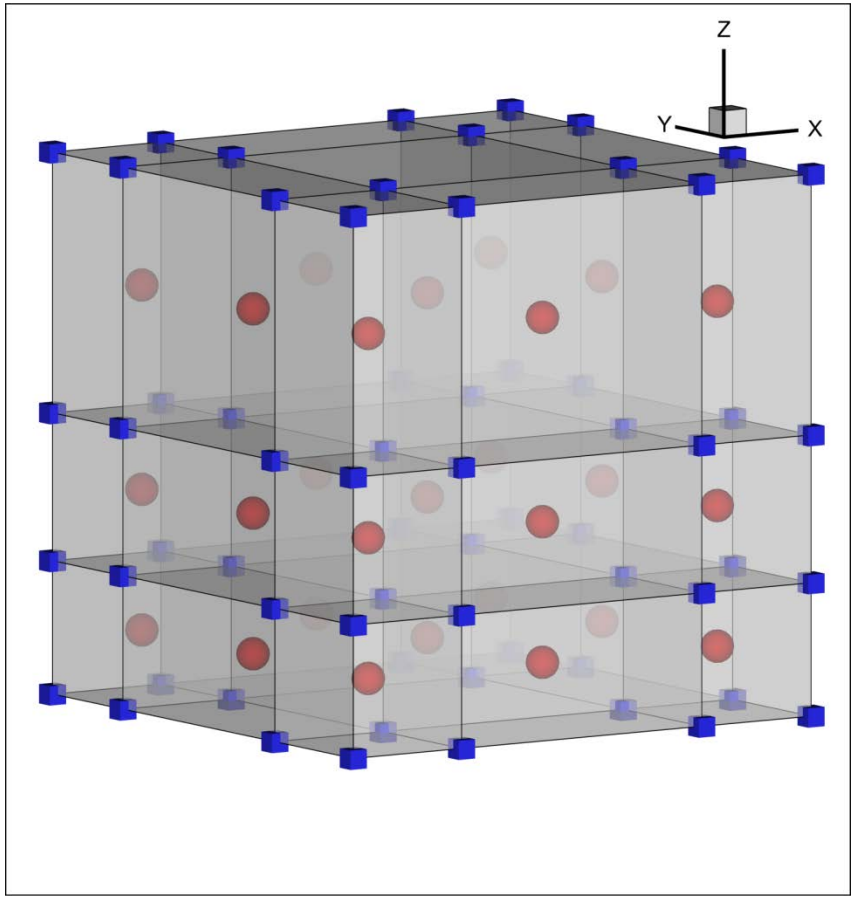
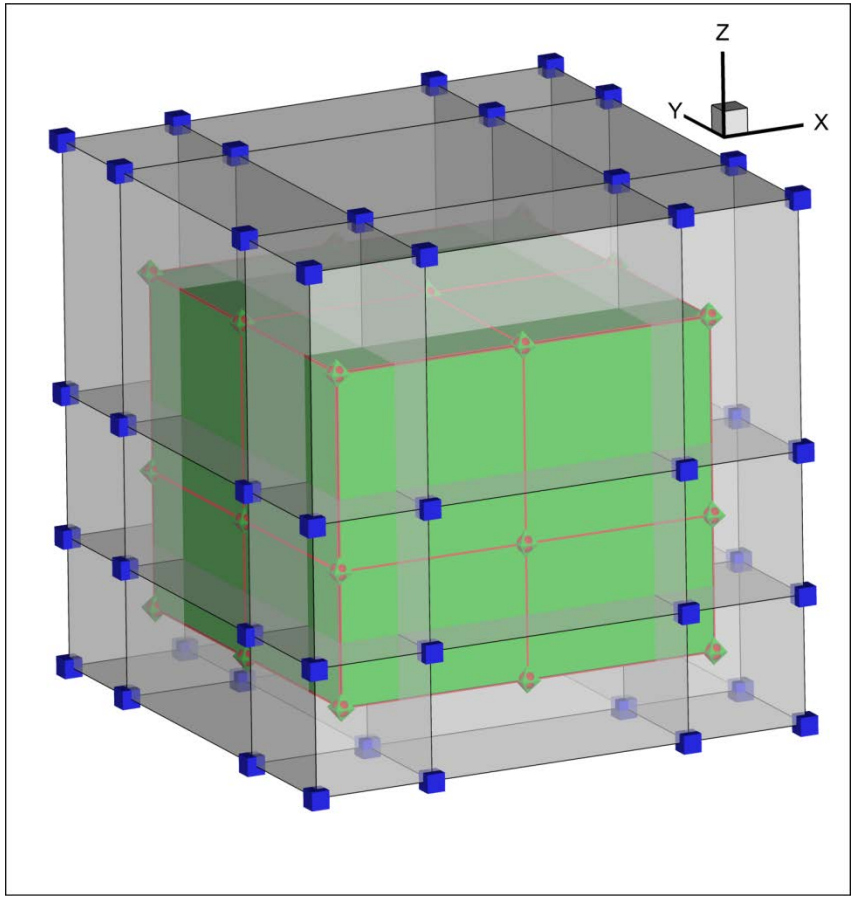


Figure 5-15(b). Cell-Centers as a Node-Base Grid (green).



This STOMP© grid does not extend to the water table or into the basalt, so it is not necessary to interpolate on either of those zones. This was done in a step wise process because it is faster than selecting all zones as the source zone(s). After the interpolation, write out only the variable "UnitID" for the STOMP© Cell-Center zone in a Tecplot® ASCII data file (call it RockSoil.dat).

Read in the STOMPCellFaces.plt; then write out only the "Easting (m), Northing (m), and Elevation (m)" variables in a Tecplot® ASCII data file (call it STOMPCellFaces.dat). Open STOMPCellFaces.dat and change the header information in this file as follows.

Original Tecplot® Header:

```
TITLE     = ""
VARIABLES = "Easting (m)"
"Northing (m)"
"Elevation (m)"
ZONE T="STOMPCellFaces"
 STRANDID=0, SOLUTIONTIME=0
 I=55, J=53, K=37, ZONETYPE=Ordered
 DATAPACKING=BLOCK
 DT=(DOUBLE DOUBLE DOUBLE )
```

New Tecplot® Header (do not include the text the arrow is pointing to). New header info is in **Bold**:

```
TITLE     = ""
VARIABLES = "Easting (m)"
"Northing (m)"
"Elevation (m)"
"UnitID"
ZONE T="STOMPCellFaces"
 STRANDID=0, SOLUTIONTIME=0
 I=55, J=53, K=37, ZONETYPE=Ordered
 DATAPACKING=BLOCK
VARLOCATION=([4]=CELLCENTERED) → Variable (4) UnitID is cell-centered
 DT=(DOUBLE DOUBLE DOUBLE, DOUBLE )
```

After changing the header information, go to the end of the file. Then open the RockSoil.dat file in another window of the text editor. Copy all the values below DT = (DOUBLE) and then paste them at the bottom of the STOMPCellFaces.dat file. These are all cell-centered values and the value numbers would be I = 55 – 1, J = 53 – 1, K = 37 – 1, or 54 × 52 × 36 = 101,088. After pasting the cell-centered values into the data file, read it into Tecplot®. Figure 5-16(a) shows the STOMP© cells using the cell-centered data as nodes (node location is correct, but the defined cells are incorrect), while Figure 5-16(b) shows the cell-centered data at the cell-centers, and the resulting cells are displayed correctly.

Figure 5-16(a). Subsurface Transport Over Multiple Phases© Cell-Centered Node Grid within Waste Management Area C Stratigraphy.

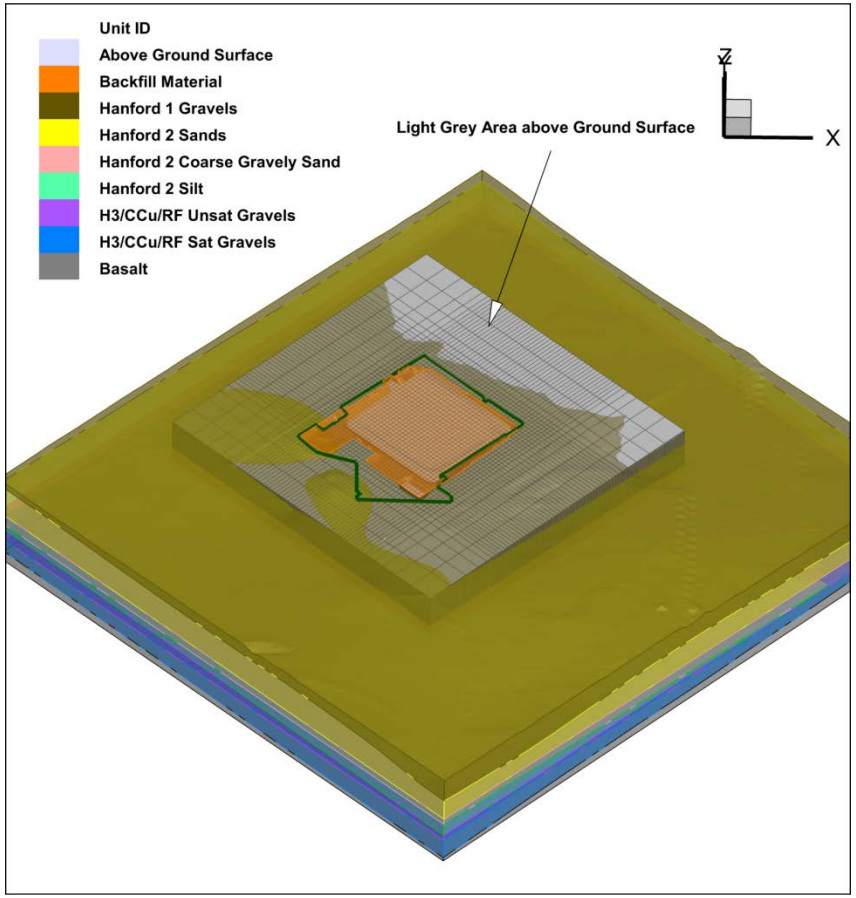
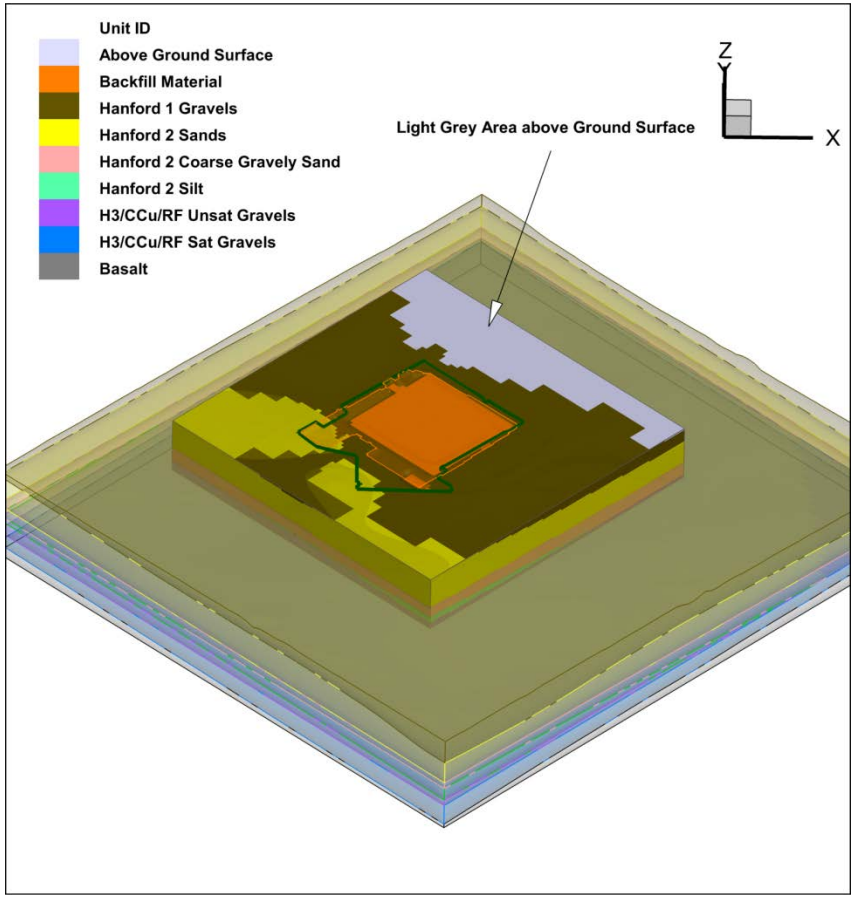


Figure 5-16(b). After the Linear Interpolation of Waste Management Area C Stratigraphy on Subsurface Transport Over Multiple Phases© Cell-Center Node Grid.



Figures 5-17(a) and 5-17(b) show the difference between the STOMP© grid in Tecplot® with the cell-centers as nodes plotted at the corners of a Tecplot® grid [Figure 5-17(a)] and with the STOMP© grid in Tecplot® with the cell-centers plotted at the cell-centers. Note that Figure 5-17(b) is larger than Figure 5-17(a) because one more node in each direction is plotted. Differences are also observed around WMA C with a row of nodes for UnitID > 7 (i.e., orange) extending beyond the fence line located parallel to the lower right of the figure.

Figure 5-17(a). Subsurface Transport Over Multiple Phases© Cell-Centered Node Grid with Rock/Material Type at Cell Corners.

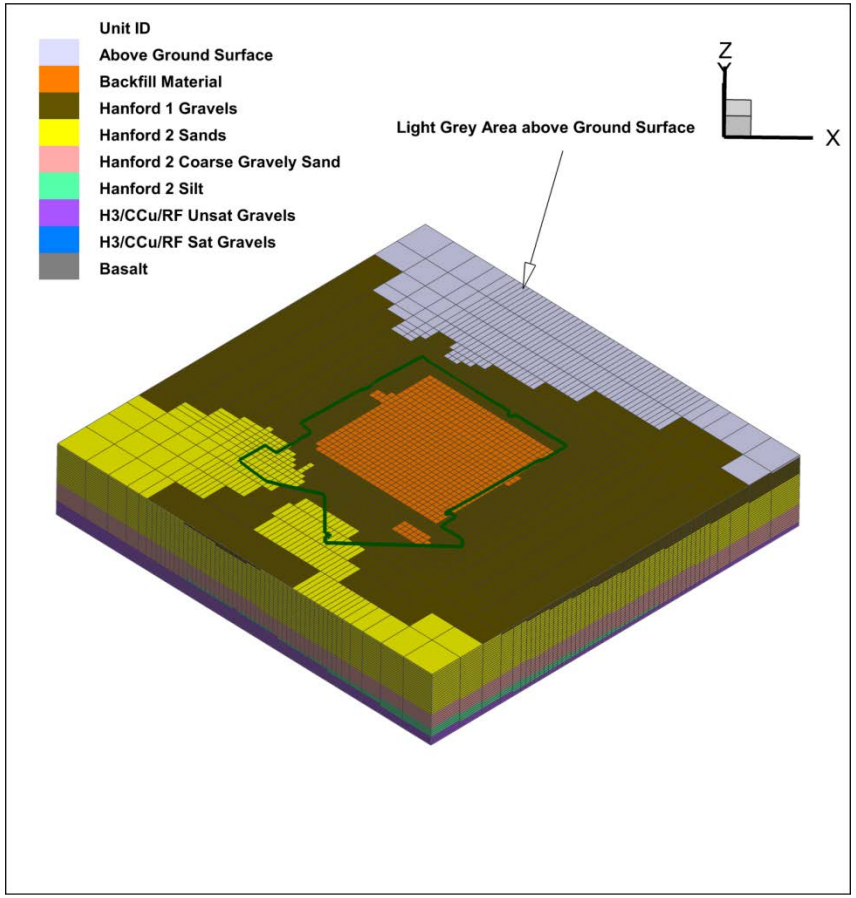
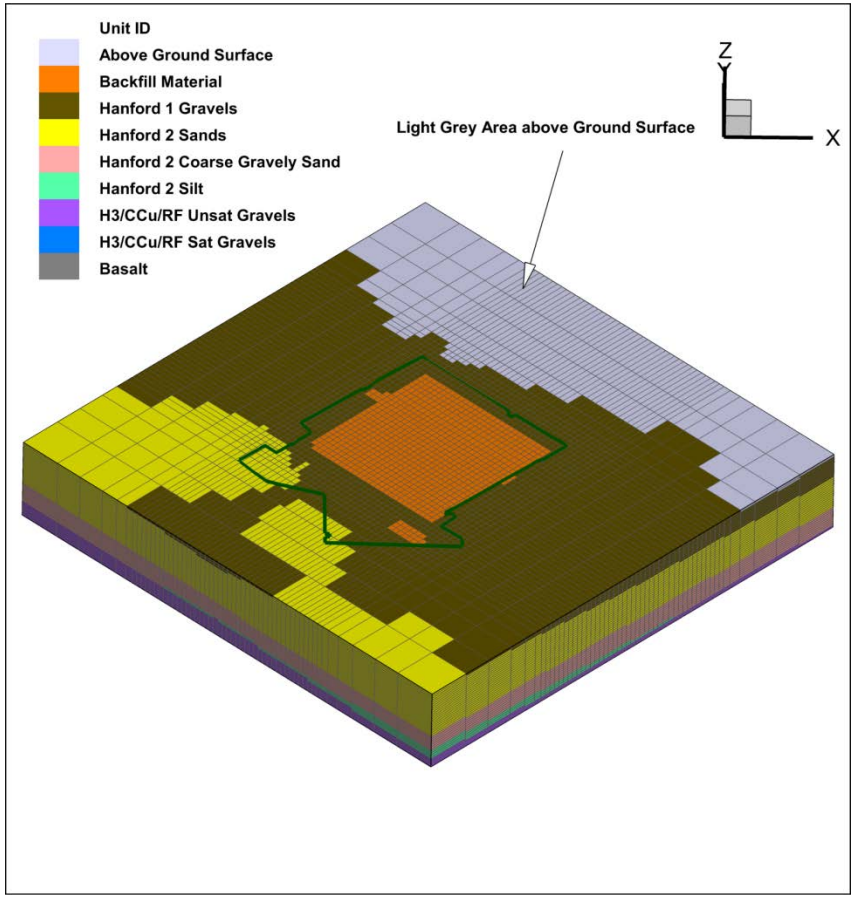


Figure 5-17(b). Subsurface Transport Over Multiple Phases© Cell-Face Grid with Rock/Soil Type at Cell Centers.



6.0 COMPARISON OF WASTE MANAGEMENT AREA C GEOLOGIC MODELS I AND II

Following building the WMA C Alternative Geologic Model I, the second model (Alternative Geologic Model II) was developed using interpretation of geologic units at selected boreholes and wells provided by the Nez Perce (see Table 3-5). The identified geologic units that are exactly the same in both geologic models are given below.

1) **Backfill** – This unit was developed using engineered drawings and pictures of the tank farm being built and would therefore be more accurate than kriging the bottom of the backfill from borehole and direct push data.

2) **H2 Silt** – A meeting was held with Mr. Kent Reynolds of Energy*Solutions*, Inc. and Dr. Stan Sobcyzk to discuss the two alternative models. During that meeting a comparison was made between an earlier version of the top of this unit using the geologic picks from Letter Report FS-NW-LT-5367 and the geologic picks from Dr. Sobcyzk. During that meeting, it was decided the geologic picks from Dr. Sobcyzk was a more accurate representation for the top of this unit because it followed the general trend of dipping to the northeast.

3) **H3/CC_U/RF Unconfined Aquifer** – The Nez Perce data did not have water table elevation in their data set, so the June 2013 water table information was used to delineate the unconfined aquifer in the Nez Perce geologic model.

4) **Basalt** – Too few wells reaching the basalt exist in the area of interest to create a top of basalt layer in the vicinity of WMA C, so the regional top of basalt from the 200 East Area LeapFrog Hydro® geologic model was used to create the basalt layer in both the WRPS and Nez Perce geologic models.

All other units were created using the same methodology as given in Sections 5.2.3.2 Kriging, 5.2.5 H2 Silt Pinched, and 5.3 Building the Digital Geologic Model. The Nez Perce data are in zones 134 through 253 in the WellsTecplot.dat file. When this data was used to create a surface, all the data was used as is. In addition to the Nez Perce data, wells outside the vicinity of WMA C were used to supplement the Nez Perce data. These outer wells are zone 254 through 263, with the exception of well 299-E26-8 which places the top of the H2 too high in relation to other nearby wells. A series of graphics have been prepared to show the differences between the two models.

Figures 6-1(a) and 6-1(b) show the top of the H2 Sand Unit underlying WMA C. In the area around UPR-86 (i.e., to the left of the WMA C fence line) the WRPS model is higher in elevation; however, within the WMA C fence line both models have the same general trend of dipping to the right. Figures 6-2(a) and Figure 6-2(b) show the top of the H2 Coarse Gravelly Sand unit underlying WMA C. Well 299-E27-14 was not included in the kriging for the WRPS model because it is anomalous compared to the other wells. This well is in the right center of Figure 6-2(a) sitting right above the red fenceline. With the removal of this well, the WRPS model is very similar to the surface created using the Nez Perce data. The general trend is for the unit to dip from the left to the right in both of these figures.

Figure 6-1(a). Waste Management Area C Alternative Geologic Model I of the Top of the H2 Sand Unit Using Washington River Protection Solutions Interpretations.

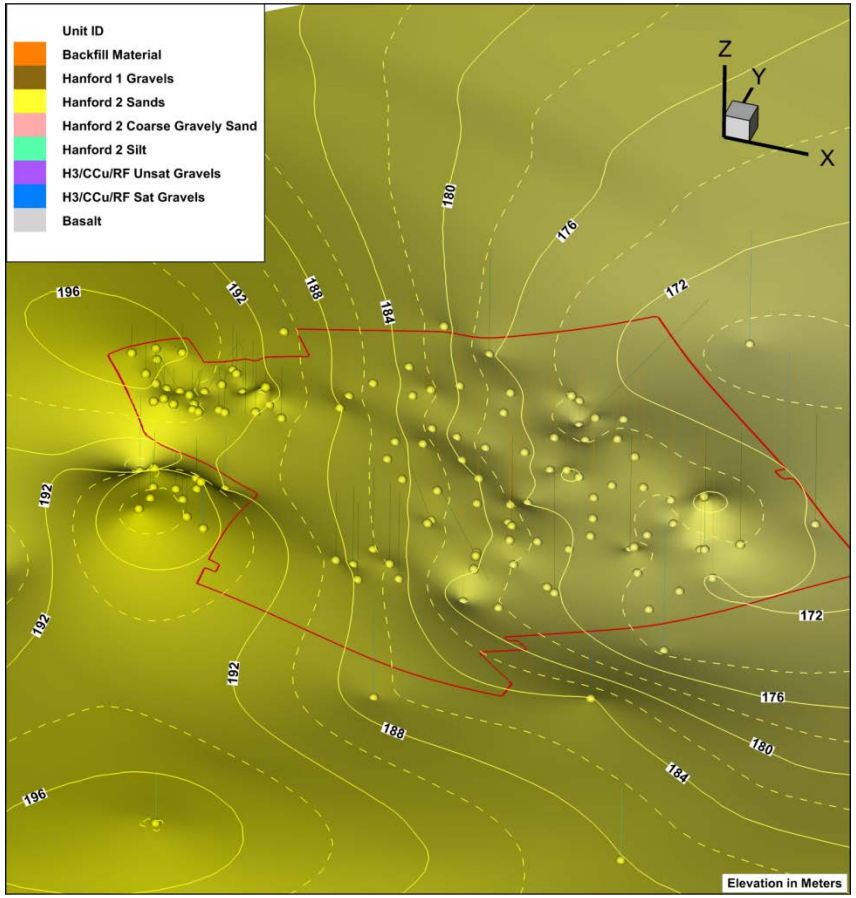


Figure 6-1(b). Waste Management Area C Alternative Geologic Model II of the Top of the H2 Sand Unit Using Nez Perce Interpretations.

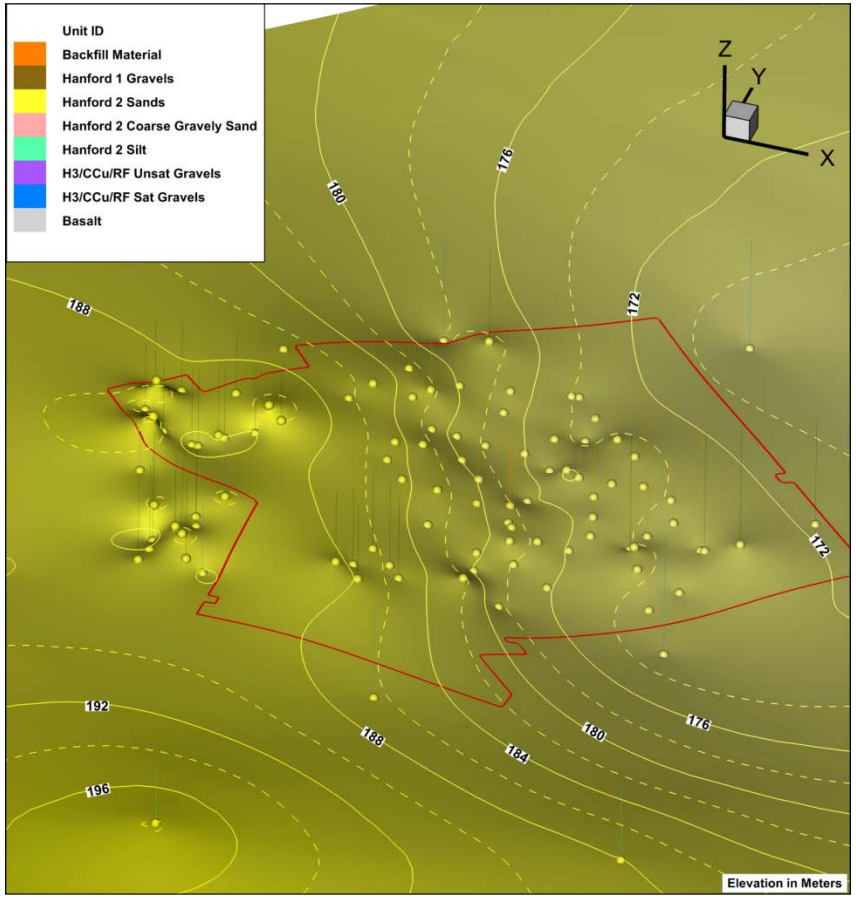


Figure 6-2(a). Waste Management Area C Alternative Geologic Model I of the Top of the H2 Coarse Gravelly Sand Unit Using Washington River Protection Solutions Interpretations.

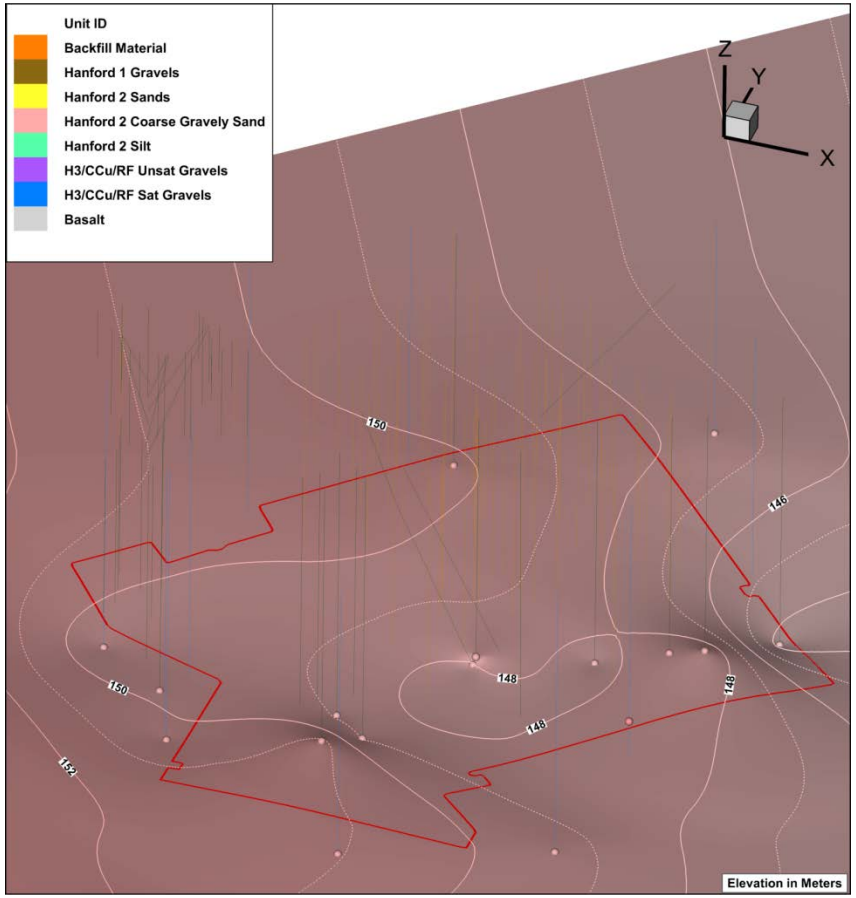
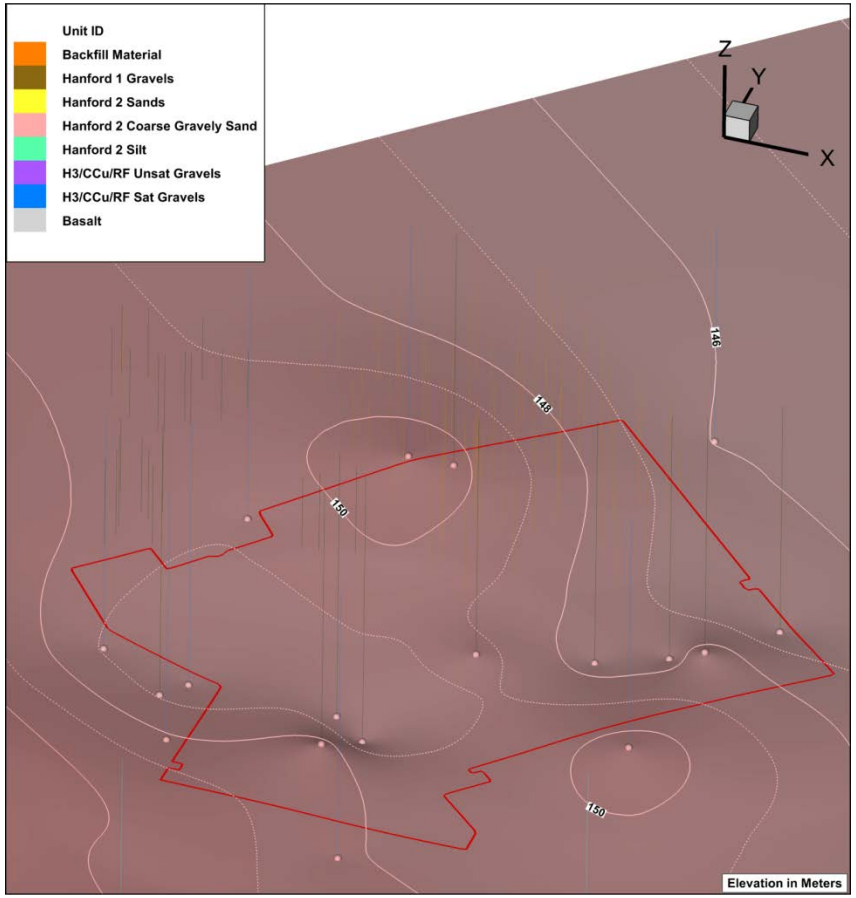


Figure 6-2(b). Waste Management Area C Alternative Geologic Model II of the Top of the H2 Coarse Gravelly Sand Unit Using Nez Perce Interpretations.



Figures 6-3(a) and 6-3(b) show the top of the H3/CC_U/RF Unit underlying WMA C. The WRPS surface for this unit is again very similar to the Nez Perce surface, with the major difference being the elongation of the basin around wells 299-E27-15 and 299-E27-22 in the Nez Perce interpretation. Well 299-E27-22 is the lowest point in both models. Figures 6-4(a) and 6-4(b) provide cross-sections through both models at the same location to allow the reader to compare the different models.

Figure 6-3(a). Waste Management Area C Alternative Geologic Model I of the Top of the H3/CC$_U$/RF Unit Using Washington River Protection Solutions Interpretations.

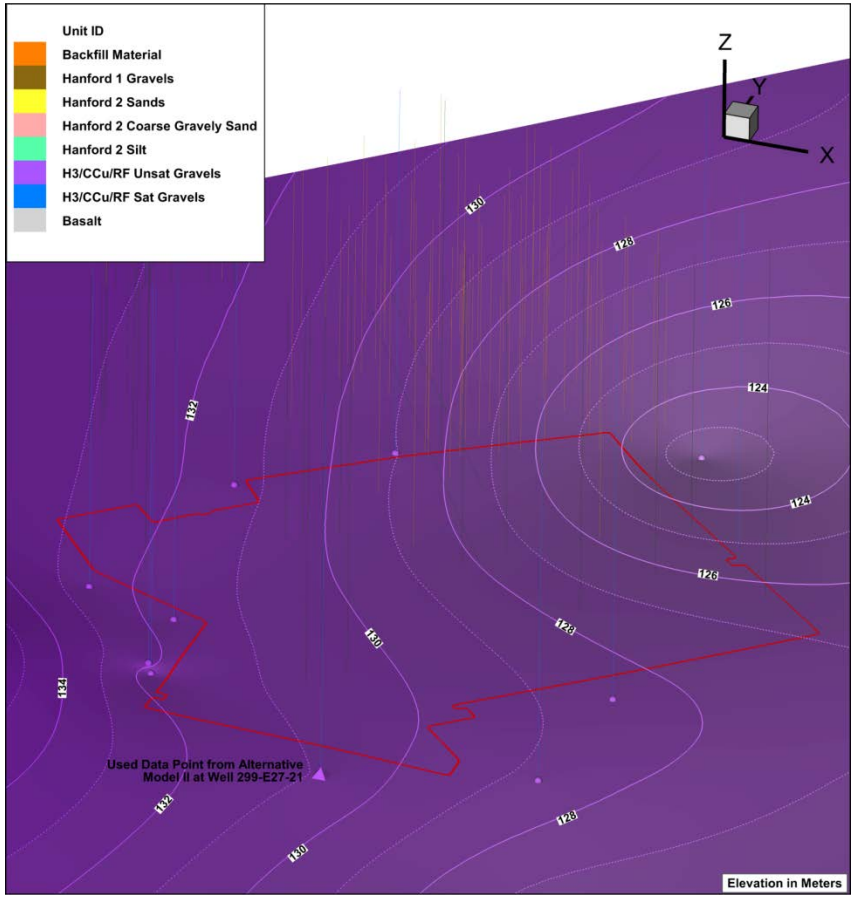


Figure 6-3(b). Waste Management Area C Alternative Geologic Model II of the Top of the H3/CC$_U$/RF Unit Using Nez Perce Interpretations.

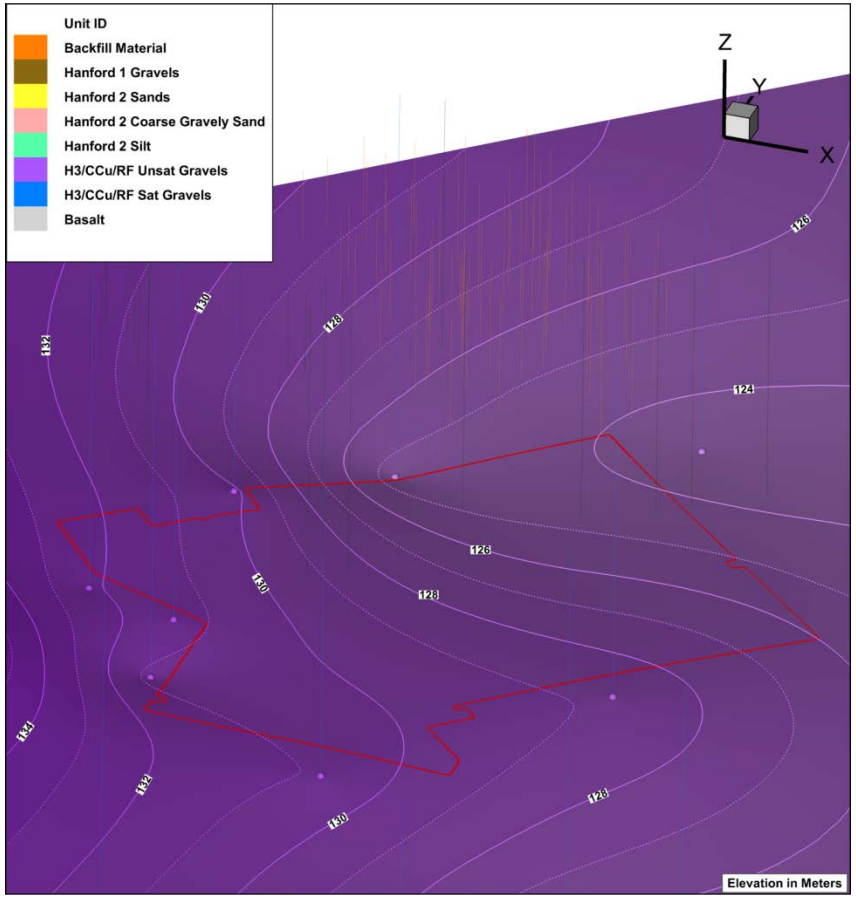


Figure 6-4(a). Cross-Sections through Waste Management Area C Alternative Geologic Model I Using Washington River Protection Solutions Interpretations.

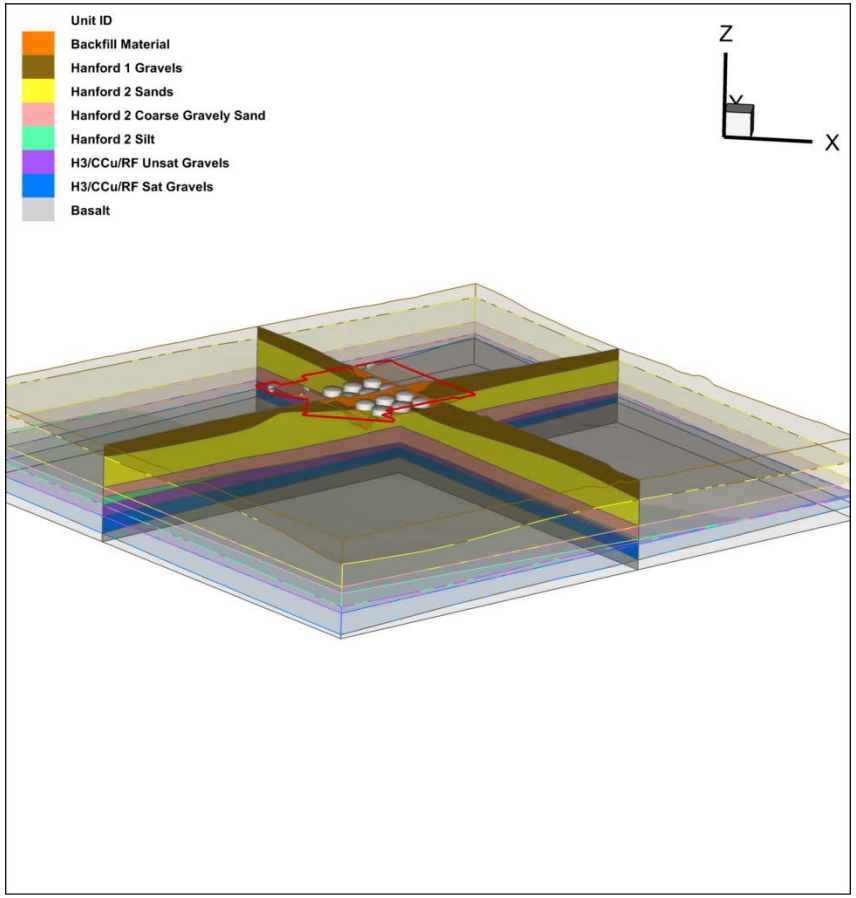
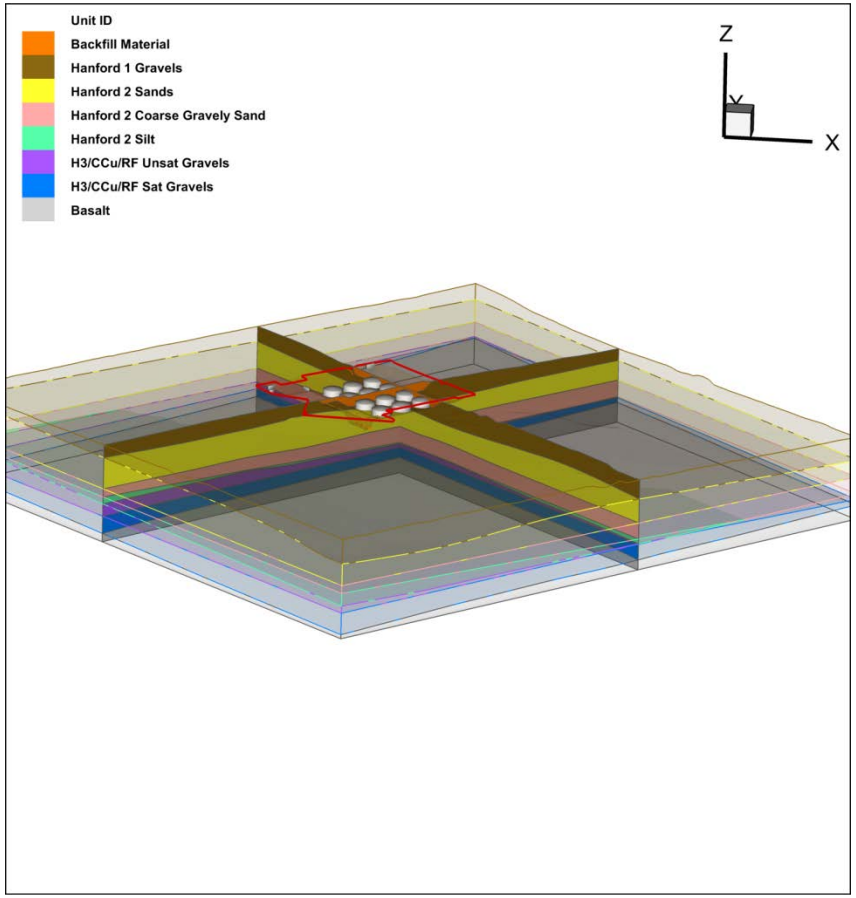


Figure 6-4(b). Cross-Sections through Waste Management Area C Alternative Geologic Model II Using Nez Perce Interpretations.



7.0 EVALUATION OF GEOLOGIC LOGS AND ARCHIVED CORE SAMPLES IN SELECTED WELLS

The previous sections used the geophysical logs (i.e., K-U-T [potassium-40, uranium-238, and thorium-228] and neutron log data) to make the determination on the location of the top each geologic surface. This section provides a summary of additional evaluations of geologic logs and archive soil samples from selected wells in vicinity of the WMA C and in WMA B-BX-BY. The primary purpose of these evaluations was to examine the physical characteristics for the finer-grained sequences inferred for the H2 unit at depth from interpretations of the geophysical logs in both of the geologic models described in this report. A secondary purpose was to compare the physical characteristics of the fine-grained sequences of the H2 unit identified in vicinity of WMA C with a fine-grained unit identified at a similar depth in selected wells that has been associated with perched water in WMA B-BX-BY. Documented perched water is present in the vicinity of WMA B-BX-BY; similar perched water has not been observed in the vicinity of WMA C.

7.1 APPROACH

Stratigraphic picks for boreholes in the vicinity of WMA C were primarily made through the interpretation of geophysical logs. Stratigraphic picks determined through interpretation of the geophysical logs differentiated two subunits of the H2, the H2 Silt (sediments comprised of silt and very fine-grained sand) and the H2 Coarse Gravelly Sand (sediments dominated by sands and gravels).

In order to confirm the presence/absence of these subunits, drill cuttings from four wells (two wells at WMA C, and two wells at WMA B-BX-BY, shown in Figure 7-1) were retrieved from the Hanford Geotechnical Sediment Library (HGSL) and photographed. The photographs are used to show differences between the geologic conditions at WMA C and WMA B-BX-BY. Each of the wells photographed are discussed in Sections 7.2 (WMA C) and 7.3 (WMA B-BX-BY). In addition to the wells photographed, a summary of physical characteristics in geologic logs from four other wells at WMA C (299-E27-22, 299-E27-4, 299-E27-21, and 299-E27-23; also shown in Figure 7-1) identify a sequence of finer-grained sediments in the lower part of the H2 unit in vicinity of WMA C are evaluated and discussed.

7.2 CHARACTERISTICS OF HANFORD FORMATION H2 SEDIMENTS IN SELECTED WELLS AT WASTE MANAGEMENT AREA C

Photographs taken during drilling of well 299-E27-155 are shown in Figures 7-2 through 7-5. Photographs taken during drilling of well 299-E27-14 were not available. Drill cuttings collected during the drilling of well 299-E27-14 were retrieved from the HGSL, and selected drill cuttings surrounding the interpreted H2 deeper fine-grained unit were photographed, and are shown in Figure 7-6. Both wells 299-E27-155 and 299-E27-14 were drilled using a cable-tool drill rig; the resultant drill cuttings are likely to be representative of actual lithologic conditions.

Figure 7-1. Selected Wells near 241-B, 241-BX, 241-BY and 241-C Tank Farms.

Figure 7-2. Drill Cuttings Photographs Encountered from 5 to 110 Feet Below Ground Surface at Well 299-E27-155 (C5852).

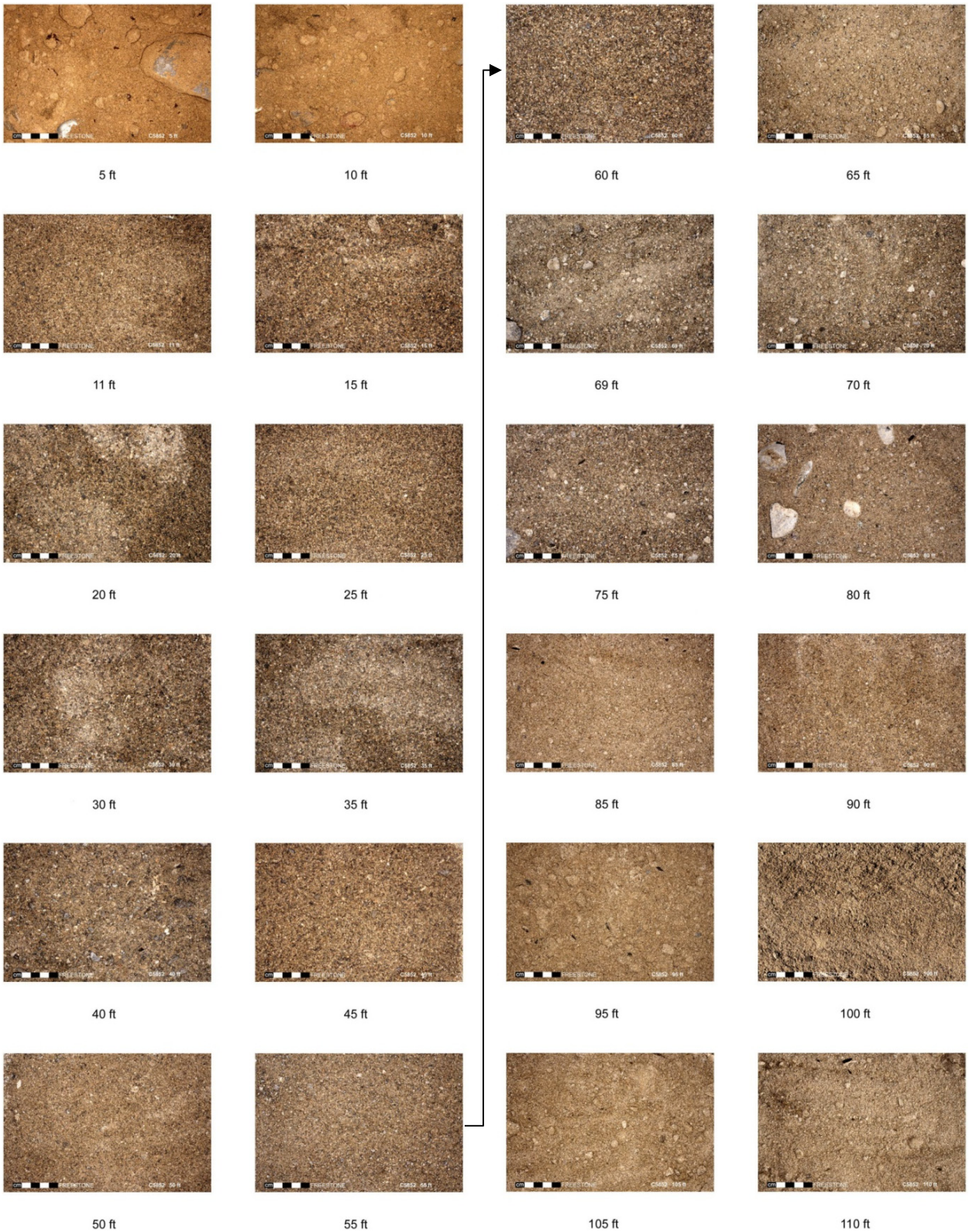


Figure 7-3. Drill Cuttings Photographs Encountered from 115 to 200 Feet Below Ground Surface at Well 299-E27-155 (C5852).

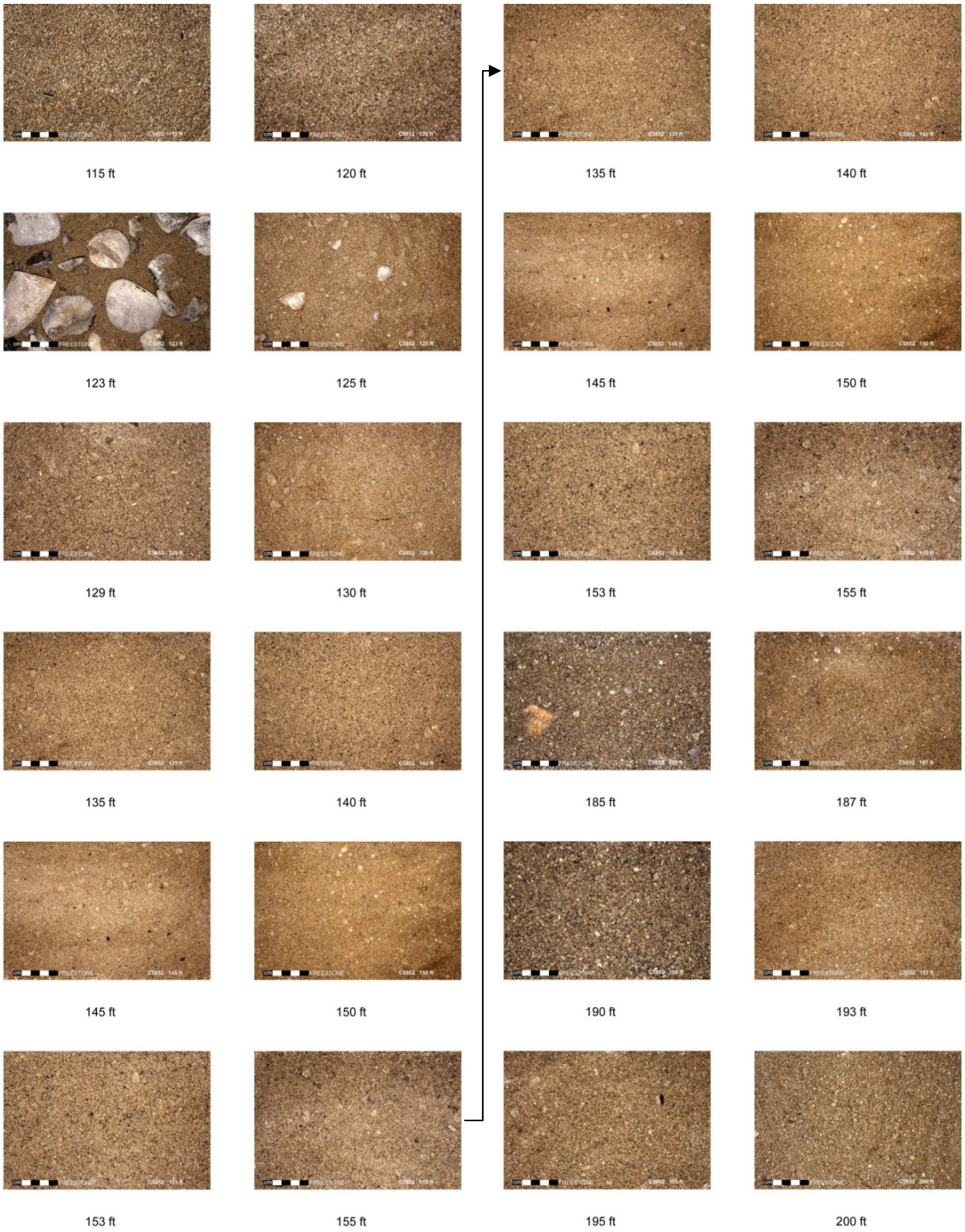


Figure 7-4. Drill Cuttings Photographs Encountered from 205 to 300 Feet Below Ground Surface at Well 299-E27-155 (C5852).

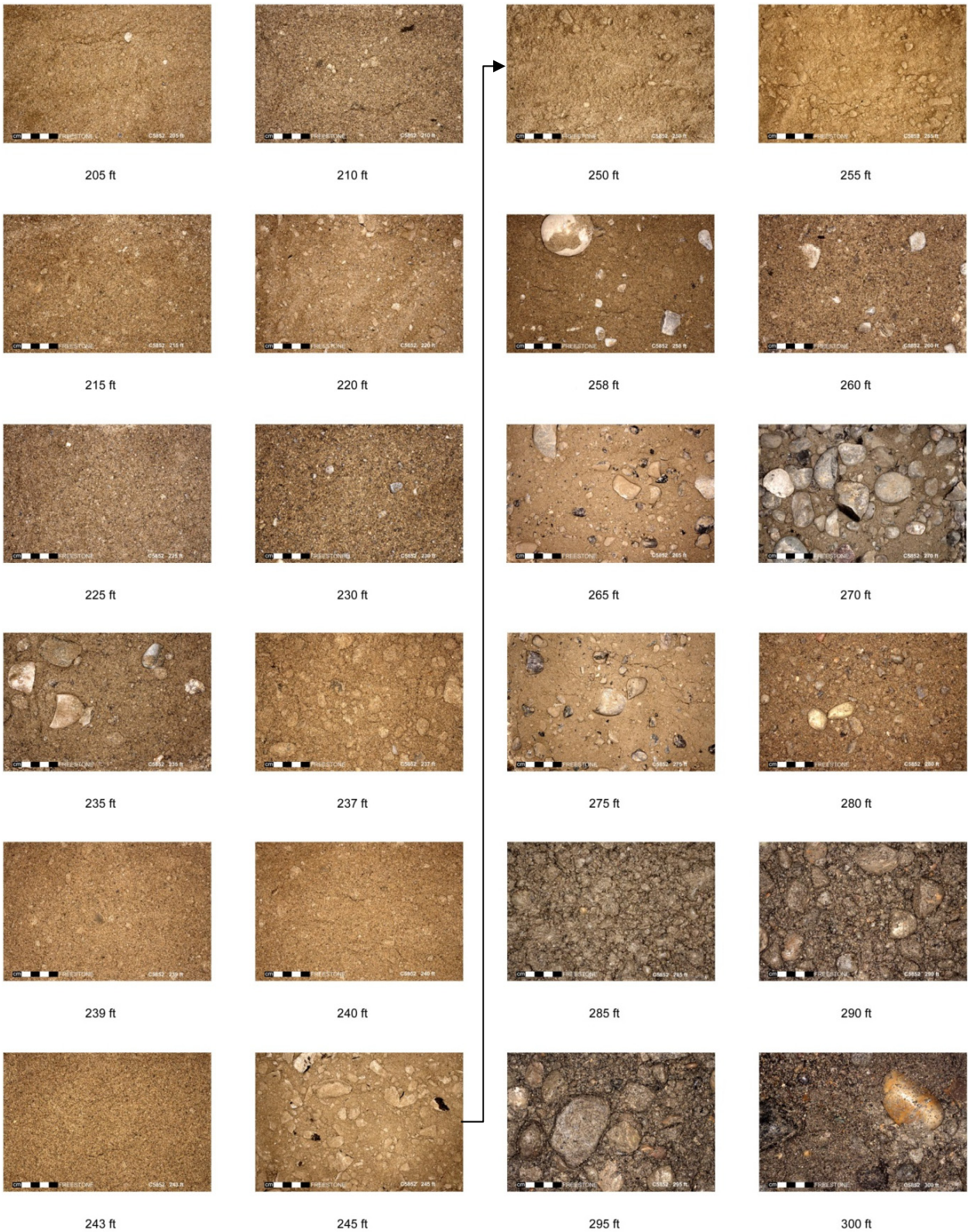


Figure 7-5. Drill Cuttings Photographs Encountered from 302 to 340 Feet Below Ground Surface at Well 299-E27-155 (C5852).

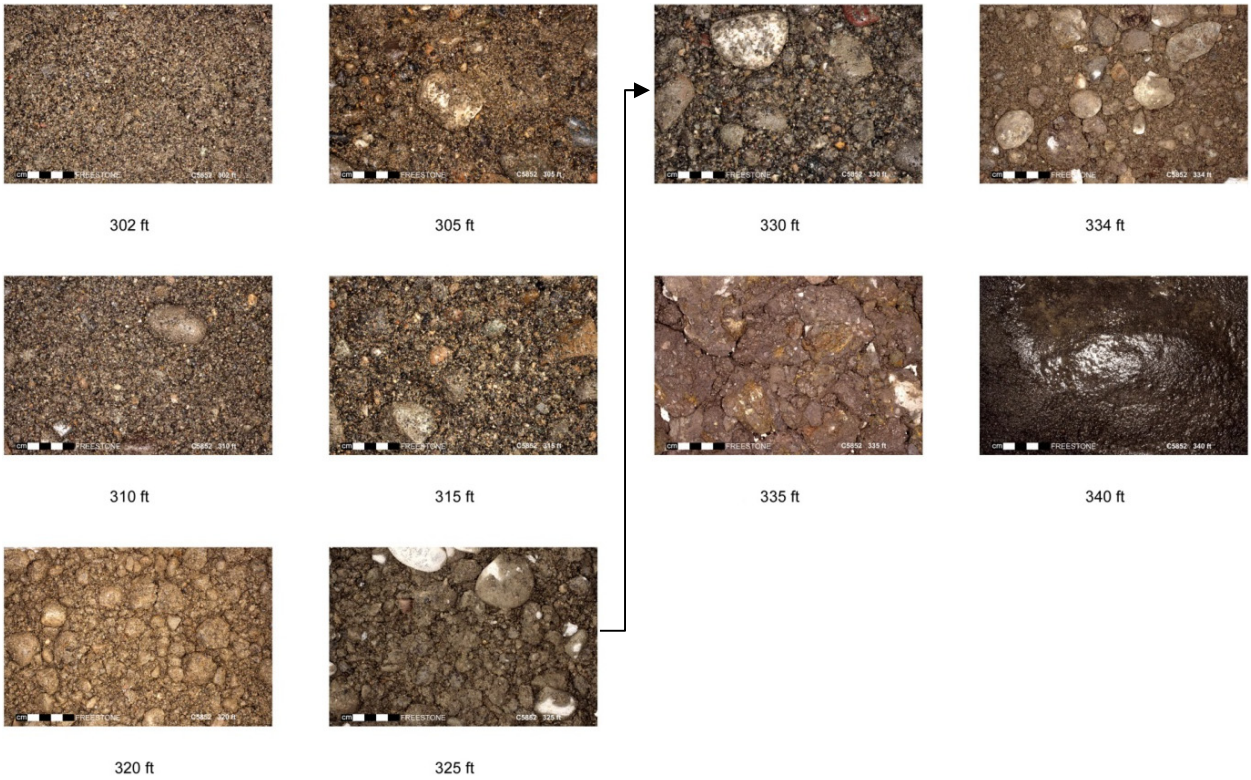
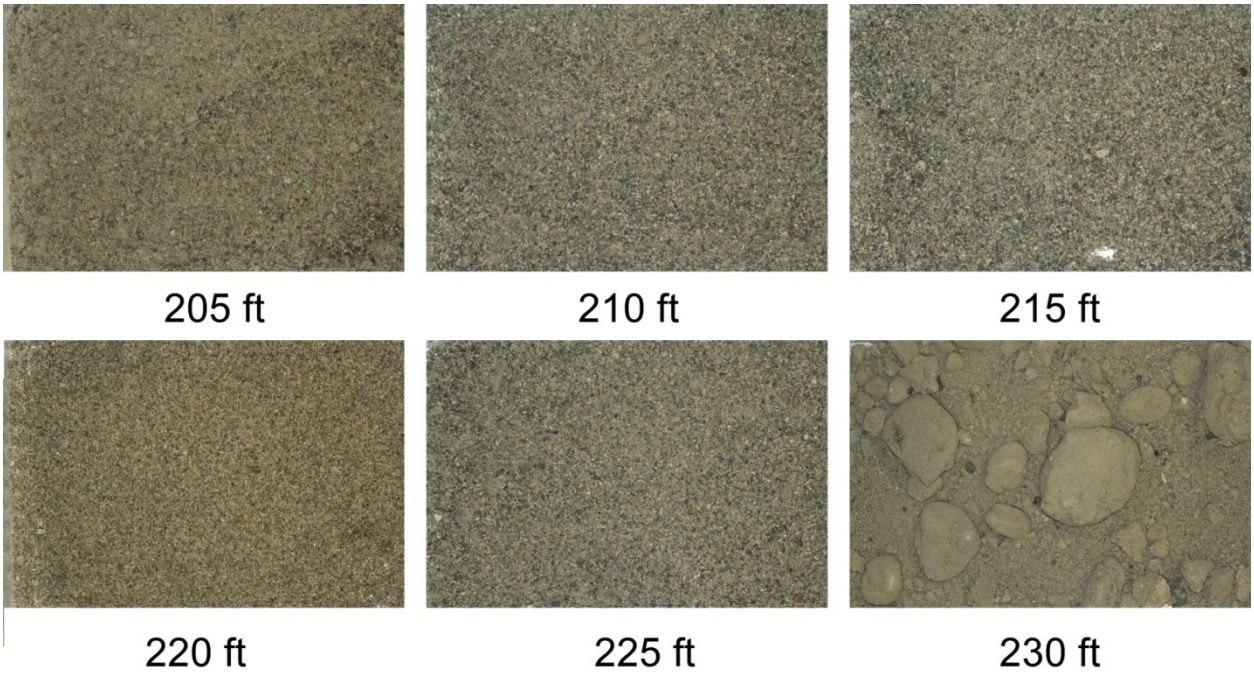


Figure 7-6. Drill Cuttings Photographs Encountered from 205 to 230 Feet Below Ground Surface at Well 299-E27-14 (A4812).



7.2.1 Well 299-E27-155 (C5852)

Stratigraphy based on interpretations supplied by the Nez Perce indicate the Hanford H2 Silt unit is at 230 ft bgs (feet below ground surface). Stratigraphic units encountered during the drilling of well 299-E27-155 were the Hanford formation (Hanford H2 and H3 units) and the Elephant Mountain basalt. Sediments encountered from the ground surface to 336 ft bgs consisted of sand, gravelly sand, sandy gravel, silty sandy gravel, and silty sand. The Elephant Mountain basalt was encountered from 336 ft bgs to the total depth of 340 ft bgs. No competent silt unit was observed within the vadose zone during the drilling of well 299-E27-155.

7.2.2 Well 299-E27-14 (C5852)

Stratigraphic interpretations based on geophysical logging results indicate the H2 Silt unit at either 213 ft bgs or 230 ft bgs. Sediments retrieved from the HGSL from 205 to 230 ft bgs consisted of sand and silty gravelly sand. No competent silt unit was encountered during the drilling of well 299-E27-14.

7.2.3 Evidence for Perched Water Near Waste Management Area C

Drilling at all wells discuss in this section encountered no evidence of perched water. While minor amounts of fine sand and silt were encountered, no thick, competent layer of silt was encountered. Elevated moisture levels, which would likely be associated with perched water, were not observed.

7.3 CHARACTERISTICS OF HANFORD SEDIMENTS IN SELECTED WELLS IN WASTE MANAGEMENT AREA B-BX-BY

Perched groundwater was encountered during the drilling of wells 299-E33-343 and 299-E33-344 (Figure 7-1). Photographs taken during drilling of well 299-E33-343 are shown in Figures 7-7 through 7-9. Photographs taken during drilling of well 299-E33-344 are shown in Figures 7-10 through 7-12.

7.3.1 Well 299-E33-343 (C5858)

Units encountered during the drilling of well 299-E33-343 (C5858) include gravel backfill, the Hanford formation, possibly the upper facies of the CC_U, and the Elephant Mountain basalt. Sediments encountered from the ground surface to 215.5 ft bgs consisted of alternating sand, sandy gravel, silty sandy gravel, gravelly sand, and silty sand. An abrupt contact with compact, faintly laminated silt occurred at 215.5 ft bgs. This silt unit continued with varying thicknesses of interstratified very fine sand and elevated moisture levels to 239 ft bgs. At 239 ft bgs, a thin layer of strongly calcium carbonate-cemented silty gravel is present. From 240 to 260.9 ft bgs, sediments encountered were gravelly sand and sandy gravel. The Elephant Mountain basalt was encountered from 260.9 ft bgs to the total depth of 263.8 ft bgs. Static water level was measured at 252.41 ft bgs on March 10, 2008, indicating an aquifer thickness of 8.49 ft in this location.

Figure 7-7. Drill Cuttings Photographs Encountered from 5 to 105 Feet Below Ground Surface at Well 299-E33-343 (C5858).

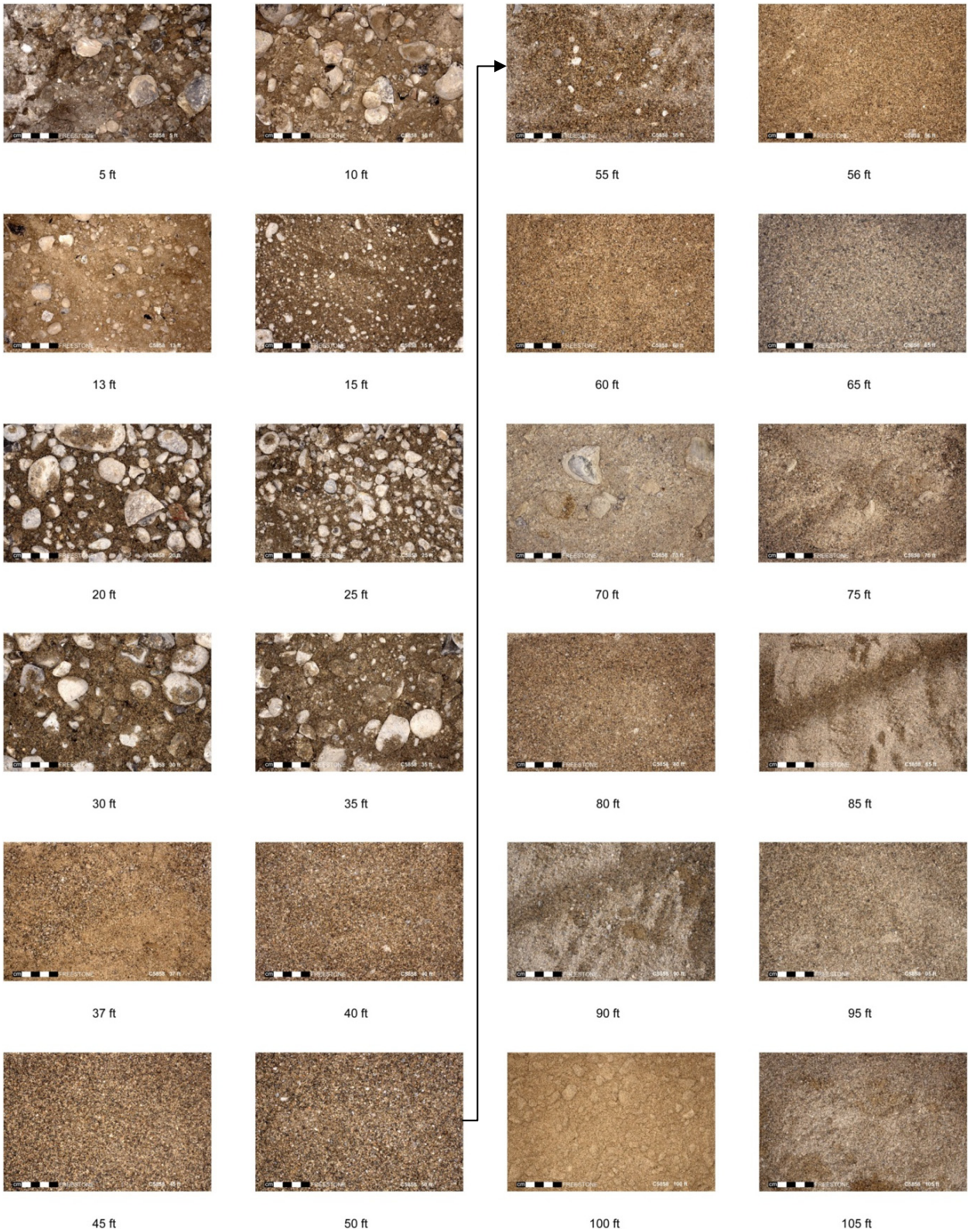


Figure 7-8. Drill Cuttings Photographs Encountered from 110 to 215 Feet Below Ground Surface at Well 299-E33-343 (C5858).

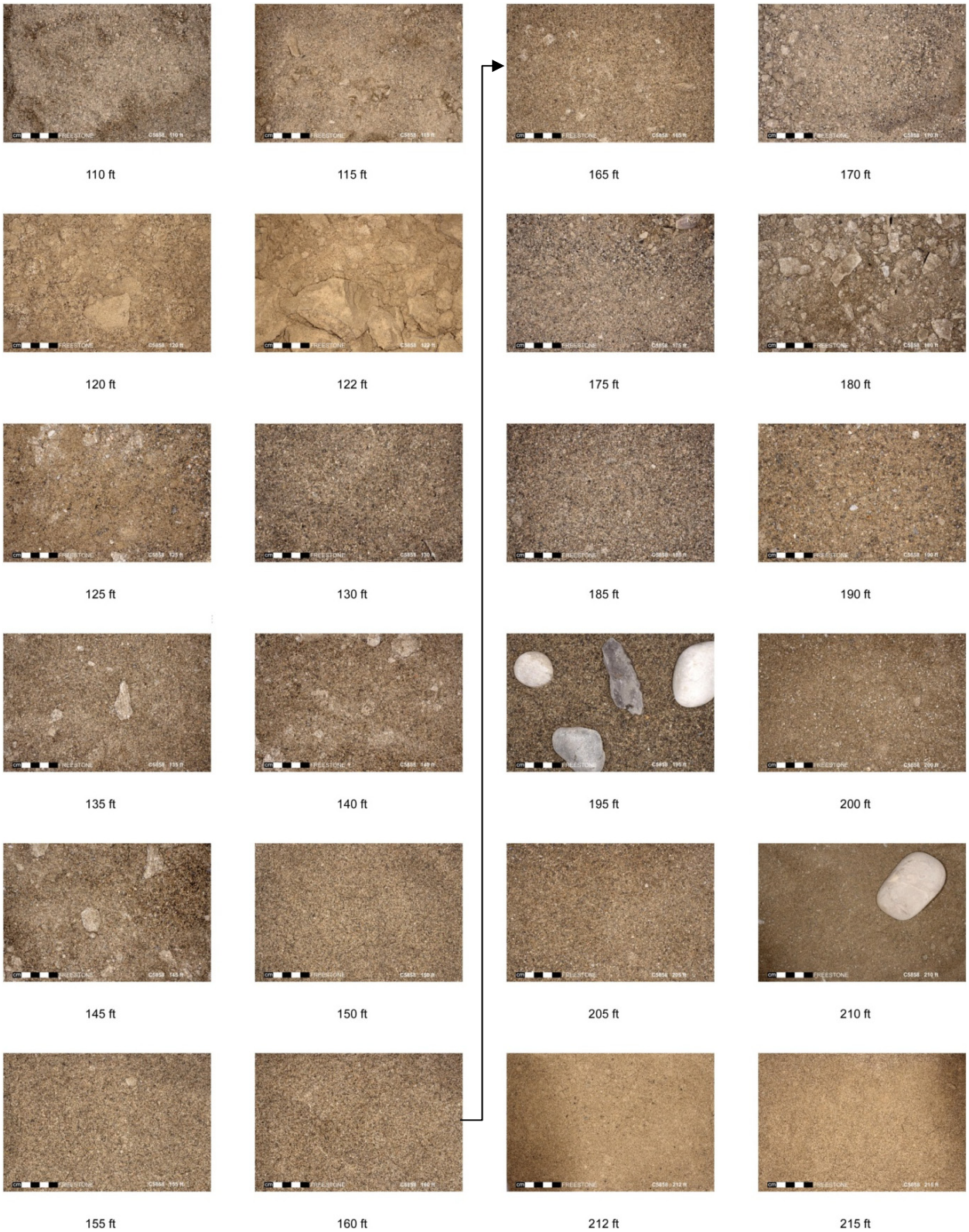
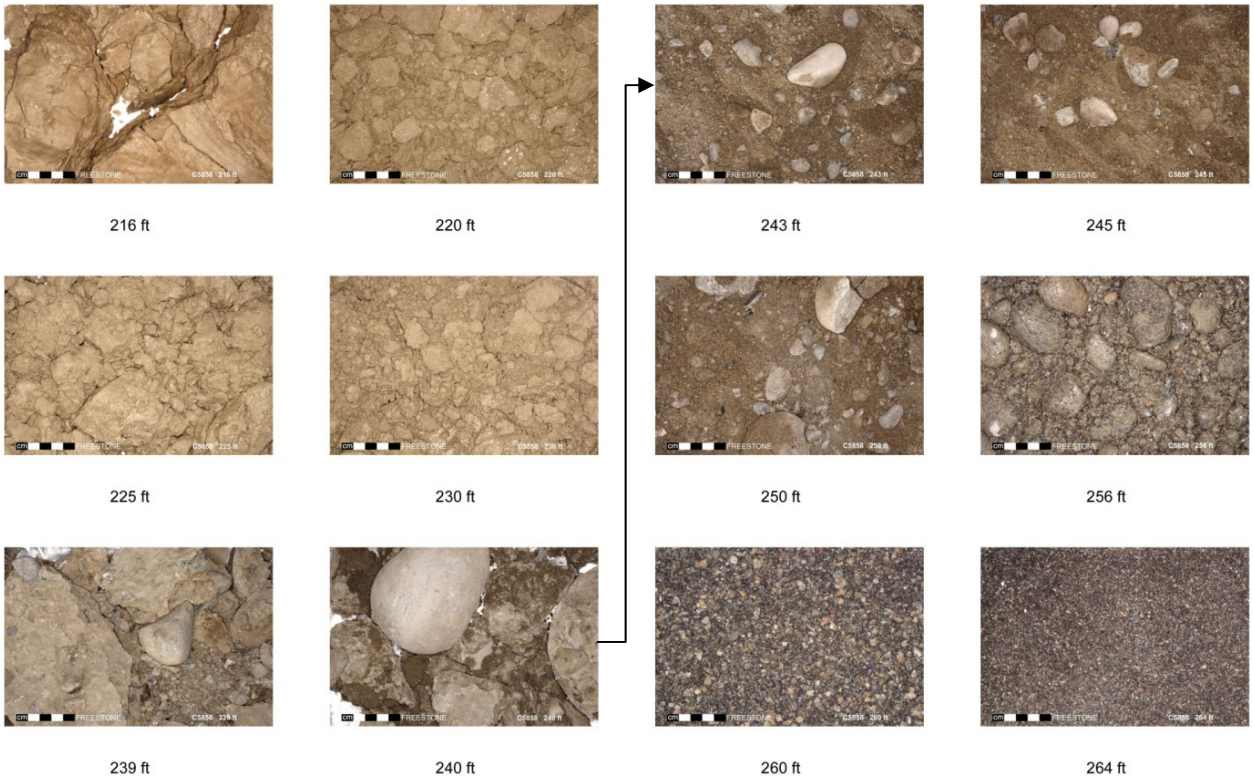


Figure 7-9. Drill Cuttings Photographs Encountered from 216 to 264 Feet Below Ground Surface at Well 299-E33-343 (C5858).



7.3.2 Well 299-E33-344 (C5859)

Units encountered during the drilling of well 299-E33-344 (C5859) include gravel backfill, the Hanford formation, and possibly the upper facies of the CC_U. Sediments encountered from the ground surface to 216 ft bgs consisted of sand, sandy gravel, silty sandy gravel, gravelly sand, and silty sand. An abrupt contact with brown silt occurred at 216 ft bgs. This silt unit continued with alternating silt and very fine sand to 235 ft bgs, with steadily increasing moisture to saturation at 225.3 ft bgs. Drilling terminated at 237 ft bgs, ~2 ft into a sandy gravel layer.

7.3.3 Perched Water Near Waste Management Area B-BX-BY

Drilling at both wells 299-E33-343 and 299-E33-344 encountered a thick (23.5 ft and 19 ft respectively), competent silt unit with elevated moisture. The elevated moisture at well 299-E33-343 and the saturation at well 299-E33-344 were interpreted to represent perched water ~8 to 10 ft thick. This perched water has been interpreted as underlying portions of the 241-B, 241-BX, and 241-BY Tank Farms.

Figure 7-10. Drill Cuttings Photographs Encountered from 10 to 125 Feet Below Ground Surface at Well 299-E33-344 (C5859).

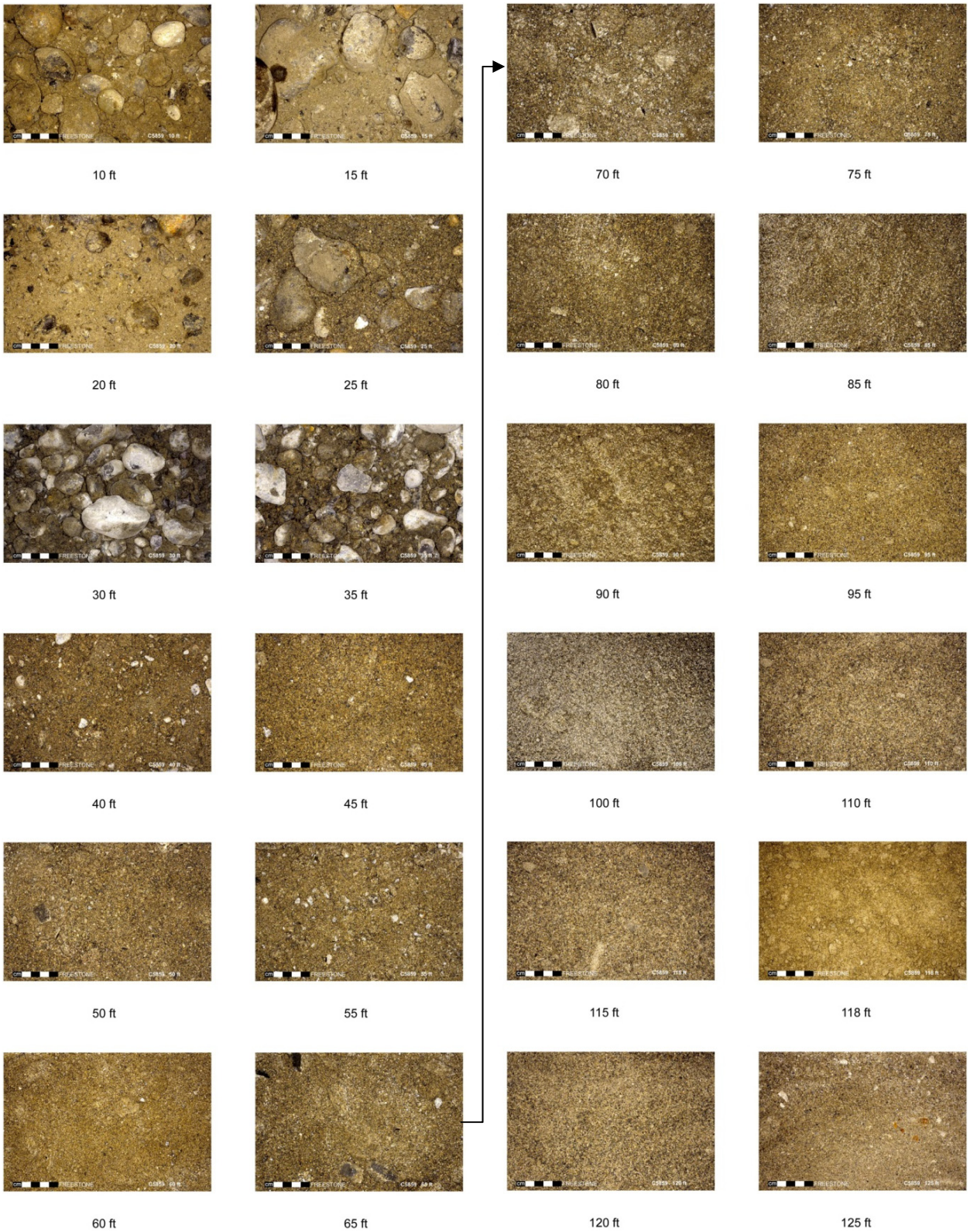


Figure 7-11. Drill Cuttings Photographs Encountered from 130 to 225 Feet Below Ground Surface at Well 299-E33-344 (C5859).

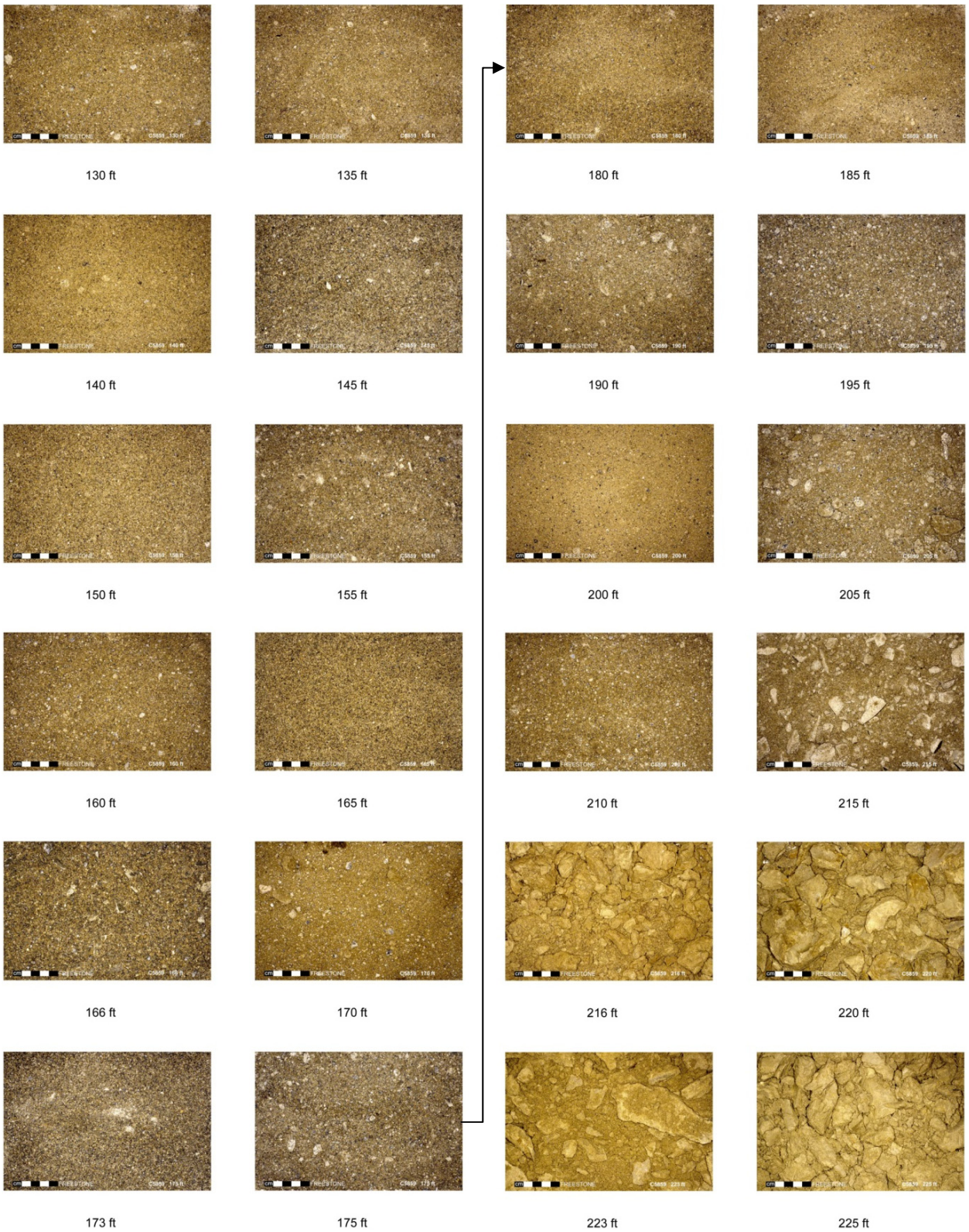
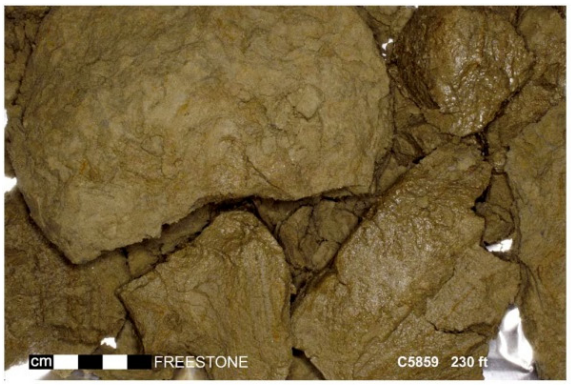


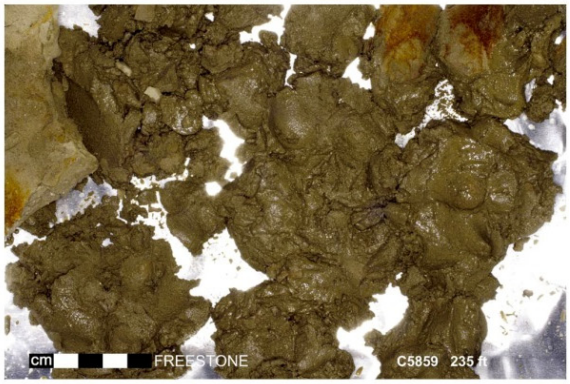
Figure 7-12. Drill Cuttings Photographs Encountered from 230 to 236 Feet Below Ground Surface at Well 299-E33-344 (C5859).



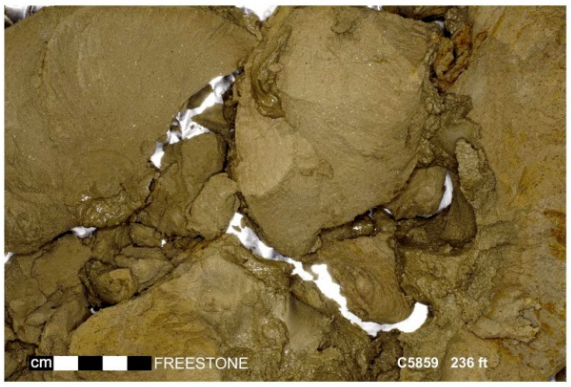
230 ft

233 ft

234 ft



235 ft



236 ft

7.4 CHARACTERISTICS OF HANFORD FORMATION H2 SEDIMENTS DESCRIBED IN PNNL-14656

The previous sections examined drill cuttings from two wells just outside the vicinity of WMA C to determine if there was a geologic layer that could cause water perching on top of it as suggested by the geophysical logs. That examination concluded that the drill cuttings did not indicate a perching layer was present at WMA C. However, drill cuttings located at HGSL from only two wells at WMA C were examined. In 2004, four wells were installed and a description of those wells along with geologic logs are included in PNNL-14656, *Borehole Data Package for Four CY 2003 RCRA Wells 299-E27-4, 299-E27-21, 299-E27-22, and 299-E27-23 at Single-Shell Tank, Waste Management Area C, Hanford Site, Washington*. That document identified four locations where finer-grained sediments were encountered during drilling in the lower portion of the H2 unit. These finer-grained sediments were at depths consistent with the H2 unit interpreted from geophysical logs for wells 299-E27-155 and 299-E27-14.

7.4.1 Well 299-E27-4 (C4125)

Units encountered during the drilling of well 299-E27-4 (C4125) include gravel backfill, the Hanford formation, and possibly the upper facies of the CC_U. Sediments encountered from the ground surface to 225 ft bgs consisted of sand, sandy gravel, and gravelly sand. A silty sand was encountered from 225 to 235 ft bgs. Sediments from 235 to 311 ft bgs (total depth) consisted of sand, gravelly sand, sandy gravel, and gravel. Drilling was terminated at 311 ft bgs in a sandy gravel. No competent silt unit was observed during the drilling of well 299-E27-4.

7.4.2 Well 299-E27-21 (C4127)

Units encountered during the drilling of well 299-E27-21 (C4127) include gravel backfill, the Hanford formation, and possibly the upper facies of the CC_U. Sediments encountered from the ground surface to 200 ft bgs consisted of sands, gravelly sand, and silty sandy gravel. Sediment encountered from 200 to 275 ft bgs consisted of silty sands and silty sandy gravels. Gravelly sand and sandy gravel was encountered from 275 to 318 ft bgs (total depth). Drilling was terminated at 318 ft bgs in a sandy gravel. No competent silt unit was observed during the drilling of well 299-E27-21.

7.4.3 Well 299-E27-22 (C4124)

Units encountered during the drilling of well 299-E27-22 (C4124) include gravel backfill, the Hanford formation, and possibly the upper facies of the CC_U. Sediments encountered from the ground surface to 227 ft bgs consisted of sand, sandy gravel, silty sandy gravel, gravelly sand, and silty sand. A silty sandy gravel was encountered from 227 to 233 ft bgs. A sandy gravel was encountered from 233 to 268 ft bgs (the total depth). The Elephant Mountain basalt was encountered at 268 ft bgs, and drilling was terminated. No competent silt unit was observed during the drilling of well 299-E27-22.

7.4.4 Well 299-E27-22 (C4124)

Units encountered during the drilling of well 299-E27-23 (C4190) include gravel backfill, the Hanford formation, and possibly the upper facies of the CC_U. Sediments encountered from the ground surface to 245 ft bgs consisted of sand, gravelly sand, silty sand, and silty sandy gravel. A silty sandy gravel was encountered from 245 to 255 ft bgs. Sediments encountered from 255 to 318 ft bgs (total depth) consisted of gravel and sandy gravel. Drilling was terminated at 318 ft bgs in a sandy gravel. No competent silt unit was observed during the drilling of well 299-E27-23.

7.5 COMPARISON OF CHARACTERISTICS OF HANFORD SEDIMENTS BETWEEN WASTE MANAGEMENT AREAS C AND B-BX-BY

The overall stratigraphy underlying WMA B-BX-BY and WMA C are quite similar. Both areas are underlain by sediments of the Hanford formation and the Elephant Mountain basalt. Sediments of the Hanford formation are principally alternating layers of sand, sandy gravel, silty sandy gravel, and gravelly sand. The principle geologic difference between sediments underlying WMA B-BX-BY and WMA C is the lack of a thick, competent silt unit at WMA C. Without a competent silt unit, the likelihood of perched water is decreased significantly.

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8.0 SUMMARY AND RECOMMENDATIONS

This document describes the process used to develop two alternative digital geologic models for WMA C. Both models are primarily based on geophysical logging to identify the tops of the geologic units underlying WMA. The basis for Alternative Geologic Model I (WRPS) is the interpretation of geophysical logs for the dry wells, direct push and nearby groundwater wells provided by a letter report by Energy*Solutions* (Letter Report FS-NW-LT-5367). This interpretation was also supplemented by data from the Hanford Site GeoContacts Database for wells in and around WMA C not included in Letter Report FS-NW-LT-5367. The basis for Alternative Geologic Model II is the interpretations of the geophysical logs provided by Dr. Stan Sobczyk, again supplemented by data from the Hanford Site GeoContacts Database for wells in and around WMA C not included in the spreadsheet transmitted to WRPS in July of 2013. The units making up the geologic model are described in Chapter 2, while the interpretations based on the geophysical logs for the top of each of these units are given in Chapter 3.

All data used to create the geologic models were imported into an Access® database so that the tops of each individual unit could be easily queried before interpolating (using the kriging method) onto a grid that can represent the top surface of each layer. The Access® database is described in Chapter 4, while the process of building the models is given in Chapter 5. Once the model is built, it can be used to linearly interpolate material property numbers onto a numerical grid that can be used simulate groundwater flow and contaminant transport. The process of interpolating those material properties onto a STOMP© model grid is given in Section 5.4. A comparison between both alternative geologic models based on the geophysical logs is given in Chapter 6. As shown in Chapter 6 both models are very similar to each other and would likely provide similar results for a numerical model.

In discussing these models with the individuals who examined the geophysical logs, along with the geologists who have created geologic logs for wells drilled in the eastern half of the 200 East Area, a concern was raised about the H2 coarse layer and the H2 silt layer located right above the undifferentiated H3/CC_U/RF layer at WMA C. Based on the considerations raised in those discussions which are documented in the following paragraph, it is recommended that for the Alternative Geologic Model I (WRPS), the three facies H2 (sand, coarse gravelly sand, and silt) be combined into one layer by the assignment of the same material properties for this model and the vadose zone model to be used in the WMA C PA. In this way, the Alternative Geologic Model I is significantly different than Alternative Geologic Model II (Nez Perce).

The geophysical logs based on the K-U-T indicated that a silt layer similar to what is seen at WMA B-BX-BY is likely to be present at WMA C. However, a thorough examination of the drill cuttings stored at HGSL for two wells at WMA C and two wells at WMA B-BX-BY, along with an examination of the geologic logs of four groundwater wells installed at WMA C in 2004, was made. This examination is given in Chapter 7. For the wells near WMA B-BX-BY, the examination shows that there is a strong competent silt layer at depth that can and does cause a localized perched water condition in this general area. At WMA C, while there is a definite fining of the sands along with silt found at the same vertical location as indicated by the K-U-T geophysical logs, a competent silt layer on which water could perch was not observed in the geologic logs. While K-U-T logs definitely indicate a change in mineralogy, it does not appear

that a competent silt layer at the bottom of the H2 unit is present in the wells for which there are good geologic logs/samples. Additionally, only the groundwater wells were drilled deep enough to encounter this unit and for these groundwater wells, Letter Report FS-NW-LT-5367 placed the confidence of the picks for the tops of the units as low for the following reason: the majority of the groundwater wells with geophysical logs that were drilled in the WMA C used a Becker Hammer method. This makes the interpretation of the geophysical logs difficult due to the double-walled casing used by this method. The double casing walls (quadruple walls at joints) shields the gamma signature that would normally be used for correlations. Additionally, for the description of the H2 Silt unit, Letter Report FS-NW-LT-5367, the strongest evidence for the presence of this unit should be observed on driller and geologist's logs and the coarse gravelly sand and silt were not observed in the geologist's logs.

In order to understand the differences between the models, four cross-sections of each model have been prepared. The plan view of WMA C showing locations of these cross-sections is given in Figure 8-1, along with the wells used to define the top of the units for each cross-section. The legend showing the colors assigned to the different stratigraphic units is given in Figure 8-2. Figures 8-3 through 8-6 show the cross-sections for each location given in Figure 8-1. In each of these four figures, three cross-sections are shown with each cross-section representing a different geologic model, thereby allowing the reader to compare the geologic models to each other along the selected section line. The upper cross-section (a) in the figures represents the Alternative Model I derived from the interpretations for the top of the units given in Letter Report FS-NW-LT-5367 and supplemented by Hanford Site GeoContacts Database. The middle cross-section (b) shows the modified Alternative Model I by combining all of the H2 Sand, H2 Coarse Gravelly Sand, and H2 Silt into one unit based on the geologic logs discussed in Chapter 7. The bottom cross-section is Alternative Model II with the top of units picked by Dr. Stan Sobcyzk.

The picks for the top of each unit are given by a circle symbol at each groundwater well, dry well, direct push, and/or borehole located on the cross section. If a well did not have a pick for the top of the unit, no circle symbol is shown. If a pick was not used in the generation of the surfaces, its location is shown as a green sphere on the cross-section (i.e., top of H2 Coarse Gravelly Sand unit shown at well E27-14). The contact between wells is represented by lines extracted from the surfaces generated in Chapter 5. That contact is influenced by interpreted contacts at selected groundwater wells, dry wells, direct pushes, and/or boreholes that are not located on the cross-section/fence diagram, which is why the contact between wells in the cross-section is not just a straight line. The reader should examine Figures 6-1 through 6-3 to evaluate how wells not shown in the cross-section affect the top of the unit surface.

It is recommended that the Modified Alternative I model be used for the denominator case in the computer modeling for the WMA C PA. Additionally, sensitivity cases based on both original Alternative Geologic Model I and Alternative Geologic Model II, in which the H2 unit is separated as shown in in the cross-section figures, should be examined to evaluate the impacts of the differences the geologic unit may have on the results of the WMA C PA.

Figure 8-1. Locations of Cross-Sections at Waste Management Area C Shown in Figures 8-3 through 8-6.

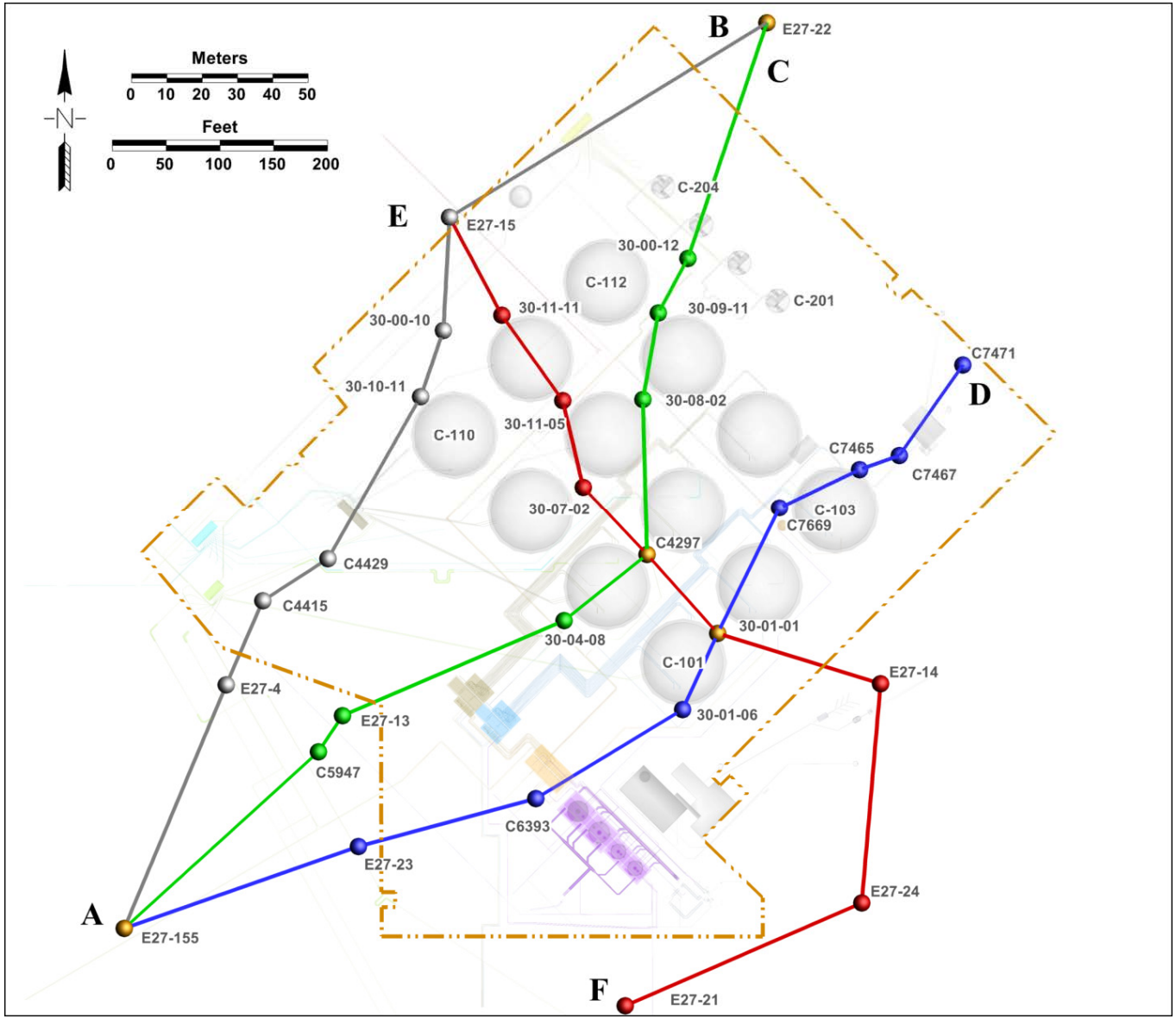
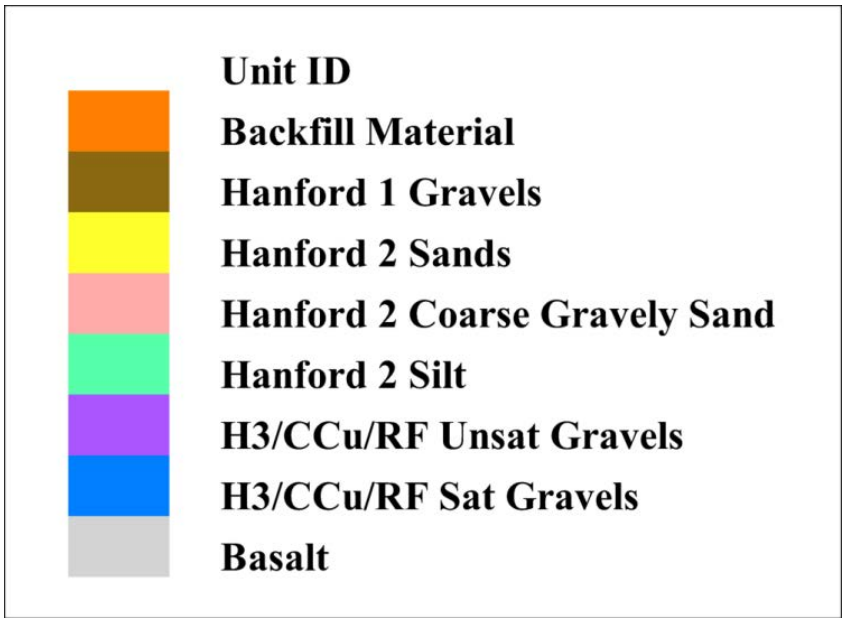


Figure 8-2. Legend for Cross-Sections Shown in Figures 8-3 through 8-6.



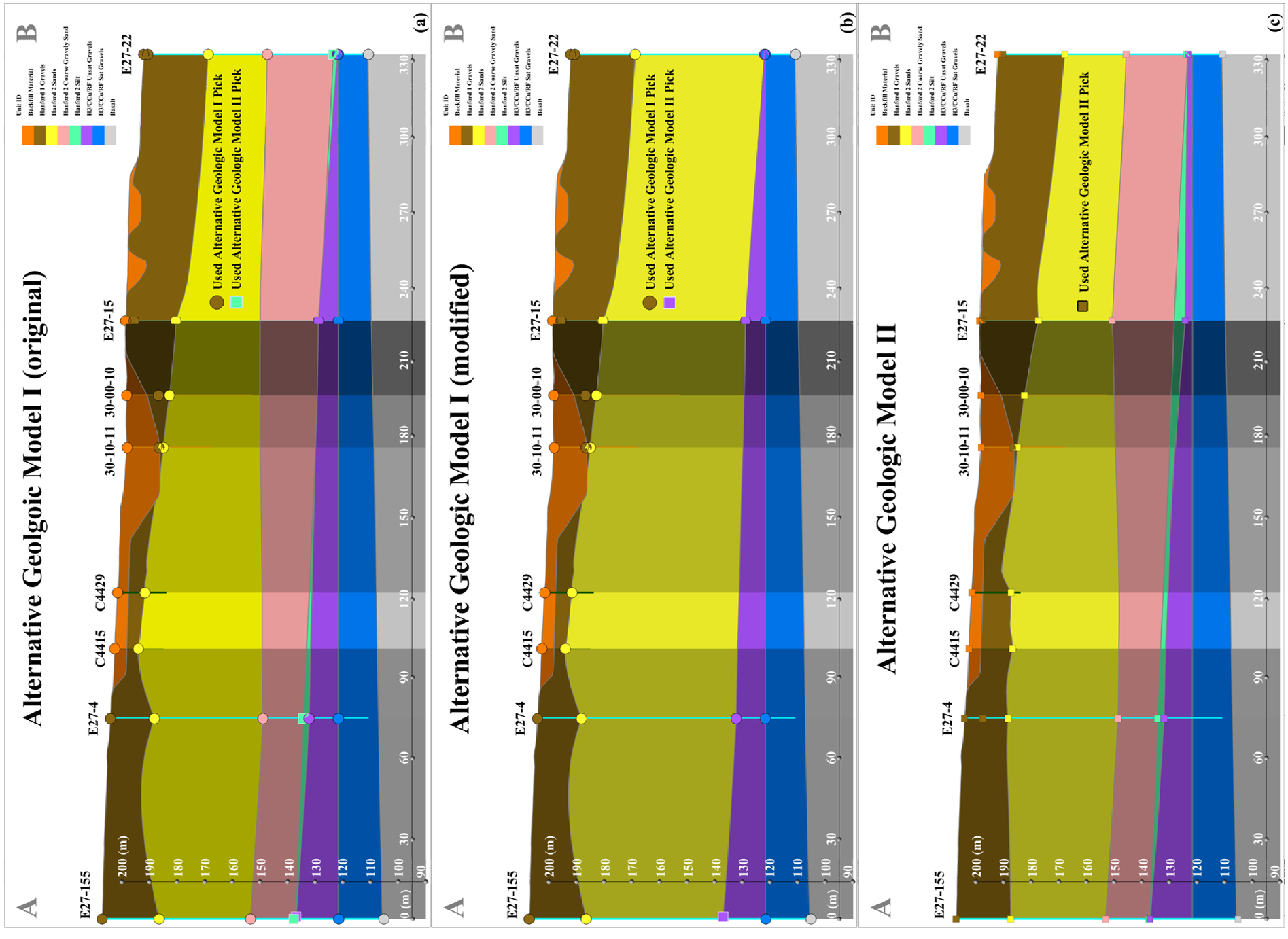


Figure 8-3. West Cross-Section A to B (Gray) for Different Alternative Models.

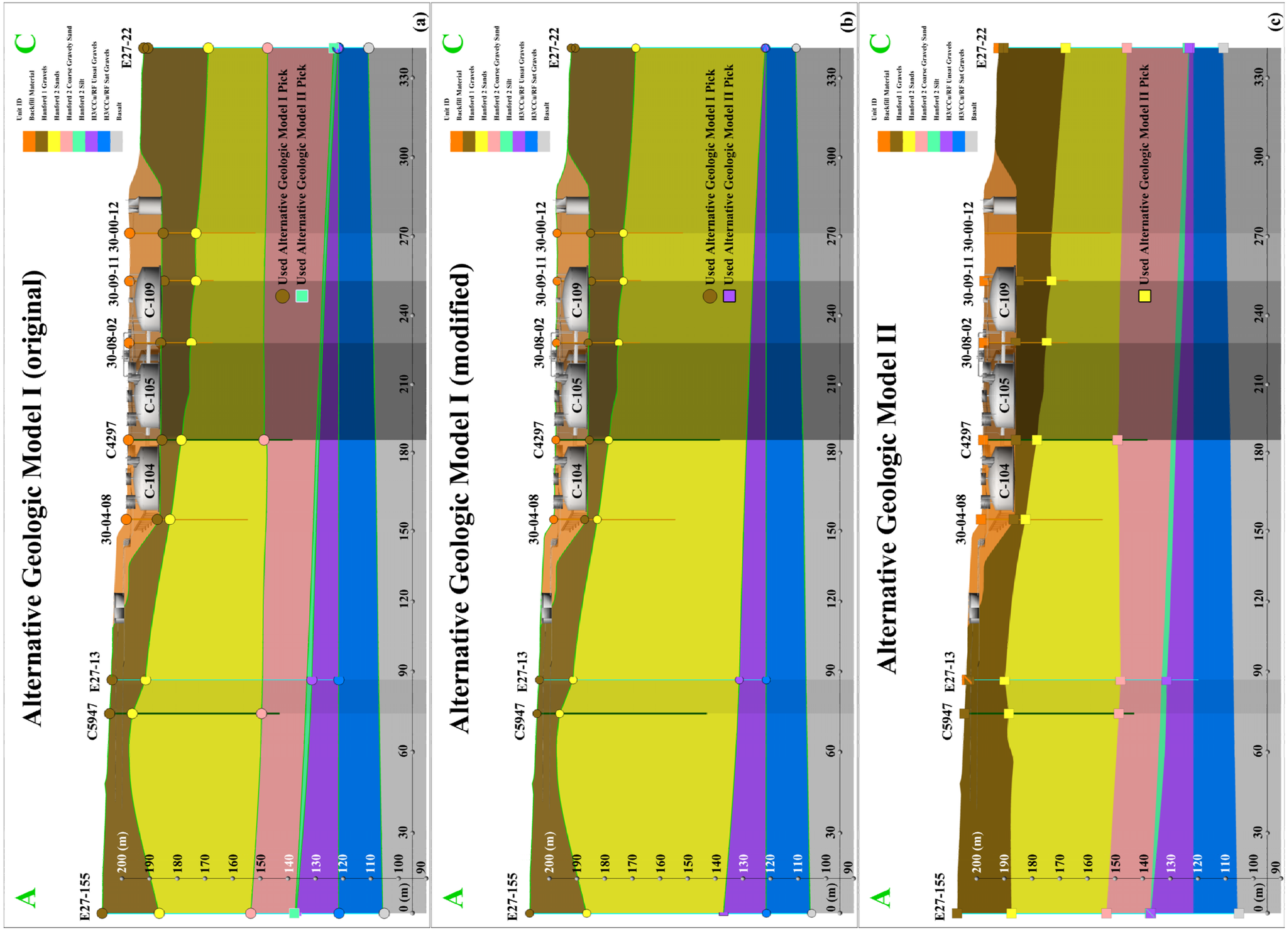


Figure 8-4. Middle Cross-Section A to C (Green) for Different Alternative Models.

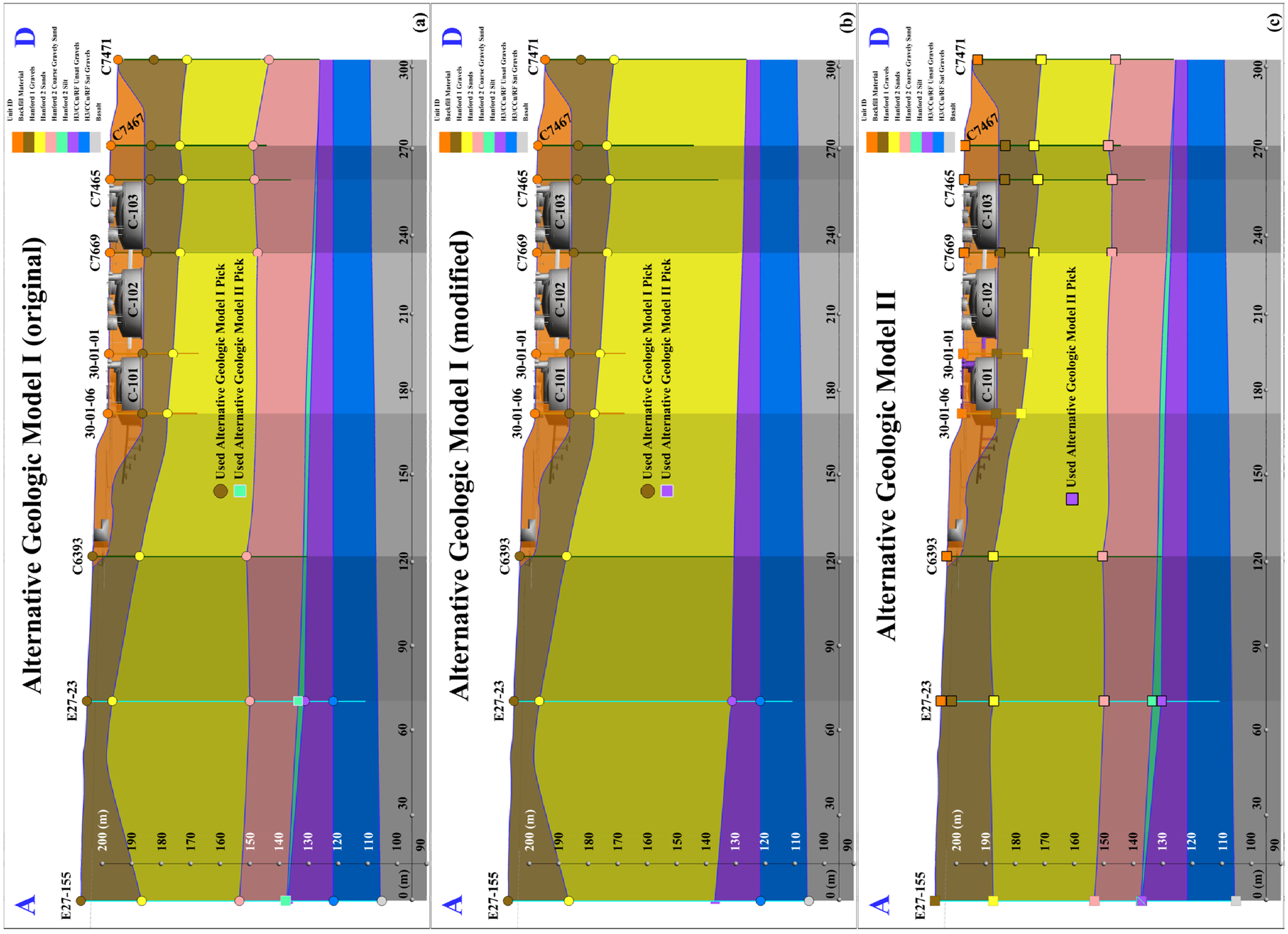


Figure 8-5. West Cross-Section A to D (Blue) for Different Alternative Models.

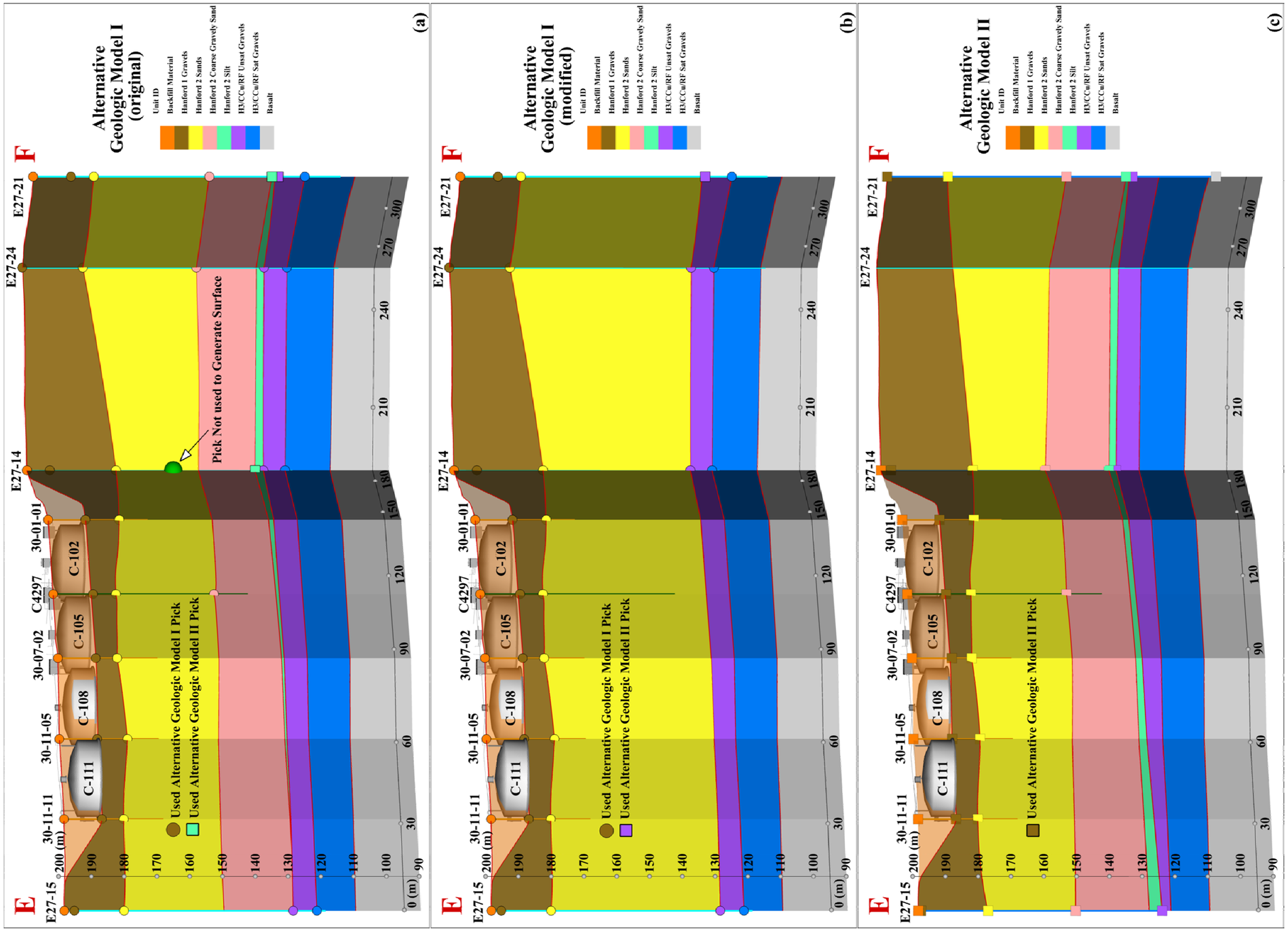


Figure 8-6. Northwest to Southeast Cross-Section E to F (red) for Different Alternative Models.

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