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QA: N/A

JUL 0 2 2002

OVERNIGHT MAIL

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TRANSMITTAL OF A REPORT ADDRESSING KEY TECHNICAL ISSUE (KTI) AGREEMENT ITEMS UNSATURATED AND SATURATED ZONE FLOW UNDER ISOTHERMAL CONDITIONS (USFIC) 5.05 AND RADIONUCLIDE TRANSPORT (RT) 2.09

This letter transmits the report entitled, *Geologic and Hydrostratigraphic Cross Sections NYE-1, NYE-2, and NYE-3, Southern Nye County, Nevada* which provides information to satisfy the following subject KTI agreements:

> USFIC 5.05 – "Provide the hydrostratigraphic cross sections that include the Nye County data."
>
> "DOE will provide the hydrostratigraphic cross sections in an update to the Hydrogeologic Framework Model for the Saturated Zone Site Scale Flow and Transport AMR expected to be available during FY 2002, subject to availability of the Nye County data."
>
> RT 2.09 – "Provide the hydrostratigraphic cross sections that include the Nye County data."
>
> "DOE will provide the hydrostratigraphic cross sections in an update to the Hydrogeologic Framework Model for the Saturated Zone Site Scale Flow and Transport AMR expected to be available during FY 2002, subject to availability of the Nye County data."

The enclosure comprises a presentation of the new cross sections developed from data from the Nye County drilling program. While the Agreement Items USFIC 5.05 and RT 2.09 stated that these new data and cross sections would be provided in an Analysis and Model Report, the information has been included in this report as discussed at the April 15-16, 2002, U.S. Nuclear Regulatory Commission/ U.S. Department of Energy (DOE) Technical Exchange and Management Meeting on KTIs.

Agreement Item General (GEN).1.01(42) is associated with characterization of the transport properties of alluvium. This agreement has been mapped to RT 2.09 because of the similarity in subject. The proposed DOE resolution in this letter does not explicitly address GEN.1.01(42). Disposition of GEN.1.01(42) will be included in the Fiscal Year (FY) 2003 and FY 2004 KTI plan.

This letter contains no new regulatory commitments. Please direct any questions concerning this letter and its enclosure to Eric T. Smistad at (702) 794-5073 or Timothy C. Gunter at (702) 794-1343.

Joseph D. Ziegler
Acting Assistant Manager, Office of
Licensing and Regulatory Compliance

OL&RC:TCG-1351

Enclosure:
Geologic and Hydrostratigraphic Cross Sections NYE-1, NYE-2, and NYE-3, Southern Nye County, Nevada

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GEOLOGIC AND HYDROSTRATIGRAPHIC CROSS SECTIONS NYE-1, NYE-2, AND NYE-3, SOUTHERN NYE COUNTY, NEVADA

June 2002

Preparation:

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ENCLOSURE

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ACRONYMS AND ABBREVIATIONS

3-D	three-dimensional
ACC	Yucca Mountain Site Characterization Project (YMP) accession number
DOE	U.S. Department of Energy
DEM	digital elevation model
DTN	YMP data tracking number
ESRI	Environmental Scientific Research Institute
GFM	Geologic Framework Model
HFM	Hydrogeologic Framework Model
km	kilometers
KTI	key technical issue
NC-EWDP	Nye County Early Warning Drilling Program
NRC	Nuclear Regulatory Commission
m	meter
RT	radionuclide transport
USFIC	unsaturated and saturated flow under isothermal conditions
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
YMP	Yucca Mountain Site Characterization Project

1. BACKGROUND

This report, *Geologic Cross Sections NYE-1, NYE-2, and NYE-3, Southern Nye County, Nevada,* presents the technical basis for closure of two key technical issue (KTI) agreements: Unsaturated and Saturated Flow Under Isothermal Conditions Subissue 5 agreement 5 (USFIC 5.05) and Radionuclide Transport Subissue 2 agreement 9 (RT 2.09).

The interest in the cross sections described in this report originated with requests by the Nuclear Regulatory Commission (NRC) under USFIC Subissue 5 pertaining to the hydrostratigraphy represented by the Nye County data. This interest was repeated in discussions pertaining to RT Subissue 2. Specifically, the NRC requested that the Department of Energy (DOE) use the new data from the Nye County wells to improve their understanding of the alluvial flow regime and to address possible data gaps. In an October 31 through November 2, 2000, technical exchange (Reamer and Williams 2000a), the request addressed in this report was formalized in an NRC/DOE agreement that the DOE provide cross sections that include the Nye County data. The agreement was stated again in a technical exchange held December 5 through 7, 2000 (Reamer and Williams 2000b).

2. APPLICABLE NUCLEAR SAFETY STANDARDS/REQUIREMENTS/GUIDANCE

2.1 APPLICABLE REQUIREMENTS

The Yucca Mountain disposal regulations include requirements for evaluating postclosure performance of the repository, including multiple barriers (10 CFR 63.113(a)) and a description of the capabilities of the barriers (10 CFR 63.115(b)). The cross sections presented in this report provide further demonstration of the characterization of the saturated zone barrier.

2.2 KTI AGREEMENTS

This report addresses two KTI agreements:

USFIC 5.05: Provide the hydrostratigraphic cross sections that include the Nye County data. DOE will provide the hydrostratigraphic cross sections in an update to the Hydrogeologic Framework Model for the Saturated Zone Site-Scale Flow and Transport Model AMR expected to be available during FY 2002, subject to availability of the Nye County data.

RT 2.09: Provide the hydrostratigraphic cross sections that include the Nye County data. DOE will provide the hydrostratigraphic cross sections in an update to the Hydrogeologic Framework Model for The Saturated Zone Site-Scale Flow and Transport Model AMR expected to be available during FY 2002, subject to availability of Nye County data.

The requested information pertains to the hydrostratigraphic cross sections using Nye County data. While the original agreement indicated that these cross sections would be provided in an analysis/model report (AMR), the DOE believes that this report contains the information necessary to satisfy the agreement.

2.3 STATUS OF AGREEMENTS

The agreement is classified as closed, pending the NRC review and acceptance of this report as sufficient to satisfy the agreement.

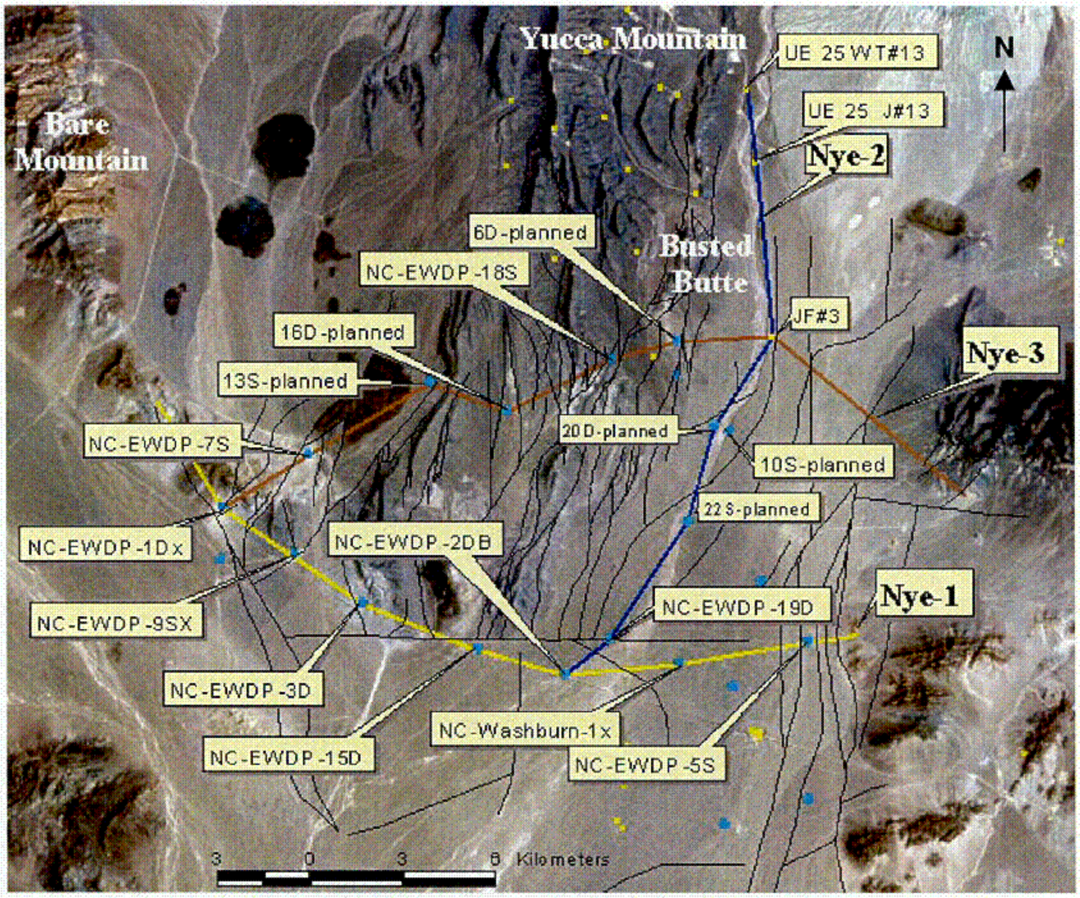
3. GEOLOGIC AND HYDROSTRATIGRAPHIC CROSS SECTIONS NYE-1, NYE-2, AND NYE-3, SOUTHERN NYE COUNTY, NEVADA

3.1 INTRODUCTION

Construction of three cross sections in the vicinity of recently drilled holes of the Nye County Early Warning Drilling Program (Figure 1) is presented in this report to contribute to the resolution of several KTIs. Relevant KTIs include the following: 1) RT2.08 (uncertainty distribution of flow paths in the alluvium), 2) RT2.09 (provide hydrostratigraphic cross sections that include the Nye County data, 3) RT3.03 (provide additional information to further justify the uncertainty of flow path lengths in the tuff), and 4) SZ5.05 (provide the hydrostratigraphic cross sections for revision of the Hydrogeologic Framework Model [HFM]). Lines-of-section for cross sections Nye-1, Nye-2, and Nye-3 extend across parts of southern Yucca Mountain, Fortymile Wash, southern Crater Flat, and northern Amargosa Valley within the central part of the area of the site-scale saturated zone model. The three cross sections integrate the following: 1) recently acquired drill-hole information from Phase I and Phase II of Nye County's Early Warning Drilling Program, 2) a few selected drill holes from the Yucca Mountain Project database (within Fortymile Wash), 3) information from the recently completed geologic map of the Yucca Mountain region (Potter et al., in press), and 4) available aeromagnetic and "depth-to-basement" geophysical data of the region.

Cross section Nye-1 extends generally in an east-west direction over a distance of about 26 km in the vicinity of Highway 95 and the southern part of Fortymile Wash (Figure 1). Cross section Nye-2 is approximately 21 km long, extending in a northerly direction close to the main drainage channel in Fortymile Wash (Figure 1). Cross section Nye-3 is 27.5 km in length, extending in a west to southwesterly direction across the middle part of Fortymile Wash, the southern part of Yucca Mountain (south of Busted Butte), and the southern part of Crater Flat (Figure 1). All three cross sections form an irregular pattern in order to capture as many drilled and planned Nye County drill holes as possible and to minimize as possible the need to project drill holes into the lines-of-section (Figure 1). The base of each of the three cross sections was designed to extend to 2 km below mean sea level. No vertical exaggeration occurs in the cross sections.

Nine moderate to deep holes were drilled in Phase I and Phase II of Nye County's Early Warning Drilling Program, which could be used to improve understanding of the subsurface geology beneath southernmost Yucca Mountain, Fortymile Wash, southern Crater Flat, and northern Amargosa Valley. These drill holes penetrated thick sections of Quaternary and Tertiary alluvial deposits, a relatively thin Tertiary volcanic sequence, and in one drill hole, the upper part of the Paleozoic rock sequence.



NOTE: The Nye-1 cross section is shown as a yellow line, Nye-2 a blue line, and Nye-3 a brown line. Locations of drilled and planned holes of the Nye County Early Warning Drilling Program are shown as cyan circles. Selected drill holes from the Yucca Mountain drill-hole database are shown as yellow circles.

Figure 1. Locations of Nye Cross Sections with Respect to Exposed Bedrock in Southern Yucca Mountain

3.2 GEOLOGIC CROSS SECTIONS

Details of methods and data sources used in the construction of cross sections are provided in both the scientific notebook SN-USGS-SCI-001 V4 (Yucca Mountain Site Characterization Project (YMP) accession number (ACC): MOL.20020109.0063) and other documentation that accompanies the data package "Geologic Cross Sections Nye-1, Nye-2, and Nye-3, Southern Nye County, Nevada" (YMP data tracking number (DTN): GS020208314211.002). This section briefly describes a few of the more salient features included in the documentation. Details can be found in, but are not intended to duplicate, scientific notebook SN-USGS-SCI-001 V4. These cross sections and accompanying documentation have been technically reviewed and have been submitted by the U.S. Geological Survey (USGS) to the Yucca Mountain Project Technical Data Management System. These cross sections have been designated as Q-data.

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The procedure uses commercially available computer-assisted drafting software to build geologic cross sections. Digital construction of cross sections has resulted in sections that are faster to construct, easier to revise, and maintain a high degree of accuracy when integrating them into revisions to the Hydrologic Framework Model. This procedure uses vector, grid, and drafting tools that are available in ARCINFO by ESRI (Environmental Scientific Research Institute) and Autodesk's AutoCAD™. Because the cross sections are digital, they are essentially scaleless and are best examined and studied using software with "zooming" capability. This approach will allow more flexibility in reading detailed stratigraphic information shown at each drill-hole location used in the compilation.

The first step in creating a geologic cross section was to create a digital template for the cross-section development and for insertion of fundamental data sets. These templates were created by: 1) digitizing and drafting cross-section traces, 2) intersecting the traces with appropriate coverages (layers) using ARCINFO, 3) digitally intersecting the trace of the cross section with modeled surfaces in ARCINFO, and 4) exporting the intersected digital files from ARCINFO into AutoCAD (Plate 1). Digital versions of the geologic map of the Yucca Mountain region (Potter et al., in press) and regional cross sections of the Death Valley region (Sweetkind et al. 2001) represent the two main sources for surface and subsurface structural and stratigraphic data used to establish templates on these more detailed cross sections.

After creation of the templates, additional information—such as new subsurface interpretations of Nye County drill-hole data, reinterpretation of subsurface fault geometries, and interpretation of variations in thickness of stratigraphic units—was inserted into the plane of the section. A complete list of sources of information that were integrated into the cross sections is shown in Table 1.

Table 1. Data Sources for Cross Sections Nye-1, Nye-2, and Nye-3

Cross Section	Cross-Section Element	Data Type	Data Source
Nye-1	Drill hole NC-EWDP-1DX	Depths of stratigraphic units	DTN: GS000808314211.005
	Drill hole NC-EWDP-9SX	Depths of stratigraphic units	DTN: GS000808314211.005
	Drill hole NC-EWDP-3D	Depths of stratigraphic units	DTN: GS000808314211.005
	Drill hole NC-EWDP-15D	Depths of stratigraphic units	DTN: GS020108314211.001
	Drill hole NC-EWDP-2DB	Depths of stratigraphic units	DTN: GS011008314211.001
	Drill hole Washburn	Drill hole location only	DTN: MO0107COV01057.000
	Drill hole NC-EWDP-5S	Drill hole location only	DTN: MO0107COV01057.000
Nye-2	Drill hole NC-EWDP-2DB	Depths of stratigraphic units	DTN: GS011008314211.001
	Drill hole NC-EWDP-19D1	Depths of stratigraphic units	DTN: GS011008314211.001
	Proposed site for Drill hole NC-EWDP-22S	Proposed location only	Nye County WEB site, www.nyecounty.com

Table 1 (continued). Data Sources for Cross Sections Nye-1, Nye-2, and Nye-3

Cross Section	Cross-Section Element	Data Type	Data Source
	Drill hole JF#3	Depths of stratigraphic units used for corroboration.	USGS WRIR-95-4245
	Drill hole UE-25 J#13	Depths of stratigraphic units	DTN: MO0004QGFMPICK.000
	Drill Hole UE-25 WT#13	Depths of stratigraphic units	DTN: MO0004QGFMPICK.000
Nye-3	Drill hole NC-EWDP-1DX	Depths of stratigraphic units	DTN: GS000808314211.005
	Drill hole NC-EWDP-7SC	Depths of stratigraphic units	DTN: GS020108314211.001
	Proposed site for Drill hole NC-EWDP-13S	Proposed location only	Nye County WEB site, www.nyecounty.com
	Proposed site for Drill hole NC-EWDP-16S	Proposed location only	Nye County WEB site, www.nyecounty.com
	Proposed site for Drill hole NC-EWDP-18S	Proposed location only	Nye County WEB site, www.nyecounty.com
	Proposed site for Drill hole NC-EWDP-6D	Proposed location only	Nye County WEB site, www.nyecounty.com
All cross sections	Surface profiles	Digital topography	DTN: GS000400002332.001; Digital Elevation Model data obtained from the USGS U.S. GeoData database
	Corroborative data indirectly used to help locate the top of Paleozoic strata along lines of section.	Gravity profiles	Ponce et al. (2001)
	Corroborative data used to help locate the top of Paleozoic strata along lines of section.	Depth-to-basement profiles	Blakely and Ponce (2001)
	Corroborative data indirectly used to aid in identifying possible buried structures.	Aeromagnetic data	Ponce et al. (2001)
	Locations of exposed faults		DTN: GS010908314221.001; Potter et al., in press
	Regional subsurface structural geometries		Sweetkind et al. (2001)
	Drill-hole locations, Nye County Phase I and Phase II		DTN: MO0107COV01057.000
	Drill-hole locations, YMP boreholes used		DTN: MO9907YMP99025.001

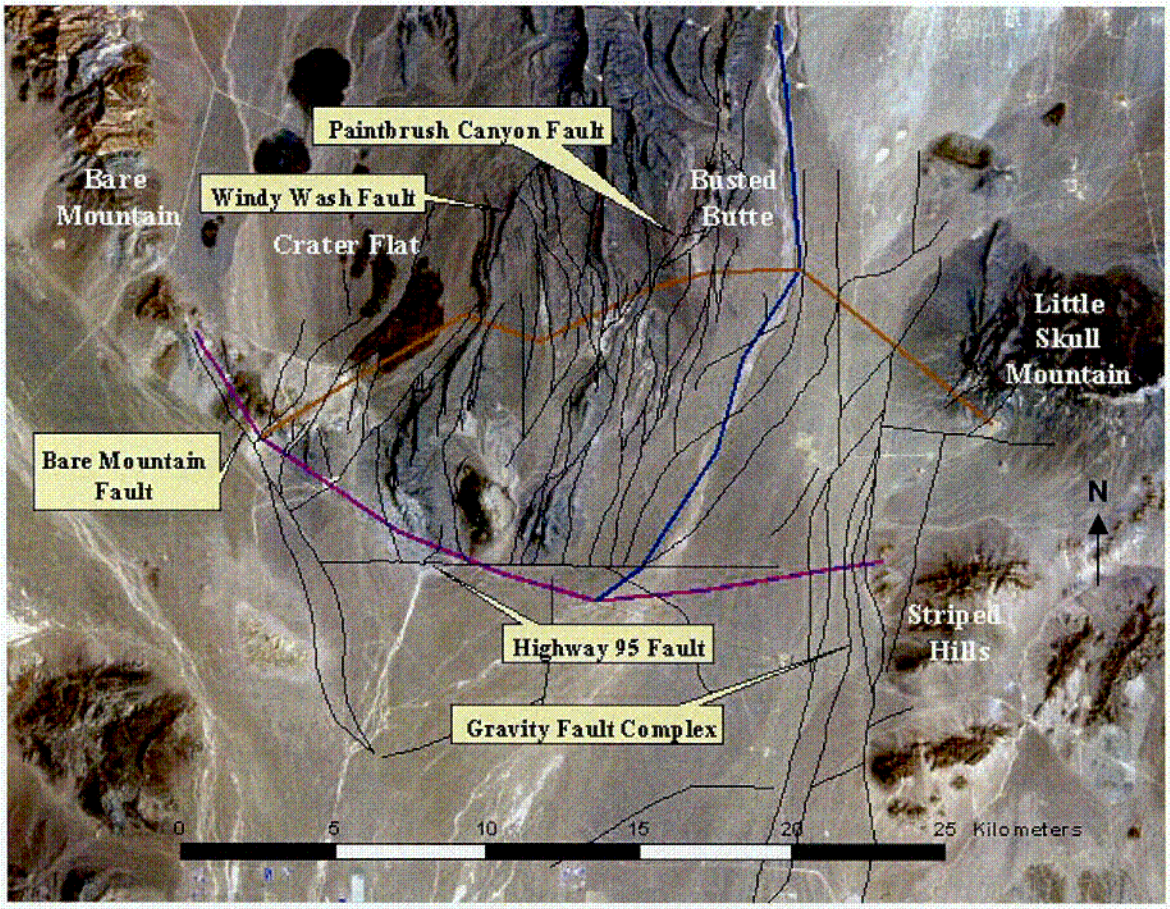
3.3 STRUCTURAL FRAMEWORK

Except for a few faults that extend into exposed bedrock, almost all surface traces of faults that were mapped in southern Yucca Mountain, southern Crater Flat, and Fortymile Wash are concealed beneath Quaternary alluvial deposits (Potter et al., in press). Therefore, all faults and/or their approximate surface locations that are indicated on cross sections are interpretive. Faults that are shown in cross sections are color-coded to indicate whether they are inferred from regional surface mapping or from available geophysical information.

The major faults used in the construction of the structural framework of the cross sections included the Paintbrush Canyon/Stagecoach Road fault, Windy Wash fault, Bare Mountain fault, the "Gravity fault," and the Highway 95 fault (Figure 2). The moderate-to-deep trough that includes the area of Crater Flat, Yucca Mountain, Fortymile Wash, and northern Amargosa Valley is bounded on the west by the east-dipping Bare Mountain fault and on the east by a series of north-trending, west-dipping faults known as the "Gravity fault" (Figures 2 and 3, Potter et al., in press). The anastomosing network of north-trending, west-dipping, normal faults that branch from the Paintbrush Canyon/Stagecoach Road fault system and Windy Wash fault have been mapped as terminating against the southern part of the Bare Mountain fault and the Highway 95 fault (Potter et al., in press). The Highway 95 structure appears to possess several unique characteristics. The fault has been mapped as extending in an east-west direction, coincident with the relatively abrupt truncation of moderate-to-steep aeromagnetic gradients (Figure 3). This fault has been mapped as showing a dominant down-to-the-north offset (Potter et al., in press). However, a strong component of left-lateral slip is also suspected. The Highway 95 fault has a near vertical dip and a length of about 15 km, terminating against the Bare Mountain on the west and extending to the middle of Fortymile Wash on the east. The fault appears to extend eastward, directly to the north of NC-EWDP-19D on cross section Nye-2. To best accommodate abrupt differences in thicknesses and lithologic character of subsurface units found in NC-EWDP-19D and NC-EWDP-2DB, a splay to the Highway 95 fault has been added to the structural framework of Potter et al. (in press) in the vicinity of the cross sections. This splay extends southeastward, east of the intersection of cross sections Nye-1 and Nye-2 (Figures 2 and 3). Where cross sections Nye-1 and Nye-2 cross these two structures, thicknesses of subsurface stratigraphic units on either side of the structures are not necessarily preserved due to the inferred lateral component of slip.

A significant number of mapped faults in the Yucca Mountain area are coincident with moderate-to-steep aeromagnetic gradients (Figure 3). Both the residual isostatic gravity maps and moderate-to-steep linear aeromagnetic gradient-contours were used to infer the existence of buried faults, particularly in the Fortymile Wash area (Figure 3).

All three cross sections indicate the topographic profile in green. Similarly, all cross sections depict a layer, color coded in light brown, that represents a depth-to-basement profile, extracted from a depth-to-basement model by Blakely et al. (2001). The depth-to-basement model represents a three-dimensional inversion of the isostatic residual gravity field of the region. To the extent possible, the depth-to-basement profile in each cross section was used in two ways: 1) the depth-to-basement profile was used as an approximate depth to presumed Paleozoic and Late Proterozoic rocks; and 2) changes in gradient or abrupt inflections along the depth-to-



NOTE: The location of the Nye-1 cross section is shown in purple, Nye-2 in blue, and Nye-3 in brown. All selected fault traces are considered inferred except for a few segments that extend into bedrock (modified from Potter et al., in press). Refer to the cross sections for a sense of displacement along selected faults.

Figure 2. Framework of Selected Fault Traces in the Vicinity of Nye Cross Sections.

basement profile were identified as potential fault scarps, offsetting the Paleozoic surface. The depth-to-basement profile provided a good estimate of the depth to Paleozoic rocks in the vicinity of NC-EWDP-2DB, where the modeled depth was only 62 m higher than the actual Paleozoic surface. However, the estimated depth-to-basement profile in the vicinity of UE-25 J#13 (see Nye-2) is significantly more than 162 m. Based on this level of uncertainty, estimates of the depth-to-basement in the vicinity of UE-25 J#13 were based on projection of stratigraphic thicknesses from nearby drill hole UE-25 p#1.

On the basis of local uncertainties with the depth-to-basement model, localized inflections and conspicuous variations in slope along the depth-to-basement profile within each cross section were used as a guide for local subsurface fault geometry near the inferred Paleozoic surface. These anomalies were only used where they are not inconsistent with surface geologic characteristics such as fault locations, attitude of stratigraphic units, attitude of exposed faults and/or drill-hole data, and other geophysical evidence.

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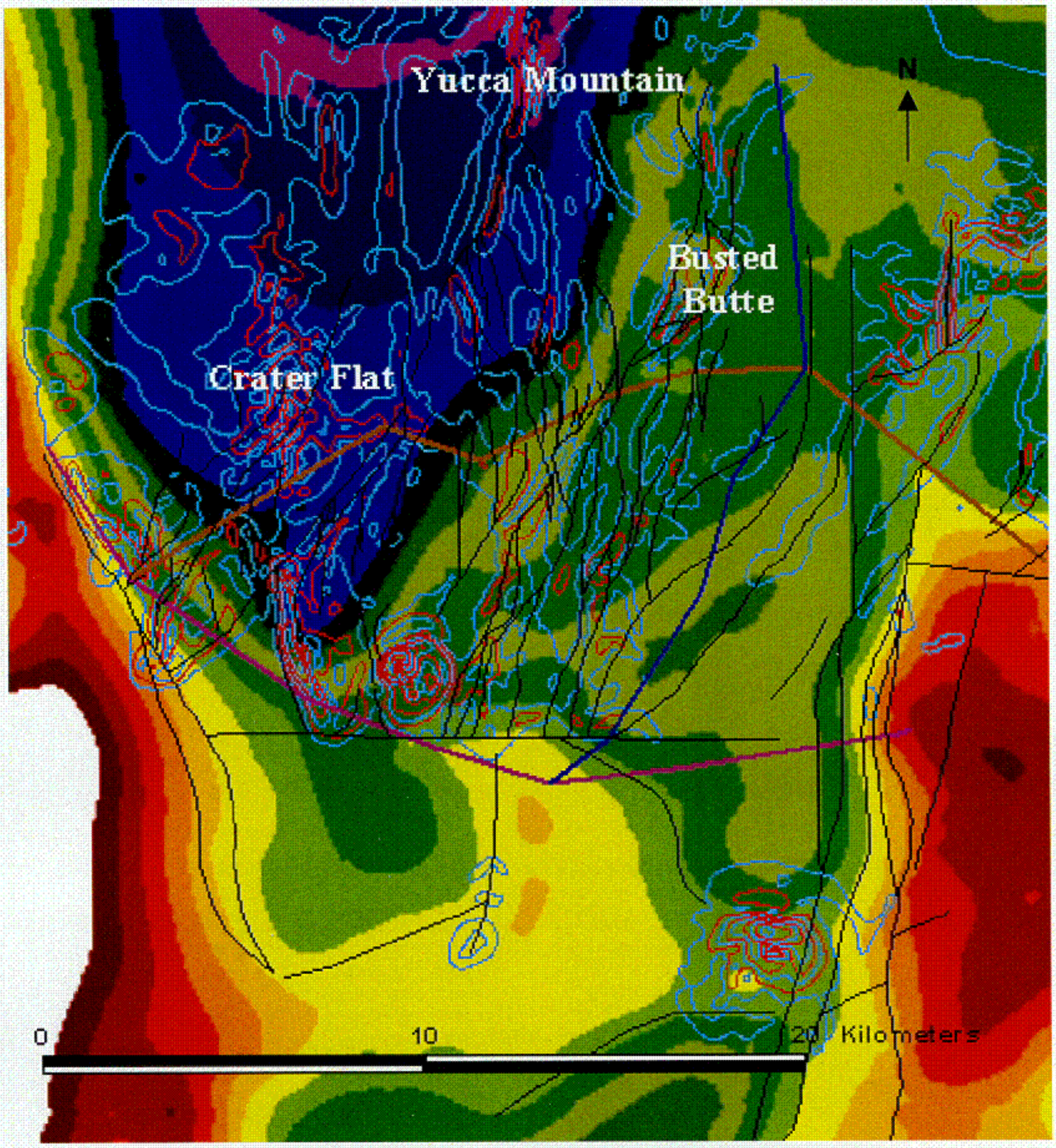

NOTE: Selected segments of residual isostatic gravity (Ponce et al. 2001) are depicted in solid colors with warm colors denoting outcrop or near-surface Paleozoic or late Proterozoic rocks and cooler colors indicating moderate to deep basins filled with Quaternary and Tertiary deposits. Contour lines map aeromagnetic gradients (Blakely et al. 2001) with steep aeromagnetic gradient contours in red and moderately steep aeromagnetic gradient contours in cyan. The Nye-1 cross section is shown as a purple line, Nye-2 as a blue line, and Nye-3 as a brown line. Inferred buried faults are shown in black.

Figure 3. Residual Isostatic Gravity and Aeromagnetic Maps with Respect to the Locations of Nye Cross Sections

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3.4 HYDROGEOLOGIC FRAMEWORK

Development of a hydrogeologic framework model (HFM) begins with the assembly of primary data: geologic maps and sections, borehole lithologic logs, and topographic digital elevation models (DEM). Standard GIS, such as ARCINFO, can manipulate each of these primary data; however, the merging of these diverse data types to form a single coherent three-dimensional (3D) digital model requires more specialized geologic modeling software.

Construction of a 3-D HFM involves the following steps:

1. Geologic units are classified into hydrogeologic units based on their hydraulic properties and lateral extent.
2. DEM data are combined with hydrogeologic maps to provide a series of points in 3-D space locating outcrops of individual hydrogeologic units.
3. Geologic sections and borehole lithologic logs are used to locate hydrogeologic units in the subsurface.
4. Geologic maps and geologic sections are used to locate faults.
5. Structure contour maps for each hydrogeologic unit are developed by interpolating both surface and subsurface positions with gridding software, which incorporates offsets of units across faults.
6. An HFM is developed when the structure contour maps for the individual hydrogeologic units are combined, utilizing appropriate stratigraphic principles to control their sequence, thickness, and lateral extent.

Table 2 correlates 2002 Hydrogeologic Unit names to the lithologic names used in the cross sections.

Table 2. Correlation of 2002 Hydrogeologic Unit Names to Lithologic Names Used in Cross Sections

2002 Hydrogeologic Unit Name	2002 Hydrogeologic Unit Number	Lithologic Acronym	Lithologic Name
Young Alluvial Aquifer	28	Qal,Qa	alluvium
Young Alluvial Confining Unit	27		Model unit not found in cross section
Older Alluvial Aquifer	26	Qtu	alluvium, undivided
		Tal	alluvium
		Trx	rock avalanche deposits
Older Alluvial Confining Unit	25[1]		Model unit not found in cross section
Limestone Aquifer	24		Model unit not found in cross section
Lavaflow Unit	23	Tby	young basalts
		Tvy	
Young Volcanic Units	22[1]		Model unit not found in cross section

Table 2 (continued). Correlation of 2002 Hydrogeologic Unit Names to Lithologic Names Used in Cross Sections

2002 Hydrogeologic Unit Name	2002 Hydro-geologic Unit Number	Lithologic Acronym	Lithologic Name
Volcanic and Sedimentary Units (upper)	21	Tge	oldest sedimentary rocks
		Tgeg1	oldest sedimentary rocks gravel # 1
		Tgeg2	oldest sedimentary rocks gravel # 2
		Tgeg3	oldest sedimentary rocks gravel # 3
		Tgeg4	oldest sedimentary rocks gravel # 4
		Tgeg5	oldest sedimentary rocks gravel # 5
		Tgeg6	oldest sedimentary rocks gravel # 6
Timber Mountain Volcanic Aquifer	20	Tmr	Rainier Mesa Tuff
		Tma	Ammonia Tanks Tuff
Paintbrush Volcanic Aquifer	19	Tpt	Topopah Spring Tuff
		Tptbt	Pre-Topopah Bedded Tuff
		Tpts	Pre-Topopah sedimentary rock
		Tpc	Tiva Canyon Tuff
		Tpcbt	pre-Tiva Canyon bedded Tuff
Calico Hills Volcanic Unit	18	Tac	Calico Hills Formation
Wahmonie Volcanic Unit	17	Tw	Wahmonie Formation
Prow Pass Aquifer	16	Tcp	Prow Pass Tuff
		Tcpbt	pre-Prow Pass bedded tuff
Bullfrog Confining Unit	15	Tcb	Bull Frog Tuff
		Tcbbt	Pre-Bull Frog bedded tuff
		Tcbss	pre-Bullfrog sedimentary rocks
Tram Aquifer	14	Tct	Tram Tuff
		Tcts	pre-Tram sedimentary rocks
		Tctbt	pre-Tram bedded tuff
Belted Range Unit	13[1]		Model unit not found in cross section
Older Volcanic Units	12	Trl	Lithic Ridge Tuff
		Trls	pre-Lithic Ridge sedimentary rocks
		Trlbt	pre-Lithic Ridge bedded tuff
		Trr	Rhyolite of Picture Rock
Volcanic and Sedimentary Units (lower)	11	Tge	oldest sedimentary rocks
		Tgeg1	oldest sedimentary rocks gravel # 1
		Tgeg2	oldest sedimentary rocks gravel # 2
		Tgeg3	oldest sedimentary rocks gravel # 3
		Tgeg4	oldest sedimentary rocks gravel # 4
		Tgeg5	oldest sedimentary rocks gravel # 5
		Tgeg6	oldest sedimentary rocks gravel # 6
		Dn	Nevada Formation
Sedimentary Confining Unit	10[1]	Du	Undivided

Table 2 (continued). Correlation of 2002 Hydrogeologic Unit Names to Lithologic Names Used in Cross Sections

2002 Hydrogeologic Unit Name	2002 Hydro-geologic Unit Number	Lithologic Acronym	Lithologic Name
Lower Carbonate Aquifer - thrust	9	Su	undivided
		Ou	undivided
		Cb	Bonanza King Formation
		Cn	Nopah Formation
		Cc	Carrara Formation
Lower Clastic Confining Unit - thrust	8		Model unit not found in cross section
Upper Carbonate Aquifer	7	Dn	Nevada Formation
Upper Clastic Confining Unit	6	Du	undivided
Lower Carbonate Aquifer	5	Su	undivided
		Ou	undivided
		Cb	Bonanza King Formation
		Cn	Nopah Formation
		Cc	Carrara Formation
		Cz	Zabriskie Quartzite
		CZw	Proterozoic/Cambrian Wood Canyon Formation
Lower Clastic Confining Unit	4	ZYm	metamorphic
		Xm	metamorphic
Crystalline Confining Unit	3		Model unit not found in cross section
Intrusive Confining Unit	2		Model unit not found in cross section
Base (-4000 m below sea level)	1		Model unit not found in cross section

NOTE: [1] These units do not occur in the site HFM area.

Surfaces of each hydrogeologic unit were created by interpolating from input data representing the top of the respective unit. These input data include: stratigraphic well tops (including the available Nye County EWDP data), cross sectional interpretations (including the three Nye geologic sections), and outcrop data. The model was built with the software-generated surfaces and still needs some hand editing.

During the interpolation, the surfaces may have extrapolated beyond the extent of the data sources. Such inconsistencies occur in the area of drill hole NC-EWDP-19D. These are most noticeable in some of the older volcanic units, such as the Crater Flat units. These extrapolations need to be hand edited to a reasonable extent based on geologic intuition. This manual editing has not yet occurred and will occur, in part, by examining areas where units are known not to occur.

3.5 HYDROSTRATIGRAPHIC CROSS SECTIONS

Three hydrogeologic cross sections represent two-dimensional vertical slices of the hydrogeology at Yucca Mountain (Table 3, Figures 4-6). Hydrostratigraphic cross sections at the same locations have been extracted from the 2002 HFM (DTN: TBD) using LAGriT version

1.0 software (Software Tracking Number: 10212-1.0-00). The 2002 HFM integrates data from the Underground Testing Areas (UGTA) geologic models (IT Corporation 1996) and the Geologic Framework Model (GFM) (BSC 2001) in addition to new lithologic well logs and newly constructed geologic maps and cross sections. The data from various sources, such as mapped outcrops, wells, geologic cross sections, and the UGTA geologic model grids, were used to construct gridded surfaces of relevant hydrogeologic units.

Table 3. Unit Names for Hydrogeologic Framework Model Surfaces

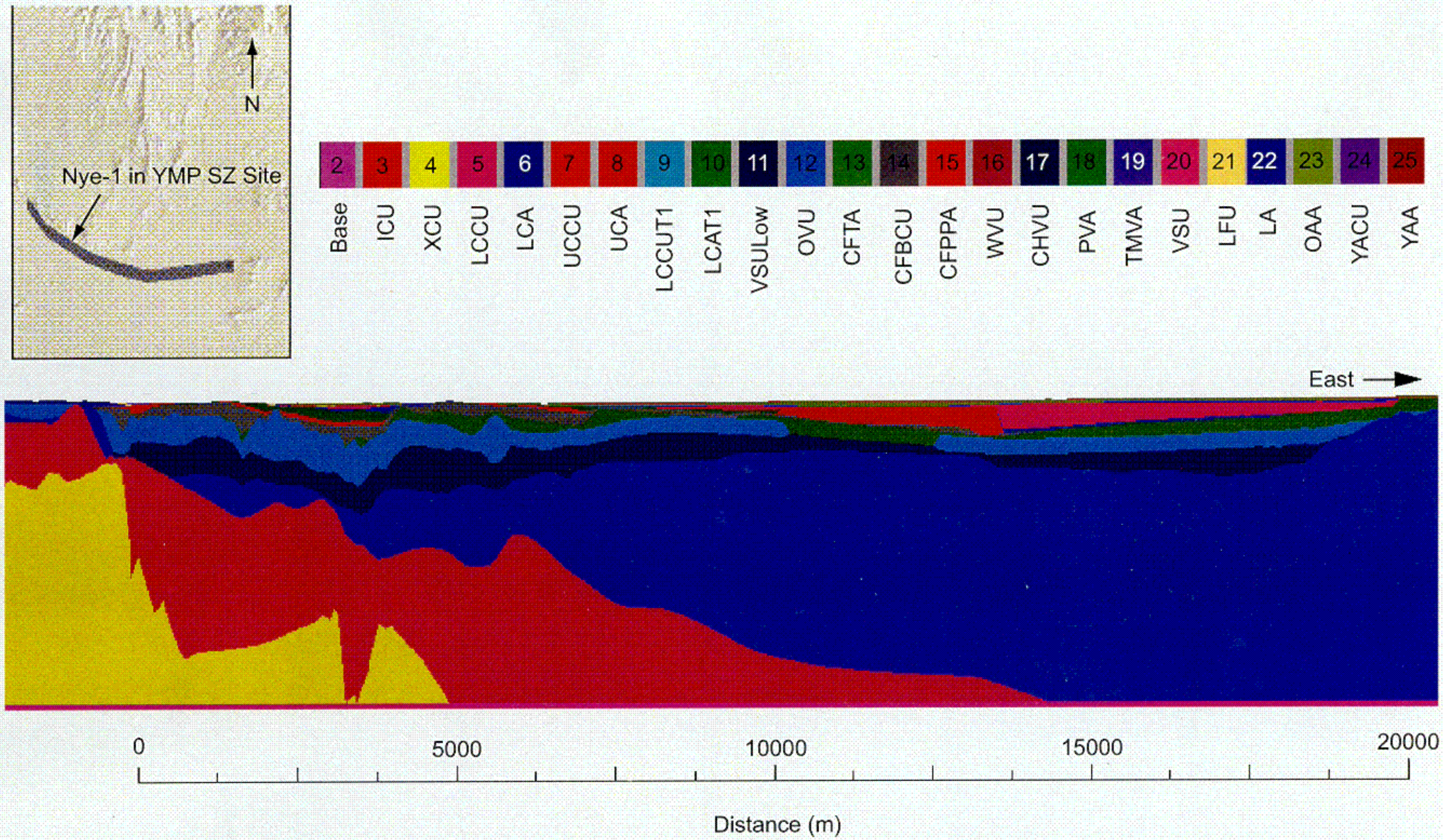
HFM Slice Unit Number	2002 Hydrogeologic Unit Number	Acronym	2002 Hydrogeologic Unit Name
<25>	28	YAA	Young Alluvial Aquifer
<24>	27	YACU	Young Alluvial Confining Unit
<23>	26	OAA	Older Alluvial Aquifer
<-->	25	OACU	Older Alluvial Confining Unit
<22>	24	LA	Limestone Aquifer
<21>	23	LFU	Lavaflow Unit
<-->	22	YVU	Young Volcanic Units
<20>	21	VSU	(Upper) Volcanic and Sedimentary Units
<19>	20	TMVA	Timber Mountain Volcanic Aquifer
<18>	19	PVA	Paintbrush Volcanic Aquifer
<17>	18	CHVU	Calico Hills Volcanic Unit
<16>	17	WVU	Wahmonie Volcanic Unit
<15>	16	CFPPA	Crater Flat – Prow Pass Aquifer
<14>	15	CFBCU	Crater Flat – Bullfrog Confining Unit
<13>	14	CFTA	Crater Flat – Tram Aquifer
<-->	13	BRU	Belted Range Unit
<12>	12	OVU	Older Volcanic Units
<10>	11	VSU	(Lower) Below Volcanic Rocks (New Surface)
<-->	10	SCU	Sedimentary Confining Unit
<10>	9	LCAT1	Lower Carbonate Aquifer – thrust
<9>	8	LCCUT1	Lower Clastic Confining Unit – thrust
<8>	7	UCA	Upper Carbonate Aquifer
<7>	6	UCCU	Upper Clastic Confining Unit
<6>	5	LCA	Lower Carbonate Aquifer
<5>	4	LCCU	Lower Clastic Confining Unit
<4>	3	XCU	Crystalline Confining Unit
<3>	2	ICU	Intrusive Confining Unit
<2>	1		Base (elevation of –4000 m)

NOTE: The numbers in the first column are the unit numbers assigned by the Stratamodel software, which was used to construct the 2002 three-dimensional HFM. These numbers are shown in the HFM slice images (Figures 4 through 12). The Stratamodel software ignores units that are pinched out by coincident surfaces. These pinched-out units are indicated by <-->. 2002 Hydrogeologic Unit acronyms and names are listed in the third and fourth columns, respectively. Table 4 correlates the 2002 Hydrogeologic Unit acronyms and names to the lithologic acronymns used in the geologic cross sections in earlier figures.

Table 4 lists borehole data used in the overview graphics and line images for cross sections Nye-1, Nye-2, and Nye-3 (Figures 4 through 12). The Nye-1, Nye-2, and Nye-3 line images consist of two images for each slice. Each of the two images are enlarged sections of each end. Dark vertical lines indicate the location of boreholes used in creating these slices. Dark horizontal lines in Figures 7 through 12 show elevations at –2000 m and –4000 m. Also on Figures 7 through 12, beneath each borehole is a list of unit materials found in the 2002 HFM (DTN: TBD) at the borehole location. Unit labels have also been added to these images where possible.

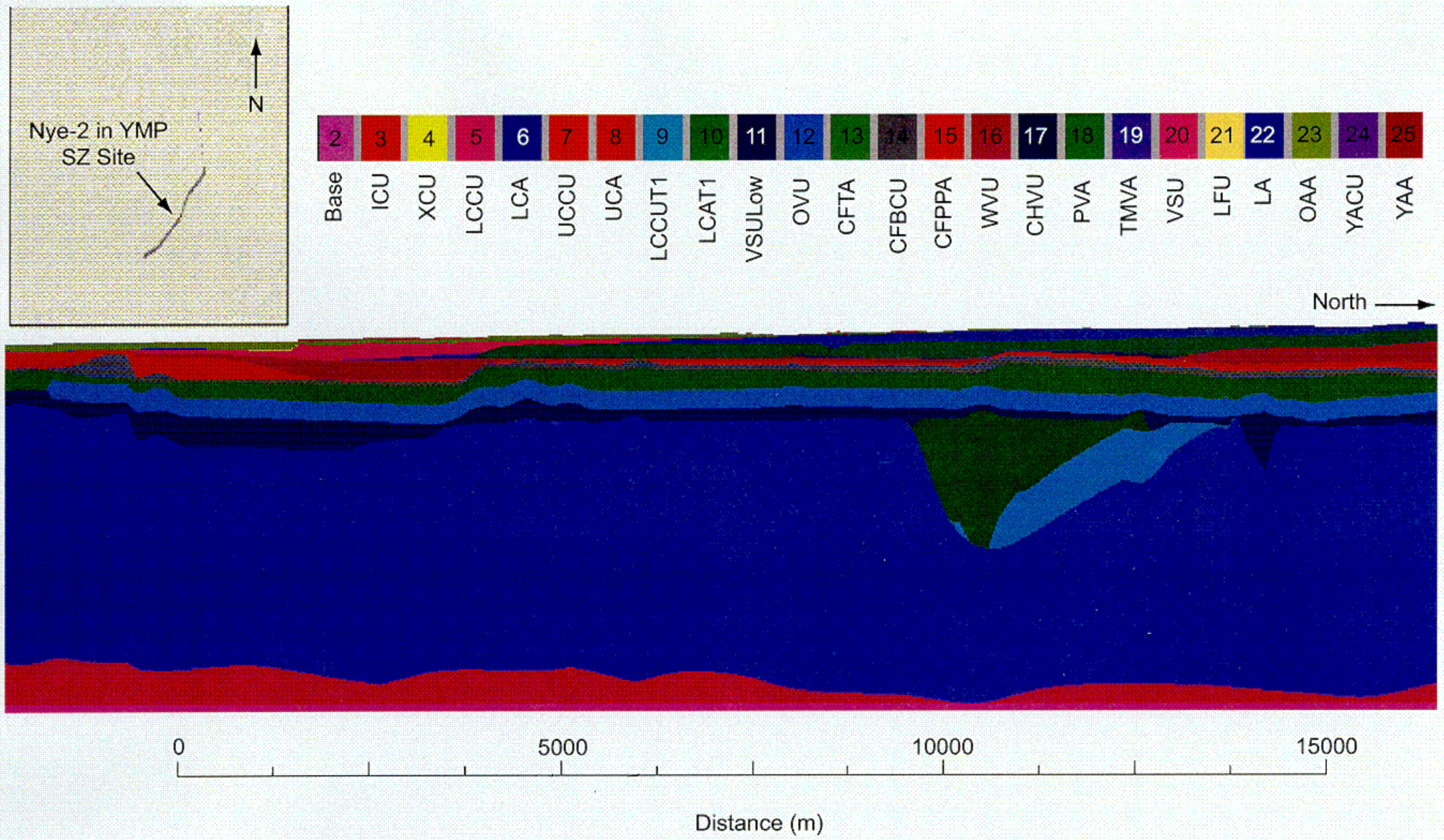
Table 4. Borehole UTM (NAD27) Data Used for Nye-1, Nye-2, and Nye-3
2002 HFM Cross-Section Images

		Borehole Data Used in Nye-1 Images		
Number	**Site Name**	**Northing (UTM)**	**Easting (UTM)**	**Cross Section Nye-1**
1	West	4065669.1	534753.3	West end of section
2	NC-EWDP-1DX	4062508.6	536847.5	bend
3	NC-EWDP-9SX	4061004.3	539038.8	bend
4	NC-EWDP-3D	4059444.2	541272.7	bend
5	NC-EWDP-15D	4058000.6	544930.5	bend
6	NC-EWDP-2DB	4057195	547800	bend
7	NC-Washburn-1X	4057569	551544	bend
8	NC-EWDP-05S	4058229	555676	bend
9	East	4058334.8	557277	East end of section
		Borehole Data Used in Nye-2 Images		
Number	**Site Name**	**Northing (UTM)**	**Easting (UTM)**	**Cross Section Nye-2**
1	UE-25 WT#13	4075827	553730	North end of section
2	UE-25 J-13	4073517	554017	bend
3	UE-25 JF #3	4067974	554498	bend
4	NC-EWDP-20D	4065117.4	552587.3	bend
5	NC-EWDP-22S	4062086	551725	bend
6	NC-EWDP-19D	4058270.6	549316.6	bend
7	NC-EWDP-2DB	4057195	547800	South end of section
		Borehole Data Used in Nye-3 Images		
Number	**Site Name**	**Northing (UTM)**	**Easting (UTM)**	**Cross Section Nye-3**
1	NC-EWDP-1DX	4062508.6	536847.5	West end of section
2	NC-EWDP-7SC	4064317	539632.1	bend
3	NC-EWDP-13D	4066463.2	543448.9	bend
4	NC-EWDP-16D	4065562	545926.8	bend
5	NC-EWDP-18P	4067233	549415.6	bend
6	NC-EWDP-6D	4067830	551418.3	bend
7	UE-25 JF#3	4067974	554498	bend
8	East end	4062897	560685	East end of section



NOTE: Table 3 gives the full names for the units in the legend. The numbers in the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the south. Because the actual cross section is curved, this flattened view has some foreshortening.

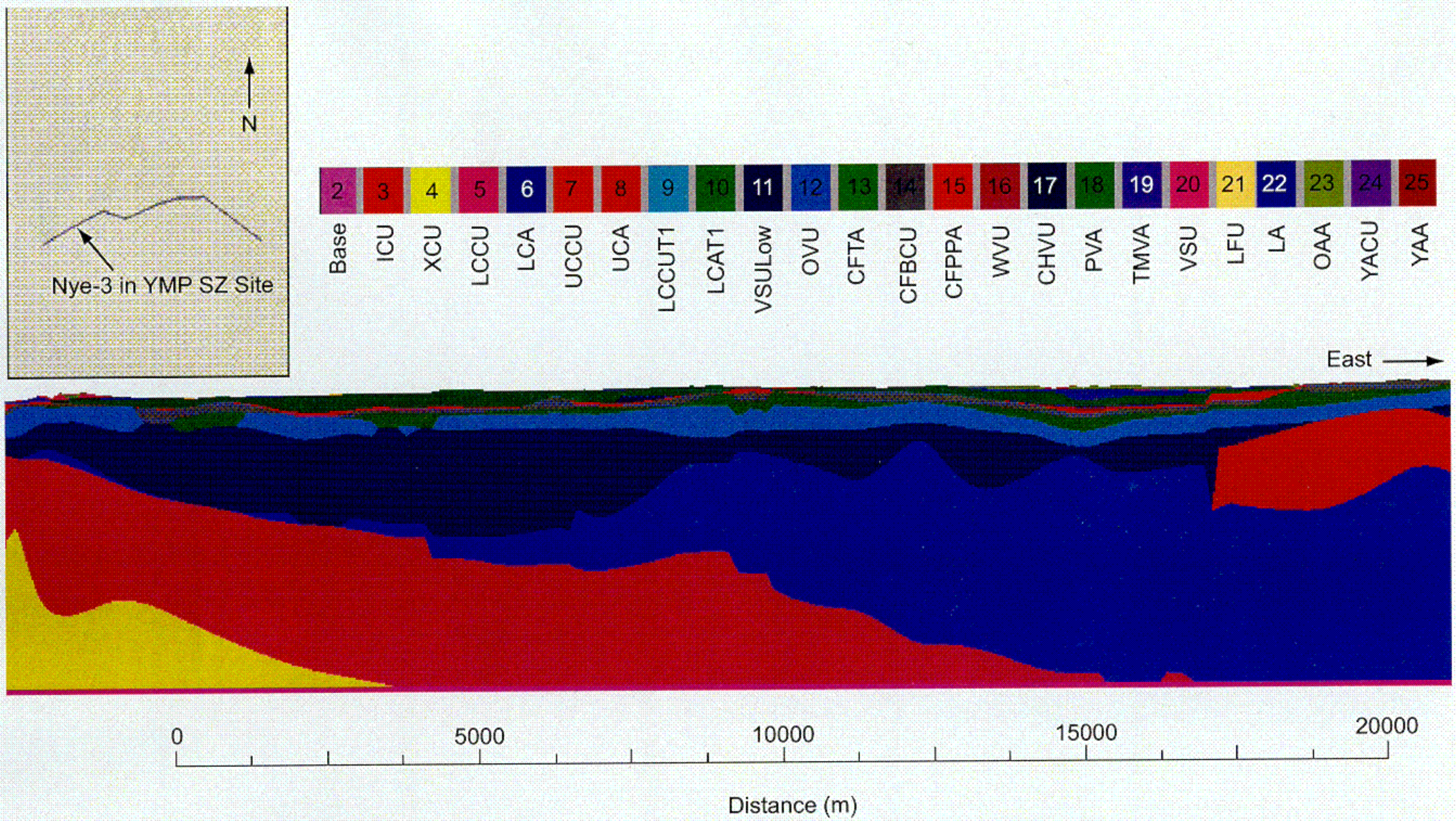
Figure 4. Overview of Nye-1 Cross Section



NOTE: Table 3 gives the full names for the units in the legend. The numbers in the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the east. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 5. Overview of Nye-2 Cross Section

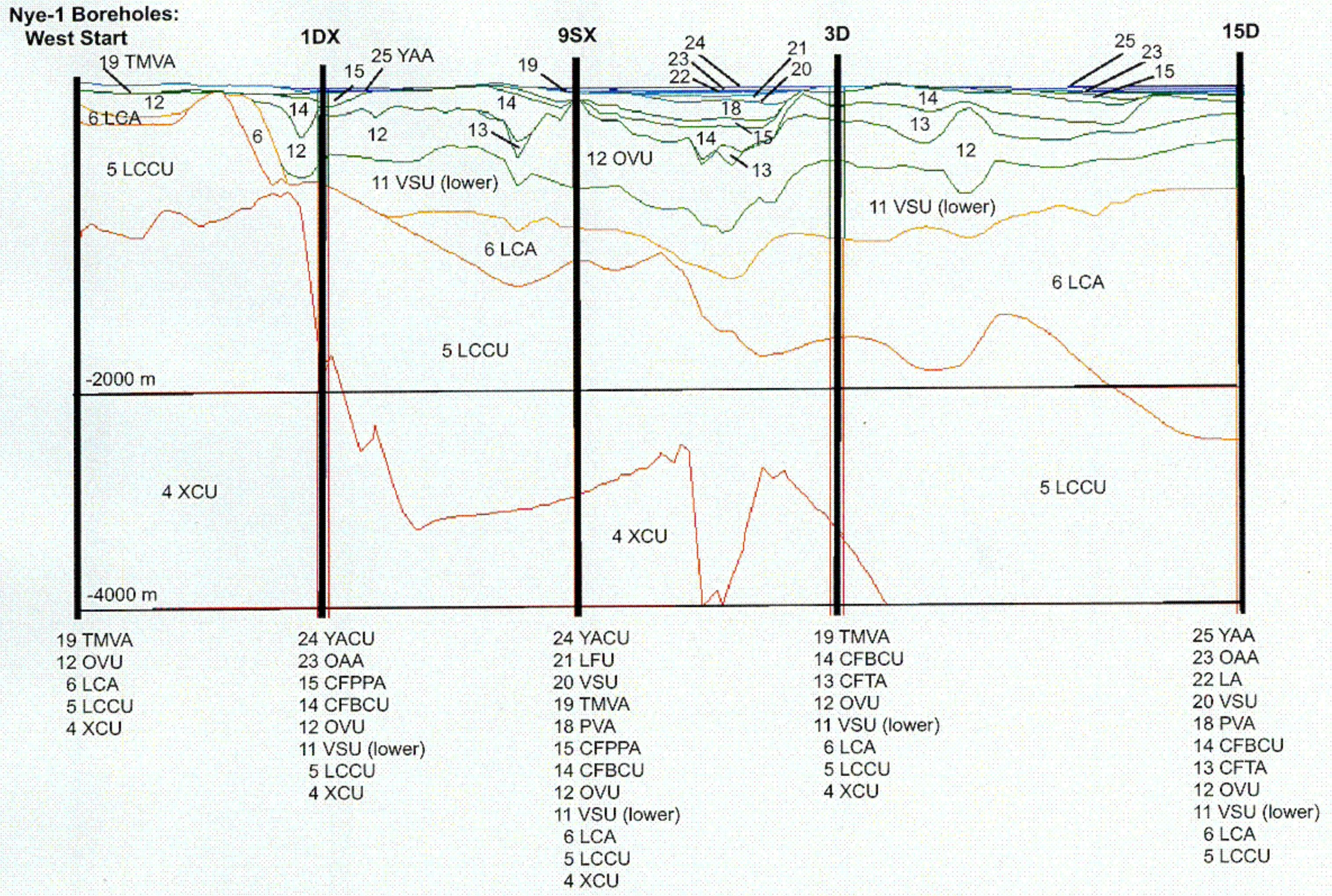
C05



NOTE: Table 3 gives the full names for the units in the legend. The numbers in the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the south. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 6. Overview of Nye-3 Cross Section

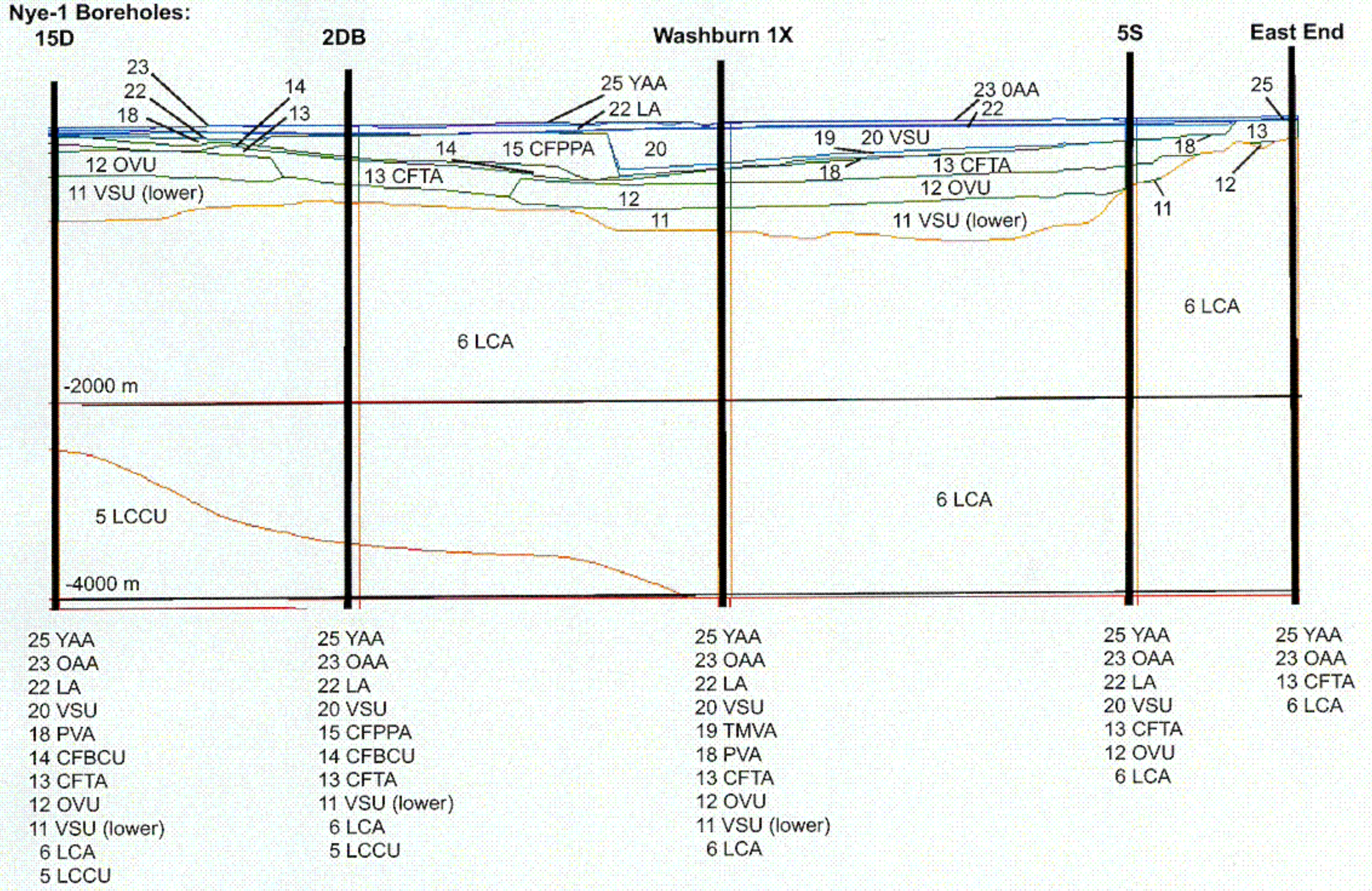
C06



NOTE: Table 3 gives the full names for the units listed below each borehole, and Table 4 gives the borehole data. The numbers in both the figure and the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the south. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 7. West End of Cross-Section Slice for Nye-1

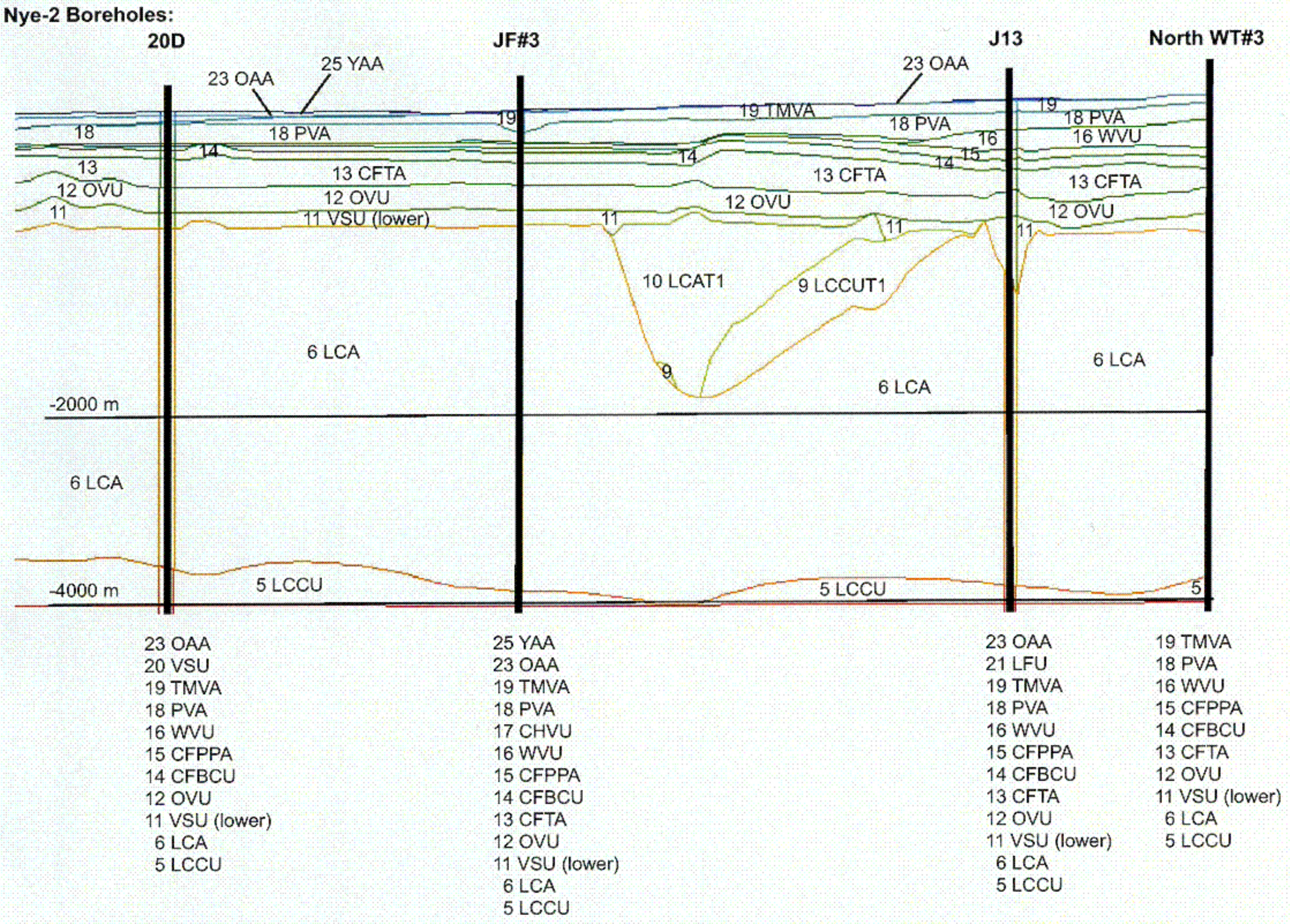
C07



NOTE: Table 3 gives the full names for the units listed below each borehole, and Table 4 gives the borehole data. The numbers in both the figure and the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the south. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 8. East End of Cross-Section Slice for Nye-1

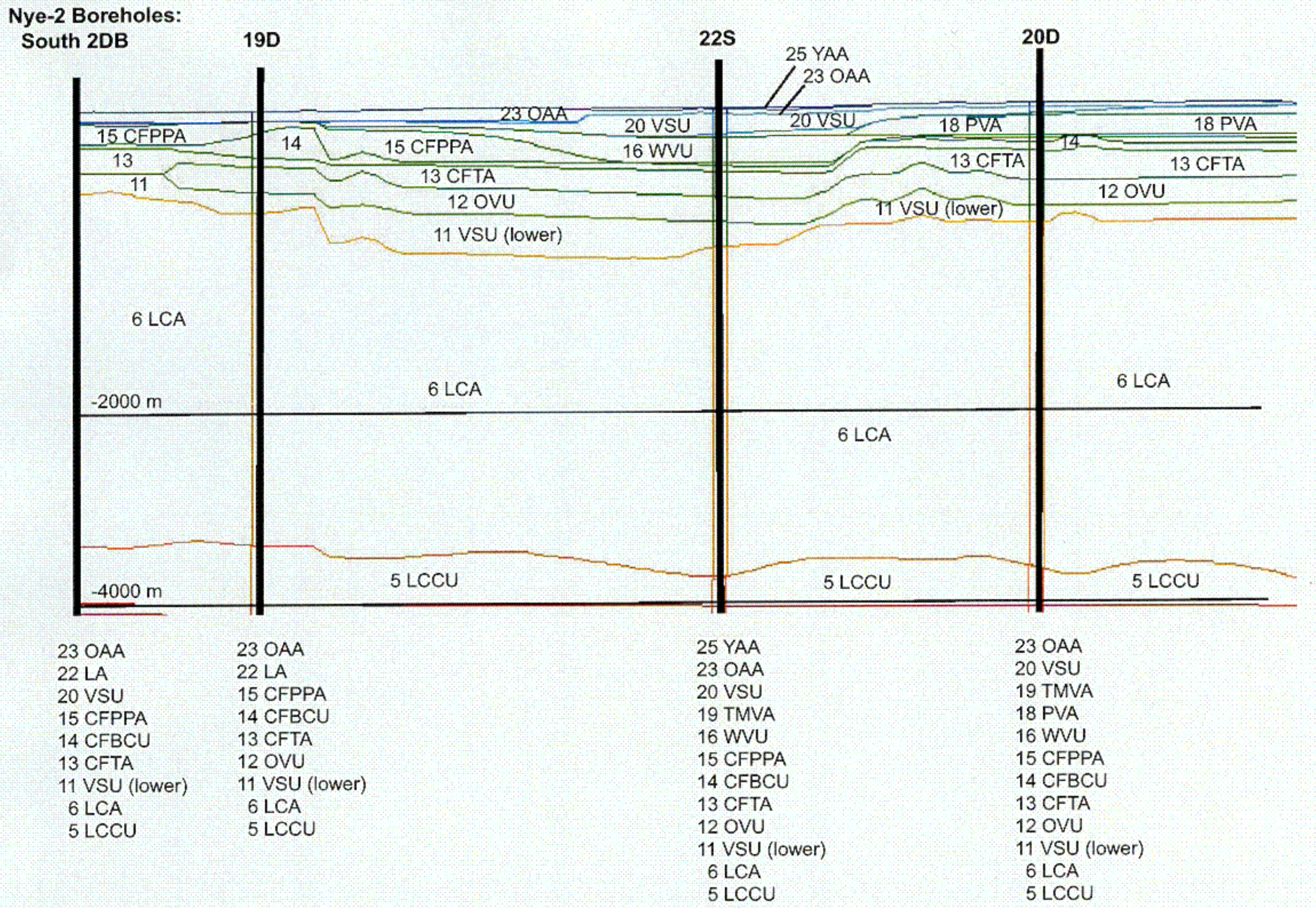
C08



NOTE: Table 3 gives the full names for the units listed below each borehole, and Table 4 gives the borehole data. The numbers in both the figure and the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the east. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 9. North End of Cross-Section Slice for Nye-2

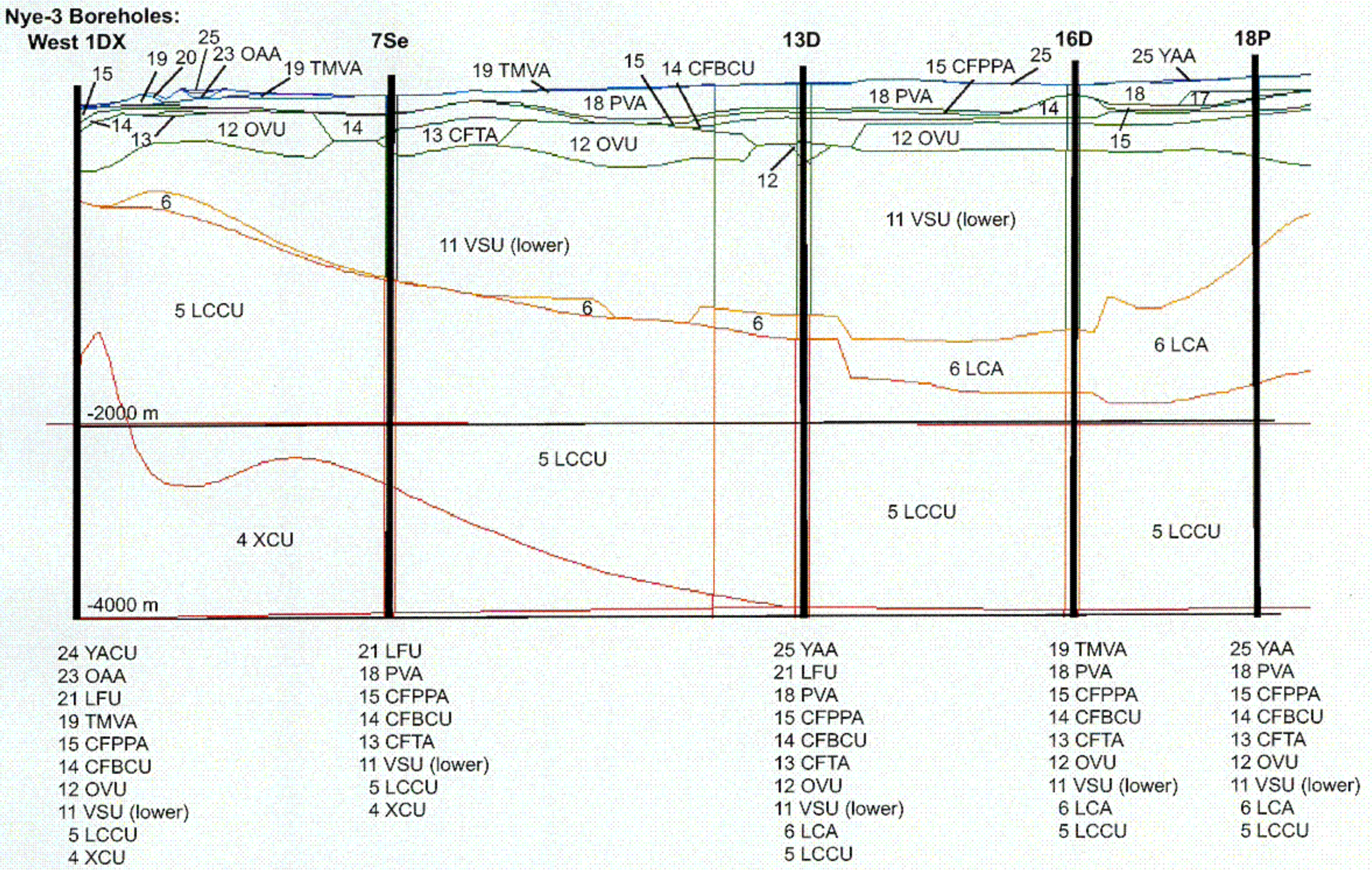
C09



NOTE: Table 3 gives the full names for the units listed below each borehole, and Table 4 gives the borehole data. The numbers in both the figure and the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the east. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 10. South End of Cross-Section Slice for Nye-2

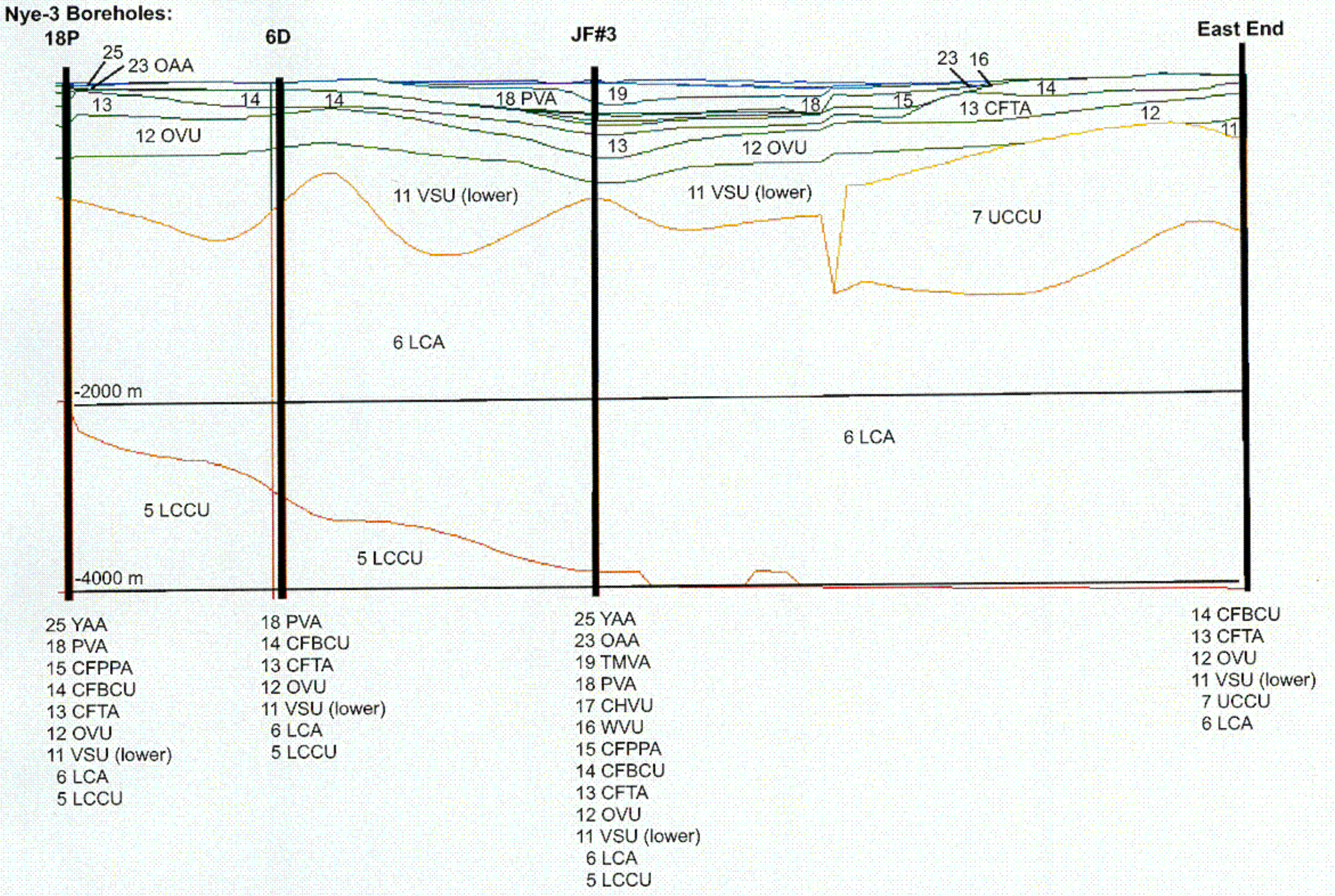
C10



NOTE: Table 3 gives the full names for the units listed below each borehole, and Table 4 gives the borehole data. The numbers in both the figure and the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the south. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 11. West End of Cross-Section Slice for Nye-3

C11



NOTE: Table 3 gives the full names for the units listed below each borehole, and Table 4 gives the borehole data. The numbers in both the figure and the legend are the HFM unit numbers (Table 3, first column) assigned by the Stratamodel software, which was used to construct the model. The view of this cross section is directly from the south. Because the actual cross section is curved, this flattened view has some foreshortening.

Figure 12. East End of Cross-Section Slice for Nye-3

C12

3.6 CURRENT STUDIES

Cross sections Nye-1, Nye-2, and Nye-3 are considered to be "work-in-progress." As additional drilling is conducted as part of Nye County's Early Warning Drilling Program, these sections may be updated. Part of the fiscal year 2002 work plan is to revise, where appropriate, cross sections based on the subsurface information that will be gathered from Nye County's Phase-III drilling. Preliminary information suggests minor or no changes will be needed along Sections Nye-1 and Nye-3. However, Section Nye-2 may require some revision, based on preliminary analysis of newly acquired subsurface information data, particularly in the vicinity of drill holes 10S and 22S (Figure 1). Based on our preliminary review, there is no evidence that this revision would impact the flow model.

Drill holes NC-EWDP-10S and NC-EWDP-22S, which were planned to be drilled as part of the Nye County Phase-III drilling, were included as "tie-points" during the construction of the north-trending cross section Nye-2. These drill holes, located near the central part of the cross section, would then be used to test our current state-of-knowledge of the subsurface geology underlying the central part of Fortymile Wash. Preliminary analyses of drill hole cuttings and geophysical logs from these two drill holes indicate thickness and lithologic rock types that differ from our prediction. These differences are currently being incorporated in scheduled revisions to cross section Nye-2. These modifications primarily include: 1) the absence of pyroclastic flow deposits (Rainier Mesa Group and Paintbrush Group) at relatively shallow depths (less than 1200 feet) and 2) the occurrence of an older tuffaceous breccia (and/or gravel) of Tertiary age within that part of the section where pyroclastic flow deposits were suspected to occur (Table 5). Much of the thick stratigraphic interval that is interpreted as a tuffaceous breccia and gravel is, for the most part, composed of subangular to angular fragments of welded Tiva Canyon Tuff enclosed within a matrix, composed of fine-grained, crystal-rich, carbonate-cemented reworked tuff. Judging from the increase in fracture faces on bit-cutting samples and the increase in density based on a borehole gravity log, this deposit appears to possess lithologic characteristics of both a welded tuff and alluvial deposits of Tertiary age. This rock type has not been observed in outcrop or in subsurface samples in the immediate vicinity of Yucca Mountain. As both drill holes were terminated at a depth of 1200 feet, thicknesses and extent of the suspected underlying tuffs remain unconfirmed.

Drill hole NC-EWDP-18P, also a part of the Nye County Phase III drilling, is located along cross section Nye-3. Preliminary inspection of predicted and actual thicknesses of the Tiva Canyon and Topopah Spring Tuff indicates a close match between existing interpretations and the new borehole data. The actual thickness of the Tiva Canyon Tuff was within 20 feet of the predicted thickness (Table 5). The actual thickness of the Topopah Spring Tuff was within 3 feet of the predicted thickness (Table 5).

Table 5. Predicted and Actual Thicknesses of Lithostratigraphic Units Found in Nye County Phase-III Drill Holes NC-EWDP-20S, NC-EWDP-22S, NC-EWDP-18P, and NC-EWDP-23P

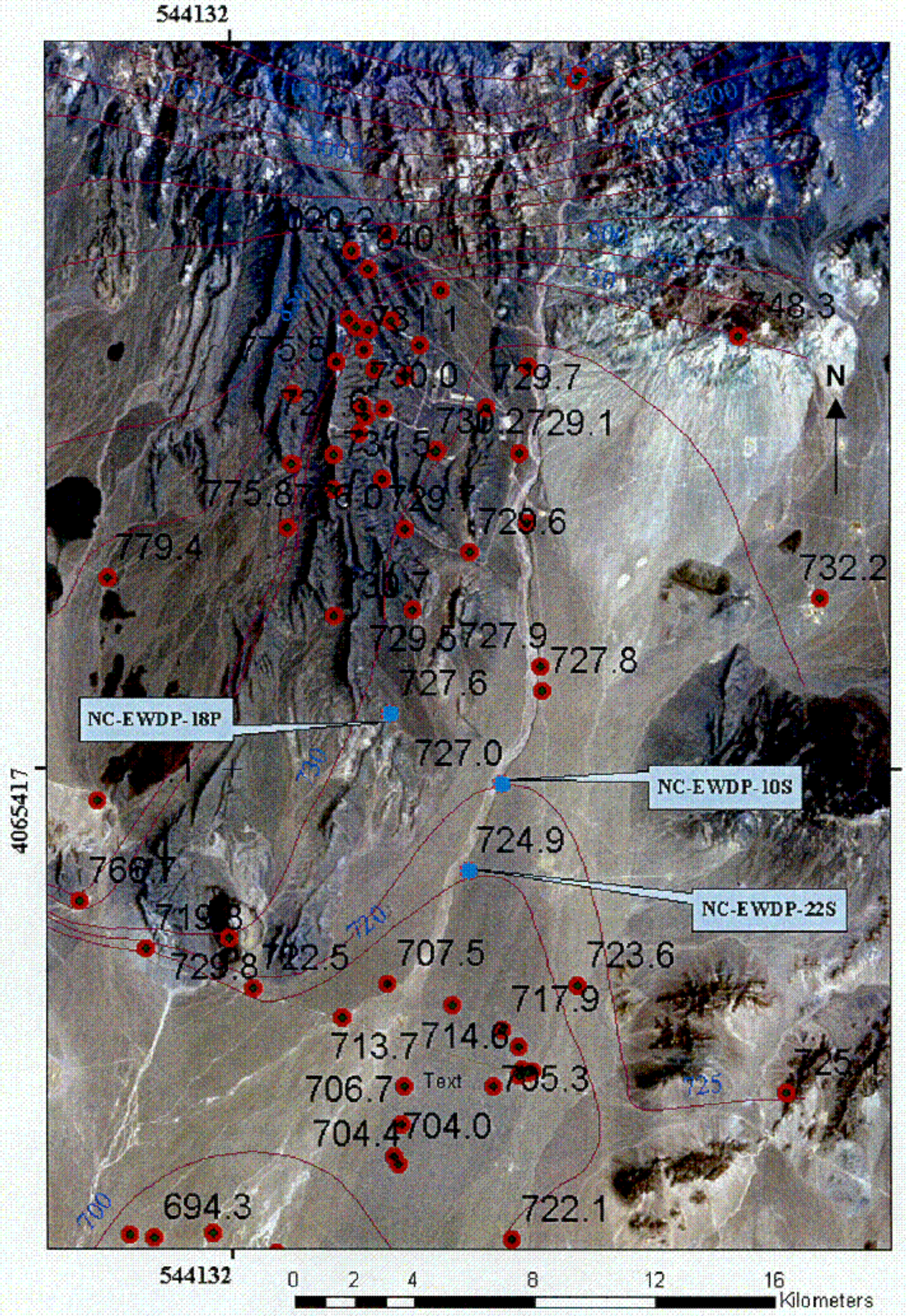
Drill Hole	Unit and Predicted Thickness (feet)		Unit and Actual Thickness (feet)	
NC-EWDP-10S	Quaternary/Tertiary Alluvium (undivided)	426	Quaternary/Tertiary Alluvium (undivided)	762
	Tertiary tuffaceous breccia and gravel	0	Tertiary tuffaceous breccia and gravel	435
	Rainier Mesa and Paintbrush Tuff	627	Rainier Mesa and Paintbrush Tuff	0
NC-EWD-22S	Quaternary/Tertiary Alluvium (undivided)	820	Quaternary/Tertiary Alluvium (undivided)	1050
	Tertiary tuffaceous breccia and gravel	0	Tertiary tuffaceous breccia and gravel	150
	Rainier Mesa and Paintbrush Tuff	984	Rainier Mesa and Paintbrush Tuff	0
NC-EWDP-18P	Quaternary Alluvium	69	Quaternary Alluvium	45
	Tiva Canyon Tuff	190	Tiva Canyon Tuff	210
	Pre-Tiva Canyon tuff	49	Pre-Tiva Canyon tuff	10
	Topopah Spring Tuff	532	Topopah Spring Tuff	535
	Pre-Topopah Spring seds	0	Pre-Topopah Spring seds	80
	Wahmonie Formation	49	Wahmonie Formation	N/C
***NC-EWDP-23P**	Quaternary/Tertiary Alluvium	N/A	Quaternary/Tertiary Alluvium	1160
	Tertiary Alluvium	N/A	Tertiary Alluvium	140
	Basalt	N/A	Basalt	40+

NOTE: *NC-EWDP-23P is a piezometer included in the table but is not in the alignment of the cross sections.

Interpretations are preliminary and subject to revision prior to submittal of a data package of Nye County Phase-III drilling.

Both NC-EWDP-10S and NC-EWDP-22S were drilled to a depth of 1200 feet; no pyroclastic flow deposits were encountered in either drill hole. Drill-hole NC-EWDP-23P was not drilled deep enough to obtain the total thickness of the basalt. (N/C = hole was not drilled deep enough to confirm presence and thickness; N/A = drill hole not situated near any cross section).

Figure 13 shows the preliminary elevation of the water table in drill-holes NC-EWDP-22S, NC-EWDP-10S, and NC-EWDP-18P with respect to the current interpretation of the potentiometric surface (Tucci 2002, written communication).



Source: Tucci (2002).

NOTE: Drill-hole NC-EWDP-23P is not included. Ground elevation at drill-hole locations that were used to calculate water-table elevations are preliminary. Map projection = UTM (NAD27).

Figure 13. Comparison of Preliminary Elevation of Water Level in Phase-III Drill Holes (shown in cyan) with Current Interpretation of Potentiometric Surface as Shown by Contours

C13

4. INPUTS AND REFERENCES

4.1 DOCUMENTS CITED

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Potter, C.J.; Dickerson, R.P.; Sweetkind, D.S.; Drake, R.M., II; Taylor, E.M.; Fridrich, C.J.; San Juan, C.J.; and Day, W.C. In press. *Geologic Map of the Yucca Mountain Region.* USGS Administrative Report, scale 1:50,000.

Reamer, C.W. and Williams, D.R. 2000a. Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Unsaturated and Saturated Flow Under Isothermal Conditions. Washington, D.C.: U.S. Nuclear Regulatory Commission.

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Sweetkind, D.S.; Dickerson, R.P.; Blakely, R.J.; and Denning, P.D. 2001. *Interpretive Geologic Sections for Death Valley Regional Flow System and Surrounding Areas, Nevada and California.* USGS Miscellaneous Field Studies Map MF-2370, scale 1:250,00.

Tucci, P. 2002, written communication.

4.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR 63. 2002. Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Readily Available.

4.3 SOURCE DATA, LISTED BY DATA TRACKING NUMBER

GS000400002332.001. Digital Elevation Models Death Valley East Scale 1:250,000. Submittal date: 04/12/2000.

GS000808314211.005. Interpretations of the Lithostratigraphy in Boreholes NC-EWDP-01DX, NC-EWDP-02D, NC-EWDP-03D, and NC-EWDP-09SX, Nye County Early Warning Drilling Program Phase I, FY 99. Submittal date: 08/14/2000.

GS010908314221.001. Geologic Map of the Yucca Mountain Region. Submittal date: 01/23/2002.

GS011008314211.001. Interpretation of the Lithostratigraphy in Deep Boreholes NC-EWDP-19D1 and NC-EWDP-2DB Nye County Early Warning Drilling Program. Submittal date: 01/16/2001.

GS020108314211.001. Interpretation of the Lithostratigraphy in Deep Boreholes, NC-EWDP-7SC and NC-EWDP-15D, Nye County Early Warning Drilling Program. Submittal date: 01/16/2001.

MO0004QGFMPICK.000. Lithostratigraphic Contacts from MO9811MWDGFM03.000 to be Qualified under the Data Qualification Plan, TDP-NBS-GS-000001. Submittal date: 04/04/2000.

MO0107COV01057.000. Coverage: NC-EWDPS. Submittal date: 07/18/2001.

MO9907YM99025.001. List of Boreholes. Submittal date: 07/19/1999.

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Section Nye-1

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