FINAL REPORT
GEOTECHNICAL INVESTIGATION

ROADWAY WIDENING/RECONSTRUCTION OF LOGAN CANYON HIGHWAY (US 89) TONY GROVE TO FRANKLIN BASIN CACHE COUNTY, UTAH

November 15, 2000
UDOT Project Number: *NH-0089(29)393

Prepared by:
Dames & Moore/URS
Salt Lake City, Utah
Project No. 21743-030-162

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EXECUTIVE SUMMARY

This report presents the results of geotechnical field and laboratory investigations, as well as geotechnical analyses and recommendations for the roadway widening and reconstruction of US 89 in Logan Canyon. The Logan Canyon highway project, as considered for this study, consists of two segments. The first segment includes the Upper Twin Bridge with approach roadways and extends a total of 0.74 kilometers (0.46 miles). The second segment extends approximately 8.1 kilometers (5.0 miles), from just south of Tony Grove, to just north of the Franklin Basin turnoff. A detailed layout of the site is presented on the plan sheets (revised July 6 and July 7, 2000) in Appendix A. Three structures were included in this study. In order to characterize subsurface stratigraphy, a total of 21 exploratory rock and soil borings were completed to maximum depths of 27.8 meters (m)(91.2 feet) below the existing ground surface. The majority of roadway borings were drilled to characterize proposed cut slopes. Boring logs are included in Appendix B and soil data sheets are included in Appendix C. Fifteen geophysical lines, with line lengths of approximately 160 feet, were completed. Eight rock surface outcrop discontinuity transects were also completed. The relative locations of the borings, geophysical lines, and transects are presented on the plan sheets in Appendix A, and on the soil data sheets in Appendix C. Laboratory testing was performed and test data are summarized in Section 5.0, "Material Properties." Strength and consolidation parameters as well as Atterberg limits and moisture and density values are provided in that section.

Field conditions are described in Section 4.0, "Findings." Site soils were generally found to consist of sands and gravels with cobbles, boulders, and, in some locations, appreciable silt and clay content. Soft clay soils were encountered in limited areas, generally, at the location of fill slopes and mechanically stabilized earth (MSE) walls. In general, bedrock encountered included limestone, dolomite, and quartzite. The rock quality generally transitioned gradually from highly weathered to intact with depth. Joint orientations were generally preferential for the proposed cut slopes. URS/Dames & Moore recommends the use of ¼H: 1V (horizontal to vertical) cut slopes in competent bedrock and 1.5H: 1V to 2H: 1V cut slopes in overburden (soil and highly weathered bedrock). Based on observations and verification of subsurface conditions by qualified personnel during construction, cut slopes of 1H: 1V may be permitted in moderately weathered bedrock.

Sufficient information was available to evaluate bearing capacity, settlement potential, and stability of five of the proposed MSE walls (R-376A, R-376B, R-376G, R-376H, and R-376L). Relatively compressible soils are present under some of these wall locations. Where encountered during construction, compressible materials should be removed from beneath the walls and replaced with compacted granular borrow. Recommended allowable bearing pressures for the MSE walls, bearing on compacted granular borrow or suitable site soils, range from 285 to 380 kPa (6,000 to 8,000 psf). Based upon available information, settlement of MSE walls bearings on granular borrow or suitable site soils is estimated to be less than 1 inch. Stability of these MSE walls, founded on compacted granular borrow or suitable site soils, should not be a concern.

There was limited subsurface information available to evaluate the proposed fills. We anticipate that relatively compressible clays will be present under some embankment locations. We recommend that compressible materials be removed from all future wall and fill locations, and be replaced with compacted granular borrow. Based on available information, settlement of proposed embankments bearing on granular borrow or suitable site soils is estimated to be less than 1 inch. Stability of proposed embankments, founded on compacted granular borrow or suitable site soils, should not be a concern.

1.0 GENERAL

The purpose of the investigation was to evaluate general subsurface soil and groundwater conditions for the proposed Logan Canyon Highway, assess the suitability for construction, analyze the settlement and stability of embankments and mechanically stabilized earth (MSE) walls, analyze cut slope stability, and identify potential problem areas where instability or other significant geotechnical challenges may exist. These tasks were performed in general accordance with the activities described in the Utah Department of Transportation (UDOT) 08-1 Design Process. In accomplishing this purpose the following services were performed.

1. Drilling and sampling of 21 soil and rock exploratory borings located along the current alignment at locations of proposed cuts, fills, retaining walls, and replacement structures, in general accordance with the 08-1 Design Process Activity Nos. 22D (roadway), 85D (initial structures), and 86D (final structures). The exploratory holes were advanced to depths ranging from 7.6 to 27.8 m (24.9 to 91.2 feet) below existing/original (original if fill was present) ground surface.
2. Completion of 15 geophysical lines and eight outcrop discontinuity transect lines.
3. Performing laboratory tests, in accordance with the 08-1 Design Process Activity Nos. 23D, 87D and 97D (for roadway, initial structures, and final structures, respectively), to aid in the determination of appropriate design parameters.
4. Initiating an office program that included the evaluation of available data and performing engineering analyses. The results are presented in this final report and include the following items:
   a. A General Location Map and Plot Plans of the Logan Canyon Highway that shows the locations of the exploratory holes.
   b. Boring logs of exploratory holes (Appendix B).
   c. A summary of laboratory test data and consolidation test data curves (Appendix D).
   d. A detailed description of surface and subsurface conditions.
   e. Summaries of site geology and hydrogeology.
   f. Recommendations for cut and fill slopes, including settlement estimates and stability analyses, in accordance with 08-1 Design Process Activity No. 24D.
   g. Settlement estimates and stability analyses for MSE walls and deep foundations, in accordance with 08-1 Design Process Activity No. 98D.
   h. Completion of Soil Data Sheets (Appendix C).
   i. Interpretation of geophysical exploration (Appendices E and F).

1.1 PROJECT SECTION DESCRIPTION

The Logan Canyon Highway, as considered for this study, consists of two segments. The first segment includes the Upper Twin Bridge with approach roadways and extends a total of 0.74 kilometers (0.46 miles). The second segment extends approximately 8.1 kilometers (5.0 miles), from just south of Tony Grove, to just north of the Franklin Basin turnoff. The general location of the site is shown on Figure 1, "Vicinity Map." A detailed layout of the site, based on design plans dated July 6 and July 7, 2000, is shown on the plan sheets in Appendix A.

This report presents results pertaining to the roadway and structure design. The Logan Canyon Highway widening and reconstruction is proposed to consist of the addition of passing lanes and the replacement of three structures. In order to accomplish this task, additional cut and fill slopes, 20 MSE walls, and 6 gabion walls will be constructed. Maximum cut slope heights of 29 m and maximum fill slopes of 11 m are proposed for the reconstruction. The MSE walls will be generally 1 to 3 m in maximum height, with the two walls at the abutments of the reconstructed Upper Twin Bridge having maximum heights of 7 to 8.5 m.

2.0 DRILLING EXPLORATION PROGRAM

Subsurface soil conditions were explored by drilling 21 exploratory holes and completing 15 geophysical lines between May 11 and June 7, 1999. Soil and rock coring was completed to determine subsurface conditions along the roadway for proposed cuts, fills, MSE walls, and structures. The number of borings and depth range for each type of boring are presented in Table 1.

Table 1
Subsurface Explorations Completed

Type of Boring	Number of Soil Borings	Depth Range (m) [1]
Cut	13	7.6 - 27.8
Fill	1	9.5
Retaining Wall	2	12.2 - 17.1
Structure	5	9.5 - 18.6

[1]Some borings were completed through fill. The fill thickness was added to the planned boring depth.

The boring locations are identified on the plan sheets in Appendix A and the soil data sheets in Appendix C. Table 2 lists the boring station, hole depth, approximate top and bottom elevations of the borings, and the approximate elevation of the roadway pavement at each boring station. Exploratory hole designations were based upon the specifications provided by UDOT. Boring and CPT designations were assigned using the following format: LC-"hole type"-"hole number." Hole types include "C" for proposed cuts, "F" for proposed fills, "RR" for proposed retaining walls, and "S" for proposed replacement structures.

Table 2
Relative Elevations of Borings and Roadway Pavement

Boring	Station (m)	Elevation at Top of Hole (m)	Depth of Hole (m)	Elevation at Bottom of Hole (m)	Approximate Pavement Station[1] (m)	Approximate Elevation Top of Roadway Pavement (m)
LC-RC-1	22+788.965	1771.4	14.0	1757.4	22+789	1762.1
LC-RC-2	23+242.378	1772.0	17.1	1754.9	23+230	1756.5
LC-RC-3	29+893.128	1876.1	7.6	1868.5	29+894	1872.5
LC-RC-4	30+671.019	1895.6	13.4	1882.2	30+671	1887.5
LC-RC-5	34+903.510	1999.5	24.4	1975.1	34+904	1981.5
LC-RC-6	35+095.117	1992.4	10.7	1981.7	35+095	1987.6
LC-RC-7	36+068.349	2017.4	13.7	2003.7	36+068	2011.9
LC-RC-8	36+940.034	2036.6	14.0	2022.6	36+940	2028.4
LC-RC-9	37+162.519	2051.4	27.7	2023.7	37+163	2031.6
LC-RC-10	37+782	2049.5	9.1	2040.4	37+782	2044.2
LC-RC-11	36+600	2046.1	17.4	2028.7	36+600	2024.4

Boring	Station (m)	Elevation at Top of Hole (m)	Depth of Hole (m)	Elevation at Bottom of Hole (m)	Approximate Pavement Station[1] (m)	Approximate Elevation Top of Roadway Pavement (m)
LC-RC-12	34+283	1985.7	21.6	1964.1	34+283	1967.8
LC-RC-13	34+024.383	1977.5	12.2	1965.3	34+024	1967.1
LC-RF-1	22+906.268	1749.4	9.4	1740.0	22+906	1755.2
LC-RR-1	22+961.934	1751.6	17.1	1734.5	22+962	1752.7
LC-RR-2	35+956.795	2007.6	12.2	1995.4	35+957	2010.4
LC-S-1	23+026.282	1750.1	18.6	1731.5	23+026	1752.1
LC-S-2	23+066.944	1747.8	18.6	1747.8	23+080	1753.5
LC-S-3	36+647.589	2022.6	10.7	2011.9	36+648	2025.0
LC-S-4	32+866.034	1929.3	15.2	1914.1	32+866	1931.6
LC-S-5	32+841.669	1928.9	9.4	1919.5	32+840	1930.7

[1] For stations without pavement elevation data, elevations were taken from nearby stations with pavement elevation data.

2.1 METHODOLOGY

Borings were drilled vertically with all-terrain vehicle mounted, light-weight, rotary drilling/coring equipment. The field program was conducted and supervised by an engineer or geologist who maintained continuous logs of the subsurface conditions encountered. Soil samples were obtained using a Dames & Moore Type-U sampler (83-mm O.D.) and a standard split spoon (standard penetration test (SPT)) sampler at 1.5 meter (5 foot) intervals or at changes in stratigraphy until rock was encountered. The sampler was driven using a 63.5 kilogram (140 pound) hammer dropped 0.76 m (30 inches) with a rope and cathead. Rock samples were obtained with an HX core barrel, with inside diameter of 61 mm (2.4 inches), outside diameter of 74 mm (2.9 inches), and length of 1.52 m (4.99 feet).

The soil and rock were classified in the field. The Unified Soil Classification System was used for soil samples. Selected samples and core segments were re-examined in the laboratory to confirm field classifications. Logs of exploratory holes are presented in Appendix B. Soil data sheets for each boring, presenting the relative boring location and a summary of the subsurface profile, are provided in Appendix C. Detailed descriptions of soil boring, rock coring, sampling, and logging procedures are presented in Sections 1.3 and 1.4 of the report entitled, "UDOT, I-15 Corridor, Subsurface Exploration and Laboratory Testing Guidelines" (Dames & Moore, 1996a). These guidelines were generally followed for the field and laboratory work for the Logan Canyon Highway.

2.2 DATA COLLECTION

Descriptions of the soil and rock classification and sample data obtained during field exploration are presented on the Explanation to Boring Logs in Appendix B. In addition to field classifications, other soil sample data collected during field exploration included penetration resistance values and sample recovery. Rock sample data included limits of drill run, recovery, rock quality designation (RQD), RQD length, whole core length, number of whole pieces, length of longest piece, length of +30.5 cm fraction, broken zone length, rubble zone length, bedding angle, number of fractures with angles greater than 60 degrees, and average hardness.

3.0 LABORATORY TESTING

A laboratory-testing program was conducted on selected samples to provide data for our engineering analyses. The program included moisture and density tests, Atterberg limits tests, gradation analyses, unconfined compression tests, consolidation tests, direct shear strength tests, uniaxial compressive strength tests, bulk density tests, porosity tests, swell and slake tests, and chemical tests. Summaries of lab test data for each boring are provided on the soil boring logs in Appendix B. The test results are also tabulated in Section 5.0, "Material Properties." ASTM/AASHTO standards used for laboratory testing are shown in Table 3.

Table 3
ASTM/AASHTO Procedure References for Laboratory Tests

Test method	**Reference (D or G = ASTM, T = AASHTO)**
Unconfined Compression	D 2166-91/ T 208-92
Direct Shear	D 3080-90/ T 236-92
Consolidation Testing	D 2435-90 D 4186-89/ T 216-94
Atterberg Limits	D 4318-93/ T 89-94, T 90-94
Moisture and Density	D 2216-92/ T 265-93
Mechanical Gradation Analyses	D 422-63/ T 88-93
Sulfate Content	EPA 375.4
Resistivity	G51/ T28
pH	D 4972
Uniaxial Compressive Strength	D 2938-95
with Poisson's Ratio	D 3148-5407
Bulk Density	---
Porosity	---
Slake	D 4644
Swell	D 4546

4.0 FINDINGS

4.1 SITE CONDITIONS

The existing Logan Canyon Highway is currently constructed in both cuts and fills through a mountain valley. Roadway expansion areas are generally undeveloped. The area surrounding the project is generally forested and heavily vegetated. Ponded surface water is present over portions of the alignment, mostly in wetlands adjacent to the Logan River. The topography along the corridor is mountainous. The roadway runs on a valley floor with elevations ranging from approximately 1,760 to 2,035 m above mean sea level (AMSL) (4,209 to 4,242 feet AMSL).

4.1.1 Upper Twin Bridge

The existing Upper Twin Bridge is founded into the exposed rock along the riverbank. The proposed replacement structure will be located immediately north of the existing bridge. The slopes in the immediate vicinity of the proposed structure are very steep and heavily wooded. The existing roadway lies approximately 5 to 6 m (16 to 20 feet) above the river elevation.

4.1.2 Beaver Creek Bridge at Franklin Basin

The existing Beaver Creek Bridge at Franklin Basin is founded into the clay/exposed rock river bank. The proposed replacement structure will be constructed at the location of the existing bridge. The majority of the land on the north and south banks of Beaver Creek in the vicinity of the existing bridge has been characterized by UDOT as "scrub/shrub wetland." The slopes on the west side of the existing bridge are moderately to very steep. The slopes on the east side of the bridge are less steep. The existing roadway lies approximately 2 to 2.5 m (6.5 to 8.5 feet) above the river elevation.

4.1.3 Red Banks Bridge

The replacement structure will be constructed in the immediate vicinity of the existing bridge. Adjacent slopes are moderately steep. The existing roadway lies approximately 2.5 to 3.0 m (8.5 to 10 feet) above the river elevation.

4.2 GEOLOGY

The highway corridor study area is located along the Logan River drainage in Logan Canyon within the Bear River Range in north-central Utah about 12 miles northeast of the city of Logan (Figure 1). The Bear River

Range is a fault-bounded horst-block flanked on the west by Cache Valley and on the east by Bear Lake Valley. The Bear River Range is located in a transition zone between the Middle Rocky Mountain physiographic province to the east and the Basin-and-Range province to the west.

The geology of the study area has been mapped by Robert Q. Oaks on two unpublished quadrangle maps and discussed in Oaks and Runnells' (1992) paper on the Wasatch Formation in the central Bear River Range. This information and outcrop mapping from our field reconnaissance was used to prepare the site specific geologic map for the project area (Figure 2).

The bedrock geology of the study area is dominated by a lower Paleozoic (Cambrian to Silurian) marine deposition sequence of carbonates (limestones and dolomites), quartzites, and some interbedded shales. The Tertiary Wasatch Formation is deposited over an unconformity on the Paleozoic rocks. Unconsolidated Quaternary fluvial, glacial, and colluvial deposits overlie the older bedrock units.

Four major tectonic events have helped shape the geologic setting of the study area: 1) Folding and faulting of the Paleozoic rocks in the Bear River Range during the compressional regime related to emplacement of the Paris-Willard thrust sheet during the late Jurassic to late Cretaceous; 2) Erosion of exposed Paleozoic rocks to create the angular unconformity over which the Wasatch Formation was deposited in the Tertiary; 3) Uplift of the entire range along bounding faults during Basin and Range extension; and 4) Continued downcutting of the Logan River during ongoing uplift and glacial deposition during the Pleistocene (Oaks and Runnells' (1992)).

4.2.1 Mapped Geologic Units

4.2.1.1 Unconsolidated Quaternary Deposits

The surficial geology along the corridor is characterized by four major depositional environments resulting in unconsolidated deposits: alluvium (alluvial fan and stream terrace alluvium), mass movement and landslide-derived deposits, glacial till, and colluvium. Map units referred to in the following section are based on the geologic mapping of Oaks and Runnells (1992) and Oaks' unpublished maps.

Alluvial Fan (Qaf)
Unconsolidated gravel, sand, silt, and clay with subangular to subrounded cobbles and boulders deposited where steeper-gradient tributaries enter the Logan River. Graded fluvial bedding packets intermixed with thicker debris flow and hyperconcentrated flow deposits. Qaf deposits are typically cut by younger stream-terrace alluvium (Qat) or covered by recent alluvium (Qal). Material characteristics and observation of existing exposures of this material suggest it is stable on slopes of approximately 1.5H: 1V.

Alluvium (Qal)

Unconsolidated gravel and sand with subrounded cobbles and boulders and lesser silt and clay deposited primarily along the active channel banks of the Logan River and tributary drainages. Geotechnical characteristics are generally good unless cuts are oversteepened (>1.5H: 1V) and except in areas of thick silt and clay accumulation where excessive settlement should be expected.

Stream-Terrace Alluvium (Qat)

Unconsolidated gravel and sand with subrounded and rounded cobbles and boulders and minor silt and clay deposited primarily along older and higher banks of the Logan River and tributary drainages. Primarily graded fluvial bedding. Geotechnical characteristics are generally good unless cuts are oversteepened (>1.5H: 1V).

Fine-grained Colluvium (Qc)

Unconsolidated residual soil-forming silt and clay deposits with some sand and minor gravel with rounded cobbles and boulders primarily found on top of older glacial till deposits. Massive bedding. Geotechnical characteristics are generally good unless cuts are oversteepened (>2H: 1V).

Colluvium with Carbonate Cobbles and Boulders (Qcc)

Unconsolidated residual soil-forming silt and clay deposits with sand, gravel, and rounded cobbles and boulders primarily found in less-active depositional areas as carbonate bedrock cover. In places contains huge slabs of limestone of the Bloomington Formation that slid and rotated on underlying Bloomington shale. Typically massive bedding. Geotechnical characteristics are generally good unless cuts are oversteepened (>2H: 1V).

Younger Colluvium with Quartzite Cobbles and Boulders (Qcq)

Unconsolidated residual soil-forming silt and clay deposits with sand, gravel, and rounded cobbles and boulders primarily found in less-active depositional areas as quartzitic bedrock cover. Typically massive bedding. Geotechnical characteristics are generally good unless cuts are oversteepened (>2H: 1V).

Glacial Till (Qgt)

Unconsolidated massive mixture of large cobbles and boulders in a fine-grained matrix. Geotechnical characteristics are generally good unless cuts are oversteepened (>1.5H: 1V).

Mass Movement Colluvium-Diamicton (Qmcd) and Mass Movement Colluvium-Fine (Qmcf)

Unconsolidated older slump deposits of Qal, Qcc, and Qcq modified by later solifluction and creep. Found primarily in the vicinity of Upper Twin Bridge. Geotechnical characteristics are expected to be satisfactory unless cuts are oversteepened (>1.5H: 1V) or saturated with groundwater.

Landslide Block (Qms)
Semi-consolidated to consolidated areas of broken bedrock blocks or areas of multiple slides and slumps in the Wasatch Formation. No Qms deposits are mapped adjacent to the corridor where construction would occur.

4.2.1.2 Consolidated Bedrock

Tertiary Wasatch Formation (Tw)
Described by Oaks and Runnells (1992) as "Red- to orange-weathering; typically red unweathered; mostly cobble- to boulder diamicton with subordinate lenses of fluvial cobble orthoconglomerate and granular to pebbly lithic arenite; cobbles and boulders in basal part derived locally; higher gravel typically includes white quartzites of the Eureka Quartzite and, locally, brown-weathering pebbly quartzites of the Geertsen Canyon Quartzite." Geotechnical characteristics of weathered Wasatch Formation along the corridor are more like a soil than a rock. Performance of cuts slopes should be satisfactory unless cuts are oversteepened (>1.5H: 1V) or saturated with groundwater.

Tertiary Cowley Canyon Member of the Wasatch Formation (Tw1)
Described by Oaks and Runnells (1992) as "Lacustrine oolitic (algal) limestone; white weathering; pale brown unweathered; locally with cobbles and minor boulders; typically two resistant units of limestones separated by several m of red granular to pebbly orthoconglomerate...". No Tw1 deposits are mapped adjacent to the corridor where construction would occur.

Silurian Laketown Dolostone (Sl)
Light-gray well-bedded fossiliferous dolomite up to 456 m in thickness.

Ordovician-Silurian Fish Haven Dolostone (OSfh)
Typically a dark gray, well-bedded, cliff-forming, cherty dolomite up to 42 m in thickness.

Ordovician Eureka Quartzite (Oeu)
Light pinkish to orange weathering quartzite up to 88 m in thickness.

Ordovician Swan Peak Formation (Osp)
Dark shale comprises the lower portion of the Swan Peak and quartzite the upper portion. Up to 88 m in thickness.

Ordovician Garden City Formation (Ogc)
Well-bedded limestone and siltstone up to 348 m in thickness. Thinner bedding in lower portion, thick to massive bedding in upper third.

Cambrian-Ordovician St. Charles Formation (COsc)
Well-bedded limestone up to 309 m in thickness. Thinner bedding in lower half, thick to massive bedding in upper half.

Cambrian Bloomington Formation (Cbo)
Limestone and interbedded shale and shaley limestone thin to massive bedded. The Bloomington comprise three members: uppermost is the limestone and shale Calls Forts, the "middle" member is mostly limestone, and the lower is the Hodge Shale. The Bloomington Formation is up to 438 m in thickness.

Cambrian Geertsen Canyon Quartzite (Cgc)
Buff to light brown medium bedded to massive quartzite up to 1,400 m in thickness (correlative with the Tintic Quartzite).

4.2.2 Geologic Hazards

Geologic hazards along the highway corridor study area consist primarily of slope stability and earthquake related hazards.

4.2.2.1 Seismic Hazards

The corridor is located near the center portion of the Intermountain Seismic Belt, a zone of concentrated earthquake activity (Lund, 1990). The nearest mapped active faults to the center of the study area are the East Cache Fault located approximately 22 kilometers (14 miles) to the southwest, and the East Bear Lake Fault located about 23 kilometers (14 miles) to the east. Geologic and geomorphic evidence suggest that normal faulting has occurred in northern Utah throughout late Quaternary time and is predicted to continue in the future (Lund, 1990). Fault scarps along the active faults are relatively well dated and aid in the interpretation of past events and prediction of future events.

4.2.2.2 Earthquake Ground Shaking

Ground shaking refers to the ground surface acceleration caused by seismic waves generated during an earthquake. Strong ground motion is only likely to present a significant risk during moderate to large earthquakes located within a 100 kilometer (60 mile) radius of the project area (Boore et al., 1993). A number of seismic sources have been identified within this distance (Hecker, 1993), including active faults such as: the East Cache Fault; the East Bear Lake Fault; the Bear River Fault; the Hansel Valley Fault; the Pocatello Valley Fault; the Collinston, Brigham City, and Weber segments of the Wasatch Fault; the East Great Salt Lake Fault; and the Morgan Fault; as well as a random or floating earthquake source. Random earthquakes may (or are hypothesized) to occur in areas that have no evidence of previous surface fault rupture.

The severity of ground shaking at any site along the corridor will vary with the magnitude of the earthquake, the distance from the earthquake epicenter, and the ground response of the soil. Improperly designed structures and embankments can suffer structural distress or even fail during earthquakes delivering strong ground motions. Peak accelerations (expressed as a ratio of the acceleration due to one standard earth gravity) at the project area for 10%, 5%, and 2% probabilities of exceedance in 50 years have been estimated at 0.15 to 0.20g, 0.25 to 0.30g, and 0.30 to 0.40g, respectively, for NEHRP B-C boundary (firm rock) sites (Frankel et al., 1996). The NEHRP map for 2% probability of exceedance in 50 years in the state of Utah is presented on Figure 3.

4.2.2.3 Surface Fault Rupture

Surface fault rupture is the hazard related to differential movement of the ground surface along a fault during large earthquakes. Faults generating earthquakes with measured Richter magnitudes of less than 6 typically do not express rupture at the ground surface.

Based on the field investigation and review of published references (Hecker, 1993) there is no evidence that the corridor crosses known active faults and therefore, there is no risk of surface fault rupture in the study area.

4.2.2.4 Liquefaction

Earthquake-induced soil liquefaction can present a significant risk to highway structures and embankments. Ground shaking may cause saturated, sandy soils to liquefy due to increased pore pressure between soil grains. Earthquakes of Richter magnitude 5 are generally regarded as the lower threshold for liquefaction. Liquefaction can cause bearing failures of structural foundations and damage roadway embankments by triggering lateral spread landslides. Lateral spread-type failures can occur on nearly flat slopes.

No liquefaction-prone sediments were encountered in the borings. Given the geologic units mapped, it is expected that earthquake-induced soil liquefaction is unlikely except in relatively small areas of saturated sand-bar units along the active stream channels. Such localized hazards would be unlikely to cause significant impact to the proposed roadway.

4.2.2.5 Slope Stability Hazards

Several areas of Quaternary landslide (Qms) and mass movement (Qmcd and Qmcf) deposits have been mapped along the highway corridor (Figure 2) indicating that slope stability hazards such as landslides, slumps, and other mass movements have occurred in the past. Based on the geologic mapping it appears that slope stability problems have been primarily caused by removal of the slope toe by stream erosion and oversteepening the slope. However, slope failures can develop along any steep slope where the slope has been

disturbed, the head of the slope is loaded, or soil pore pressures are increased, resulting in driving forces within the slope exceeding the restraining forces. Detailed slope stability analyses are provided in later sections of this report to provide recommendations for slope designs with adequate factors of safety against slope failure.

4.2.2.6 Debris Flow and Rock Fall

Debris flow and rock fall hazards naturally present a risk to highways in mountainous areas. However, no areas of debris flow deposits or rock fall talus have been mapped along the corridor as a significant hazard. Site-specific rock fall hazard analysis was not conducted as part of this study and our design recommendations for cut slopes do not include provisions for potential rock fall hazards. Potential hazards imposed from rock fall along new cut slopes should be addressed during construction when site-specific conditions are exposed. Rock fall from cuts slopes, especially the cuts in glacial till, will need to be monitored during construction to remove large perched rocks that pose a potential rock fall hazard. Additionally, it is expected that these cuts and collection ditches below the cuts will require periodic maintenance (scaling and cleaning) following construction.

4.3 SUBSURFACE CONDITIONS

Subsurface conditions at the site were evaluated by 21 soil and rock exploratory holes. Boring logs are presented in Appendix B. The Explanation to Boring Logs in Appendix B provides a guide to soil classification symbols. The stratigraphy presented on individual boring logs may be referenced for general profile conditions at the specific location.

4.3.1 Cut Slopes

Subsurface conditions for proposed cut slopes were evaluated with 13 borings ranging in depth from 7.8 to 27.8 m below the existing ground surface. Subsurface conditions encountered varied over the site. Generally, the subsurface conditions over the southern portion of the proposed alignment consist of limestone and dolomite bedrock, varying from intact to highly weathered, overlain by sand and gravel soils with cobbles and boulders. The subsurface conditions over the northern portion of the alignment generally consist of deep bedrock layers overlain by sandy silt, silty sand, and glacial till, consisting of cobbles and boulders in a fine grained matrix.

4.3.2 Fill Slopes

One boring was completed to characterize subsurface conditions at a proposed fill slope location. Boring LC-RF-1 was completed to a depth of 9.5 m below the existing surface grade. Subsurface conditions encountered consisted of 0.9 m of dark brown clayey silt (topsoil) underlain by 1.9 m of gravels, cobbles, and boulders. The layer of gravels, cobbles, and boulders was underlain by limestone bedrock to the depth explored. Groundwater was encountered at a depth of 8.6 m.

4.3.3 Retaining Walls

Two borings were completed to characterize subsurface conditions at proposed retaining wall locations. Borings LC-RR-1 and LC-RR-2 were completed to depths of 12.2 m and 17.1 m, respectively. Subsurface conditions encountered in Boring LC-RR-1 consisted of 1.4 m of silty clay with sand and gravel underlain by boulders in a clay matrix with gravels and cobbles. The boulders in a clay matrix were encountered from a depth of 1.4 to 4.1 m and were underlain by limestone bedrock. Groundwater was encountered at a depth of 7.7 m.

Subsurface conditions encountered in Boring LC-RR-2 consisted of 1.4 m of sandy silt and silty clay. The silty clay and sandy silt were underlain by boulders in a clay matrix with gravel and cobbles. The boulders in a clay matrix were dense, graded without clay at a depth of 3.9 m, and extended to a depth of 7.3 m. Sandy clay was encountered from a depth of 7.3 to 12.2 m. The sandy clay was very stiff to hard. Groundwater was encountered at the ground surface.

4.3.4 Upper Twin Bridge

Site conditions at the location of the proposed replacement Upper Twin Bridge were characterized by drilling two borings to depths of 18.6 m. Materials encountered generally included surficial soils and fill underlain by moderately to highly weathered limestone bedrock. In Boring LC-S-1, 4.3 m of non-engineered fill was encountered at the ground surface. The fill was composed of a 1.5 meter thick layer of loose sandy gravel with clay, a 0.5 meter thick layer of loose clayey gravel with sand, and a 2.3 meter thick layer of quartzite boulders. This fill was underlain by highly weathered limestone bedrock to the maximum depth explored, 18.6 m. The limestone was moderately weak to weak, slightly fractured to fractured, and thinly bedded. In Boring LC-S-2, 0.5 m of topsoil was encountered at the ground surface. The topsoil was dark brown silty sand with some gravel. The silty sand was loose to medium dense and moist with moderate plasticity. Predominantly quartzite, dense, boulders were encountered from a depth of 0.5 to 1.8 m. Slightly fractured, thinly bedded, moderately strong limestone bedrock was encountered from a depth of 1.8 to 18.6 m (limit of investigation). Groundwater depths were not determined due to hole cave-in, but are expected to be at the river elevation.

4.3.5 Beaver Creek Bridge at Franklin Basin

Subsurface conditions at the location of the proposed Beaver Creek Bridge replacement at Franklin Basin were characterized by drilling one exploratory boring to a depth of 10.7 m. Boring LC-S-3 encountered surficial soils overlying limestone bedrock. A 0.5-meter-thick layer of fill was encountered at the ground surface. The fill consisted of dark brown silty sand with gravel and trace organics. The fill was medium dense and moist with low plasticity. Dark brown silty clay with boulders, gravel, sand, cobbles, and trace organics was from a depth of approximately 0.5 to 4.5 m. The silty clay was soft to medium stiff, wet, and slightly plastic. Moderately strong, highly fractured, thinly bedded limestone bedrock was encountered from a depth of 4.5 to 10.7 m (limit of investigation). Groundwater was at a depth of 1.8 m.

4.3.6 Beaver Creek Box Culvert

Subsurface conditions at the location of the proposed Beaver Creek Box Culvert were explored by drilling two exploratory borings to depths of 9.5 and 15.3 m below the existing subsurface grade. In boring LC-S-4, brown to dark brown clayey sand with gravel was encountered from the ground surface to a depth of 0.6 m. The clayey sand was medium stiff to stiff, highly plastic, and underlain by boulders in a clay matrix with gravel. The boulders in a clay matrix were very dense and extended to a depth of 2.1 m. Gray, yellowish red, and brown conglomerate bedrock was encountered from a depth of 2.1 to 15.2 m (limit of investigation) with the exception of a 0.9-meter-thick layer of yellowish red sandy clay with gravel encountered at 10.3 m. The conglomerate consists of gravel and cobbles in a cemented sand matrix. The clasts were generally limestone fragments with some siltstone and sandstone fragments. The conglomerate was highly weathered and weakly cemented in the upper 1.4 m and became strongly cemented at a depth of approximately 3.5 m. The sandy clay layer was stiff and of moderate plasticity. Groundwater was at a depth of approximately 0.6 m.

In Boring LC-S-5, brownish yellow boulders in a clay matrix were present from the ground surface to a depth of approximately 2.6 m. The boulders in a clay matrix were very dense, moderately plastic, and underlain by gray, yellowish red, and brown conglomerate bedrock. The conglomerate was strongly cemented to a depth of approximately 7.5 m, and extended to a depth of 9.1 m. The conglomerate became weakly cemented with increasing clay content at this depth. There was yellowish red silty clay from a depth of 9.1 to 9.4 m (limit of investigation). The silty clay was stiff and moderately plastic. Groundwater was at a depth of approximately 1.1 m.

4.4 GEOHYDROLOGIC CONDITIONS

Where groundwater was encountered, the depth to groundwater ranged from the existing ground surface to a maximum depth of about 2.6 m (8.5 feet) below existing grade. Groundwater depths are noted on the boring logs presented in Appendix B. The recorded depth to the water table at some boring locations may reflect groundwater dynamics in local drainage basins such as Beaver Creek and major drainage basins such as the Logan River. Groundwater seepage was noted in areas of Transects 3 and 4, located in the Beaver Creek drainage, and is perhaps related to perched ground water. In general, the Logan River is the predominant drainage for the study area. However, several intermittent drainage regions, such as Beaver Creek, contain perennial streams that cross the roadway corridor. Surface water runoff and related groundwater seepage is likely to vary seasonally.

4.5 GEOPHYSICAL EXPLORATION

The purpose of the geophysical exploration was to help provide depth to bedrock and material competency estimates in proposed road cuts and bridge abutments. In most of these areas, a single borehole was used to provide stratigraphic control and the geophysical surveys allowed extrapolation away from these areas. The scope of work consisted of field data collection, analysis and interpretation of the data, and preparation of this summary report.

4.5.1 Field Data Collection

The geophysical field work was conducted over the period of May 26, 1999 through June 10, 1999 by URS/Dames & Moore. A 24-channel Geometrics SmartSeis refraction seismograph was used to record arrival times from a sledge-hammer energy source. Typically up to10 hammer blows were "stacked" at each shot point to increase signal to noise ratio. Individual records were screened for excess noise or other problems prior to being added to the stacked data. Stacked data were saved to disk for subsequent processing. Hard copy paper records were printed from the seismograph in the field as a backup.

Geophones were typically spaced at 6.1 m (20 feet). A geophone spacing of 3.05 m (10 feet) was used for lines G1 and G4, while a geophone spacing of 1.53 m (5 feet) was used for line G2. All lines consisted of a single 24-station spread, except line G-4, which consisted of two overlapped 24-station spreads. Data were recorded at seven shot points along each spread. In all, 15 lines were completed along the proposed roadway improvement project. The relative locations of the geophysical lines are presented on the plan sheets in Appendix A.

Selected points on the refraction lines were staked during the field work and surveyed by UDOT staff to provide vertical control for topographic adjustments and datum corrections during the refraction analysis.

4.5.2 Data Analyses

All processing and analyses were facilitated by use of the SIPT2 (version 4.1) computer code, an interactive PC program for interpreting seismic refraction data. SIPT2 is an improvement over the previous U.S. Geological Survey versions SIPT1 (Haeni et al., 1987) and SIPT (Scott, 1977), and the U.S. Bureau of Mines FSIP1 (Scott et al., 1972; Scott, 1973).

A number of seismic refraction analysis methods were evaluated for use with the project data (intercept-time, critical-distance, and generalized-reciprocal methods, for example). However, given the combination of the quantity of shot points per line and the irregular subsurface contacts, the delay-time method employed in the SIPT2 code provided the best results.

The inversion algorithm used in the SIPT2 approach "uses the delay-time method (Pakiser and Black, 1957) to obtain a first-approximation depth model, which is then trimmed up by a series of ray-tracing and model-adjustment iterations that seek to minimize the discrepancies between the field-measured arrival times and the corresponding times traced through the 2½-D cross-sectional depth model." (Rimrock Geophysics, 1995).

The SIPT2 method is a fairly robust refraction interpretation method; however, there are several assumptions that must be recognized in processing the data:

1. Seismic refraction layers are continuous and extend from one end of the refraction line to the other.
2. Layer velocities increase with layer depths.
3. Although each refraction layer may be assigned different vertical and horizontal velocities, these velocities are assumed to remain constant from one end of a spread to the other. In multi-spread data sets, every layer of every spread may be assigned different values of vertical and horizontal velocity.

Typically, seismic refraction processing and analysis includes the following tasks:

- picking first break arrival times from seismic records,
- velocity analysis,
- plotting travel times versus distance (time-distance graphs),

- creating depth models,
- creating depth cross sections, and
- interpreting subsurface geology based on velocity, depth, and other observed (e.g., bore hole) information.

Arrival times were picked from the digital records using the SIPIK program. This program makes initial picks of first breaks on screen on the seismic records. The picks may then be adjusted by the data analyzer based on experience and observed trends in the data. Many of the seismic records for the Logan Canyon project were quite noisy, due to highway traffic, persistent wind, and occasional rain. Therefore, each record required careful analysis and hand picking of first break arrivals.

Travel time information, geophone and shot point elevations, distances, and numbers of layers were summarized for each spread in an Input Data File. Input data files were printed for each spread and are included in Appendix F.

Velocity analysis was performed for each spread and summary files are included in the Supplemental Geophysical Data (Appendix F). The refracted arrivals for each layer were computed by two methods: Regression, in which a straight line is fitted by least squares to the arrival times representing the velocity layer; and the Hobson-Overton method (Scott, 1973), which is a least-squares adaptation of the Plot of Differences method (Redpath, 1973). The velocity of the layer is then computed by taking the weighted average of the two methods based on the number of shot points used in the velocity calculation. The Hobson-Overton weighting factor was doubled because each Hobson-Overton point represents two arrival times received by a geophone from opposing shotpoints. All velocities were datum-corrected for elevation variances along the individual lines. Time-distance graphs were generated for each spread or line. These included datum-corrected arrival times.

Depth models were generated by the SIPT2 program for each spread. The depth model tables for each refraction spread summarize the depth and elevation of layers directly beneath each shot point and geophone. Depth model cross sections were generated based on the tabulated data. A velocity profile showing the emergent ray end points was plotted to help determine the accuracy of the model's fit of the data to the layer geometry. Less scatter of the depth points indicates a more accurate or more valid model of subsurface velocity layers. In every case the depth points between layers 1 and 2 are less scattered than those of deeper layers because layer-2 arrivals are generally sharper (hence easier to pick more accurately) and the velocity used to convert layer-2 times to depths is slower than the velocity used for deeper layers, so any errors in layer-2 picks are less magnified than errors with picks for deeper, higher velocity layers, when times are converted to depths.

Highly undulating and irregular contacts between subsurface units or a gradual increase of velocity with depth (no sharp velocity contrasts) will also cause scatter of the emergent ray end points.

The depth model cross sections are included in Appendix E. The following supplemental information is included in Appendix F:

- Input Data Files.
- Velocity Analysis Tables.
- Time-Distance Graphs.
- Depth Model Tables.

4.5.3 Geological Interpretations

The relative location of refraction lines G1 through G15 are shown in Appendix A. The geological interpretations for each line are discussed below and were based on seismic velocities, depth sections, boring logs, observed geology in surface outcrops or cuts, and published geologic maps.

4.5.3.1 Line G1

Line G1 was located along the west abutment of the Upper Twin Bridge, 8.2 m east of boring LC-S-1, at about STA 23+030. The line was located so that the center of the line was near the center of the proposed new abutment. Due to the bend in the river, the line has a bend of approximately 21° at geophone STA #8 as shown on Sheet 5B, Appendix A. Seismic records were of poor quality due to constant noise from the river (near flood stage).

Three layers were interpreted beneath this line. The near surface soil/alluvial layer (V=397 m/s) is predominantly of stream origin (Qal). The intermediate layer (V=1,120 m/s) consists of weathered limestone (Ogc) on the north end (upstream) and varies to stream alluvium (boulders, cobbles and gravel, Qal) on the south end (downstream). The third layer appears to be very competent limestone bedrock (V=6,298 m/s) of the Garden City Formation (Ogc).

4.5.3.2 Line G2

Line G2 was located along the east abutment of the Upper Twin Bridge, 3.7 m west of boring LC-S-2 at about STA 23+060. The line was located so that the center of the line was near the center of the proposed new abutment.

Seismic records were of fair quality. Two layers were interpreted beneath this line, including a near surface soil/alluvial layer (V=363 m/s) of stream origin (Qal) and an underlying layer of competent limestone (V=3,741 m/s) of the Garden City Formation (Ogc).

4.5.3.3 Line G3

Line G3 was located on a large proposed road cut (between STA 22+160 to STA 23+300) and centered on boring LC-RC-2. Seismic records were of poor quality due to wind on the ridge top.

Three layers were interpreted beneath this line, including a near surface soil layer (V=419 m/s), a middle layer of competent limestone (V=3,510 m/s) and a deeper layer (V=4,899 m/s) of more competent limestone bedrock. The limestone layers appear to be part of the Garden City Formation (Ogc).

4.5.3.4 Line G4

Line G4 was located on a long proposed road cut between STA 30+600 and 30+740 and centered on boring LC-RC-4. Seismic records were of poor-to-fair quality.

Three layers were interpreted beneath this line, including a near surface soil layer (V=450 m/s), an intermediate layer (V=973 m/s) of glacial till and associated sediments (Qgt), and an underlying layer (V=2,182 m/s) of poorly consolidated sediments of the Wasatch Formation (Tw) or glacial till (Qgt). Competent bedrock was not detected with the seismic method.

4.5.3.5 Line G5

Line G5 was located on a proposed road cut between STA 34+820 and STA 39+960. Boring LC-RC-5 was located along the line between geophone STA #15 and STA #16. Seismic records were of poor-to-fair quality.

Three layers were interpreted beneath this line, including a near surface soil/colluvial layer (Qcq_1, Qcq_2 or Qcc, V=369 m/s), an intermediate layer (V=979 m/s) of clayey sand (Qgt), and an underlying layer (V=2,438 m/s) of weathered limestone or glacial till (Qgt). Competent bedrock was not detected with the seismic method.

4.5.3.6 Line G6

Line G6 was located between STA 35+020 and STA 35+160 and was centered on boring LC-RC-6. Seismic records were of poor quality due to running water and nearby traffic.

Three layers were interpreted beneath this line. The near surface layer is likely soil and colluvium (Qcq_1 or Qcc, V=411 m/s). The intermediate layer (V=1,721 m/s) may consist of colluvium (Qcq_1), weathered limestone, or glacial till (Qgt) The third layer (V=1,957 m/s) may also be colluvium (Qcq_1), weathered limestone, or glacial till (Qgt). Competent bedrock was not detected with the seismic method.

4.5.3.7 Line G7

Line G7 was located between STA 36+000 and STA 36+140 and was centered on boring LC-RC-7. Seismic records were of fair quality.

Three layers were interpreted beneath this line, including a near surface soil layer (V=353 m/s), an intermediate layer (V=875 m/s) of sandy clay (Qal) or glacial till (Qgt), and an underlying layer (V=1,670 m/s) of glacial till (Qgt) or weathered limestone. Competent bedrock was not detected with the seismic method.

4.5.3.8 Line G8

Line G8 was located along a large road cut between STA 36+520 and STA 36+660 and was centered on boring LC-RC-11. Data quality was poor due to windy conditions.

Three layers were interpreted beneath this line, including a near surface soil layer (V=543 m/s), an intermediate layer (V=1,044 m/s) of weathered limestone, and an underlying layer (V=3,629 m/s) of more competent limestone. Limestone was exposed at the surface in several locations along the line.

4.5.3.9 Line G9

Line G9 was located between STA 36+700 and STA 36+840 and there was no corresponding, co-located boring. Seismic records were of fair quality.

Three layers were interpreted beneath this line, including a near surface soil layer (V=544 m/s), an intermediate layer (V=1,360 m/s) of glacial till (Qgt), and an underlying layer (V=4,303 m/s) of competent limestone bedrock.

4.5.3.10 Line G10

Line G10 was located between STA 36+880 and STA 37+020 and was centered on boring LC-RC-8. Seismic records were of fair quality for this line.

Three layers were interpreted beneath this line, including a near surface soil layer (V=437 m/s), an intermediate layer (V=1,135 m/s) of weathered limestone or glacial till (Qgt), and an underlying layer (V=3,793 m/s) of fairly competent limestone bedrock.

4.5.3.11 Line G11

Line G11 was located between STA 37+000 and STA 37+140, with no corresponding boring. It overlapped lines G10 and G12 (see Sheet 7H, Appendix A). Seismic records were of fair quality.

Three layers were interpreted beneath this line, including a near surface soil layer (V=350 m/s), an intermediate layer (V=1,207 m/s) of weathered limestone or glacial till (Qgt), and an underlying layer (V=2,425 m/s) of less weathered, more competent, limestone or glacial till (Qgt).

4.5.3.12 Line G12

Line G12 was located on a proposed road cut between STA 37+100 and STA 37+240. Boring LC-RC-9 was located between geophone STA #11 and STA #12. Seismic data were of fair quality.

Three layers were interpreted beneath this line, including a near surface soil layer (V=429 m/s), an intermediate layer (V=1,361 m/s) of weathered limestone (Pz), and an underlying layer (V=2,743 m/s) of less weathered, more competent limestone bedrock.

4.5.3.13 Line G13

Line G13 was located between STA 37+680 and STA 37+820 at the north end of the proposed project area. Boring LC-RC-10 was located at geophone STA #20. Seismic data were of fair quality.

Three layers were interpreted beneath this line, including a near surface soil layer (V=341 m/s), an intermediate layer (V=1,626 m/s) of weathered limestone or dolostone, and an underlying layer (V=4,865 m/s) of competent limestone or dolostone bedrock.

4.5.3.14 Line G14

Line G14 was added at the end of the project and was located between STA 34+220 and STA 34+360. Boring LC-RC-12 was located between geophone STA #12 and STA #13. Data quality was fair.

Three layers were interpreted beneath this line, including a near surface soil/colluvium layer (Qc, V=347 m/s), an intermediate layer (V=701 m/s) of colluvium (Qc) or glacial till (Qgt), and an underlying layer (V=1,693 m/s) of clay/sandy clay (Qc).

4.5.3.15 Line G15

Line G15 was also added at the end of the project and was located between STA 33+960 and STA 34+100. Boring LC-RC-13 was located between geophone STA #12 and STA #13. Data quality was fair.

Three layers were interpreted beneath this line, including a near surface soil/colluvium/clayey sand layer (Qc, V=355 m/s), an intermediate layer (V=1,225 m/s) of colluvium (Qc) or glacial till (Qgt), and an underlying layer (V=1,516 m/s) of colluvium (Qc), weathered limestone, or glacial till (Qgt).

Table 4 lists material types encountered during the geophysical exploration, typical seismic velocities for these materials reported by Redpath (1973), and measured velocities in the project area. Note that the velocities are dependent on degree and depth of weathering, moisture content, fractures, secondary mineralization, and other factors. There is generally good correlation between reported and measured velocities for this project.

Table 4
Material Types Encountered During The Geophysical Exploration

Material	Reported Velocity[1] (m/s)	Measured Velocity (m/s)
Weathered surface material (dry)	183-655	341-544
Weathered surface material (wet)	305-762	450
Clayey sand/Sandy clay/Clay	914-1,799	875-1,693
Boulders, cobbles, gravel	468-1,830	1,120
Glacial till, colluvium	762-2,256	701-2,438
Limestone/Dolomite	2,140-6,100	1,044-6,298

[1]from Redpath (1973)

4.5.4 Seismic Velocity-Derived Rippability

Ripping techniques may be used during construction depending on material hardness. Table 5 lists velocity, material description, and estimated rippability for material in the Logan Canyon study area based on geophysical interpretations. The rippability of material was estimated from velocity values attained by geophysical methods as described in the Caterpillar Handbook of Ripping (1983). It is emphasized that Table 5 is intended to provide a generalized estimate of the rippability of the site materials based solely upon seismic velocity and correlations in the Caterpillar Handbook. Estimates of equipment and ripping/ blasting techniques

should not be based solely upon the estimate of rippability presented in Table 5. Other factors, such as bedding and rock discontinuities, must also be considered in the evaluation of rippability.

Table 5
Rippability of Material

Refraction Line	Station Direction	Quality	Velocity (m/s)	Interpretation of Material (LS = Limestone)	Estimate of Rippability of Material (according to "Handbook of Ripping" (1983))
G – 1	23+026.282 NW.-.SE	Poor	397 1120 6298	Soil / alluvium LS (weathered) LS (competent)	Rippable Rippable Non – Rippable
G – 2	23+066.944 NW.- SE	Fair	363 3741	Soil / alluvium LS (less weathered)	Rippable Non – Rippable
G –3	23+242.378 SW – NE	Poor	419 3510 4899	Soil / alluvium LS (less weathered) LS (competent)	Rippable Non – Rippable (Marginal with D – 10 performance) Non – Rippable
G – 4	30+671.019 SW – NE	Poor – Fair	450 973 2182	Soil / alluvium Glacial till LS (weathered) / Glacial till	Rippable Marginal: Depends on size of boulders present Rippable, unless large boulders found in glacial till
G – 5	34+903 510 SW - NE	Poor – Fair	369 979 2438	Soil / colluvium Clayey sand LS (weathered) / Glacial till	Rippable Rippable Rippable, unless large boulders found in glacial till
G – 6	35+095.117 SW – NE	Poor	411 1721 1957	Soil / colluvium LS (weathered) / Glacial till LS (weathered) / Glacial till	Rippable Rippable, unless large boulders found in glacial till Rippable, unless large boulders found in glacial till
G – 7	36+068 349 S - N	Fair	353 875 1670	Soil Sandy clay / Glacial till LS (weathered) / Glacial till	Rippable Rippable, unless large boulders found in glacial till Rippable, unless large boulders found in glacial till
G – 8	26+600 SW - NE	Poor	543 1044 3629	Soil LS (weathered) LS (competent)	Rippable Rippable Non – Rippable
G – 9	36+760.852 SW - NE	Fair	544 1360 4303	Soil Glacial till LS (competent)	Rippable Rippable, unless large boulders found in glacial till Non – Rippable
G – 10	36+940 034 SW - NE	Fair	437 1135 3793	Soil LS (weathered) / Glacial till LS (competent)	Rippable Rippable, unless large boulders found in glacial till Non – Rippable
G – 11	37+049.546 SW - NE	Fair	350 1207 2425	Soil LS (weathered) / Glacial till LS (weathered) / Glacial till	Rippable Rippable, unless large boulders found in glacial till Rippable, unless large boulders found in glacial till
G – 12	37+162.519 SW - NE	Fair	429 1361 2743	Soil LS (weathered) LS (less weathered)	Rippable Rippable Marginal Rippability
G – 13	37+782 SW - NE	Fair	341 1626 4865	Soil LS (weathered) / Dolostone LS (competent) / Dolostone	Rippable Rippable Non – Rippable
G – 14	34+283 S - N	Fair	347 701 1693	Soil Glacial till / Colluvium Clay / Sandy clay	Rippable Rippable, unless large boulders found in glacial till Rippable
G – 15	34+024.383 S - N	Fair	355 1225 1516	Soil Glacial till / Colluvium LS (weathered) /Glacial till / coll.	Rippable Rippable, unless large boulders found in glacial till Rippable, unless large boulders found in glacial till

It should be noted that large boulders present in glacial till are considered non – rippable. Controlled blasting techniques should be used for non – rippable material to minimize any additional breakage of the rock mass.

4.6 POTENTIALLY HAZARDOUS MATERIALS

No analysis for hazardous materials was performed on soil or groundwater samples. However, no evidence such as soil staining, odor, or sheen on groundwater was observed during the exploration program.

5.0 MATERIAL PROPERTIES

The following sections summarize values of soil parameters that may be used in future design analyses.

5.1 IN-PLACE MOISTURE AND DENSITY

Moisture and density tests were performed on selected soil samples to aid in determining weight and volume relationships of soils encountered. The results of these tests are presented on the boring logs.

5.2 ATTERBERG LIMITS

Atterberg limits testing was performed on selected samples to aid in soil classification and to provide index parameters for correlation. The results of the Atterberg limits testing are presented in Table 6.

Table 6
Atterberg Limits Test Results

Boring Number	Sample Depth (m)	Plasticity Index	Liquid Limit	Unified Soil Classification
LC-RC-02	3.4 – 1.9	22	43	CL
LC-RC-03	3.4 – 4.9	18	36	GC
LC-RC-04	0.3 – 1.8	25	40	CL
LC-RC-05	6.3 – 7.9	9	29	SC
LC-RC-05	18.0 – 19.8	9	29	SC
LC-RC-07	3.4 – 3.8	16	37	CL
LC-RC-08	7.9 – 8.4	40	62	CH
LC-RC-10	1.8 – 2.3	21	41	CL
LC-RC-12	1.8 – 3.4	28	49	CL
LC-RC-12	17.7 – 18.6	33	54	CH
LC-RC-13	6.1 – 7.5	49	76	CH
LC-RF-01	0.0 – 0.3	10	35	ML
LC-RR-01	0.0 – 0.5	16	41	CL
LC-RR-02	0.0 – 0.5	20	55	MH
LC-RR-02	7.9 – 9.5	40	66	CH
LC-RR-02	9.5 – 11.0	51	80	CH
LC-S-01	1.5 – 2.0	15	31	GC (Fill)
LC-S-02	0.0 – 0.2	8	52	SM
LC-S-03	3.4 – 3.8	6	25	CL-ML

5.3 GRADATION ANALYSES

To aid in classifying soils, gradation analyses were performed on selected samples. The gradation analyses included mechanical sieving, washing over the No. 200 sieve (to determine fines content, percent finer than No. 200 sieve), and hydrometer analyses. Hydrometer analyses were performed on selected samples to determine the percentages of clay and silt. Results of the gradation analyses are presented in Table 7.

Table 7
Mechanical Gradation Analyses Test Results

Boring Number	Sample Depth (m)	Percent Gravel	Percent Sand	Percent Fines		Unified Soil Classification
				Silt	Clay	
LC-RC-02	1.8 – 3.4	13	22	65		CL
LC-RC-03	3.4 – 4.9	71	5	24		GC
LC-RC-04	0.3 - 1.8	47	27	6	20	GC
LC-RC-04	6.4 – 6.9	29	57	14		SM
LC-RC-05	4.6 – 6.3	20	50	30		SC
LC-RC-05	12.2 – 13.4	24	40	19	17	SC
LC-RC-05	18.0 – 19.8	60	18	22		GC
LC-RC-07	6.4 – 6.9	1	28	49	22	CL
LC-RC-08	3.4 – 3.8	0	3	97		CH
LC-RC-08	6.4 – 6.9	0	4	21	75	CH
LC-RC-10	1.8 – 2.3	5	22	39	34	CL
LC-RC-12	1.8 – 3.4	57	9	34		GC
LC-RC-12	6.3 – 6.9	45	26	29		GC
LC-RC-12	10.4 – 10.7	17	34	49		SC
LC-RC-12	17.7 – 18.6	0	22	27	51	CH
LC-RC-12	20.1 – 21.7	0	84	16		SC
LC-RC-13	1.8 – 3.4	0	52	48		SC
LC-RC-13	6.1 – 7.5	3	12	35	50	CH
LC-RC-13	9.5 – 11.0	33	22	45		GC
LC-RF-01	0.0 – 0.3	1	9	90		ML
LC-RR-01	0.0 – 0.5	25	14	61		CL
LC-RR-02	3.4 – 3.8	53	34	13		GC
LC-RR-02	7.9 – 9.5	5	35	60		CH
LC-RR-02	11.0 – 12.2	0	10	37	53	CH
LC-S-01	1.5 – 2.0	50	33	17		Fill (GC)
LC-S-02	0.0 – 0.2	11	52	37		SM
LC-S-03	0.0 – 0.3	18	68	14		Fill (SM)

Boring Number	Sample Depth (m)	Percent Gravel	Percent Sand	Percent Fines		Unified Soil Classification
				Silt	Clay	
LC-S-03	3.4 – 3.8	0	27	73		CL-ML
LC-S-04	0.0 – 0.5	22	29	49		SC

5.4 COMPRESSIBILITY

Consolidation tests were performed on relatively undisturbed samples to provide data necessary for settlement analyses. Samples were obtained from brass rings retrieved by the Dames & Moore Type-U sampler. Consolidation test results are presented in Table 8. Consolidation test curves and plots used to determine C_v are presented in Appendix D.

Table 8
Consolidation Test Results

Boring Number	Sample Depth (m)	Virgin Compression Index (Strain Basis)	Recompression Index (Strain Basis)	P_p (kPa)	C_v (cm^2/s @ kPa)	Unified Soil Classification
LC-RR-01	0.9 – 1.4	0.096	0.017	229.8	0.0047 @ 310	CL
					0.0052 @ 610	
					0.0048 @ 1230	
LC-RR-02	0.9 – 1.4	0.093	0.015	Not Available	0.0017 @ 310	CL
					0.0018 @ 610	
					0.0016 @ 1230	

5.5 UNIAXIAL COMPRESSIVE STRENGTH WITH POISSON'S RATIO

Uniaxial compressive strength tests were performed on selected intact section of rock core. Poisson's ratio was also identified for these samples. Test results are presented in Table 9. Figures 4a and 4b present the uniaxial compressive strength with depth for the Upper Twin Bridge area and STA 29+735 through STA 37+795, respectively.

Table 9
Uniaxial Compressive Strength Test Results

Boring Number	Sample Depth (m)	Wet Unit Weight (kN/m^3)	Compressive Strength (kPa)	Poisson's Ratio	Material Description
LC-RC-01	5.6-6.4	26.06	43,650	0.118	Limestone Bedrock
LC-RC-01	9.3-11.0	25.81	158,400	0.141	Limestone Bedrock
LC-RC-02	7.9-9.5	25.80	34,250	0.34	Limestone Bedrock
LC-RC-06	3.1-4.6	25.76	18,600	0.103	Limestone Bedrock
LC-RC-06	7.9-9.5	26.60	52,900	0.257	Limestone and Quartzite Bedrock
LC-RC-08	11.0-12.5	25.64	35,950	0.021	Limestone Bedrock
LC-RC-09	1.8-3.4	26.47	52,650	0.034	Dolomite Bedrock
LC-RC-11	1.8-2.7		28,800	0.265	Limestone Bedrock
LC-RC-11	9.0-10.5	26.19	49,600	0.339	Limestone Bedrock
LC-S-01	6.4-7.5	24.82	10,850	0.198	Limestone Bedrock
LC-S-01	11.3-12.5	25.29	4,700	0.073	Limestone Bedrock
LC-S-02	3.1-4.6	26.00	20,200	0.077	Limestone Bedrock
LC-S-02	7.9-9.5	26.14	15,700	0.07	Limestone Bedrock
LC-S-02	17.1-18.6	26.11	23,300	0.06	Limestone Bedrock
LC-S-05	1.8-2.0	25.25	45,600	0.208	Boulders
LC-S-05	4.9-6.4	26.05	48,450	0.183	Conglomerate

5.6 BULK DENSITY

Bulk density, moisture content, and specific gravity tests were performed on selected intact sections of rock core. Test results are presented in Table 10.

Table 10
Bulk Density Test Results

Boring Number	Sample Depth (m)	Wet Unit Weight (kN/m^3)	Moisture Content (%)	Specific Gravity	Material Description
LC-RC-1	5.6 – 6.4	26.06			Limestone Bedrock
LC-RC-1	6.4 – 7.6		0.9	2.81	Limestone Bedrock
LC-RC-1	9.3 – 11.0	25.81			Limestone Bedrock
LC-RC-2	7.9 – 9.5	25.8			Limestone Bedrock
LC-RC-6	3.1 – 4.6	25.76			Limestone Bedrock

Boring Number	Sample Depth (m)	Wet Unit Weight (kN/m^3)	Moisture Content (%)	Specific Gravity	Material Description
LC-RC-6	7.9 – 9.5	26.6			Limestone and Quartzite Bedrock
LC-RC-8	11.0 – 12.5	25.64			Limestone Bedrock
LC-RC-9	0.3 – 1.8				Dolomite Bedrock
LC-RC-9	1.8 – 3.4	26.47			Dolomite Bedrock
LC-RC-9	9.5 – 11.0		0.1	2.97	Dolomite Bedrock
LC-RC-11	1.8 – 2.7		0.4	2.83	Limestone Bedrock
LC-RC-11	9.0 – 10.5	26.19			Limestone Bedrock
LC-RF-1	6.4 – 7.9		0.6	2.75	Limestone Bedrock
LC-S-1	6.4 – 7.5	24.82			Limestone Bedrock
LC-S-1	7.9 – 9.5		0.2	2.91	Limestone Bedrock
LC-S-1	11.3 – 12.5	25.29			Limestone Bedrock
LC-S-2	3.1 – 4.6	26			Limestone Bedrock
LC-S-2	7.9 – 9.5	26.14			Limestone Bedrock
LC-S-2	12.5 – 14.0		0.3	2.87	Limestone Bedrock
LC-S-2	17.1 – 18.6	26.11			Limestone Bedrock
LC-S-3	6.7 – 7.9		1.1	2.78	Limestone Bedrock
LC-S-4	9.5 – 11.0		4.2	2.78	Conglomerate
LC-S-5	1.8 – 2.0	25.25			Boulders
LC-S-5	4.9 – 6.4	26.05			Conglomerate

5.7 CHEMICAL TESTS

Resistivity, sulfate content, soluble salt content, and pH tests were performed on representative soil samples to evaluate whether site soils will react detrimentally with steel or concrete. Test results are presented in Table 11.

Table 11
Results of Chemical Tests

Boring Number	Sample Depth (m)	pH	Minimum Resistivity (ohm-cm)	Soluble Sulfates, SO^4 (mg/kg)	Soluble Salts (mmhos/cm)
LC-RR-01	0.9 – 1.4	-	-	< 80	-
LC-RR-02	0.9 – 1.4	9.3	4000	<40	0.2
LC-S-03	1.8 –2.3	7.8	999	<40	1.1
LC-S-05	9.0 – 9.5	8.0	800	<40	0.1

6.0 ANALYSES AND RECOMMENDATIONS

6.1 DEEP FOUNDATIONS

A properly designed and constructed drilled pier is an acceptable foundation system for the bridge structures. Subsurface conditions at many of the bridge locations consist of a surficial soil or fill underlain by surficial, highly weathered bedrock. Drilled piers should be socketed into competent bedrock to the depths detailed in the following sections. All soil and rock parameters as shown on the Log of Boring and as presented in the laboratory testing section of this report are based on limited sampling of borings. While soil and rock layering inferred from the borings, and soil and rock properties obtained from laboratory testing provide information useful for design; the extent that they are truly representative of site conditions is not known and a conservative design using reasonable safety factors is essential.

If soil or bedrock conditions encountered in the field are different than anticipated, URS/Dames & Moore should be contacted to revise their design recommendations. Depths to competent bedrock should be verified in the field by experienced geotechnical engineering personnel. Drilled pier capacities are presented in Tables 12, 13 and 14. Capacities were developed using the AASHTO design manual (AASHTO, 1996, section 4.6.5.3) procedure for drilled piers. Both the methodology provided for rock and for an equivalent soil mass were used in design. The method states that rock end bearing capacities should never be lower than that for an equivalent soil mass. Therefore, the capacities obtained through the standard AASHTO method were compared to capacities obtained using the traditional soil bearing capacity equation with an equivalent cohesion and friction angle values for the weathered rock. The greater of the two values of bearing capacity were used in design of the drilled pier foundation.

As discussed with UDOT, lateral loading, due to seismic forces should be assumed to be resisted by the rock only. Overlying non-engineered fill or soil should be assumed to provide nominal resistance and will deform causing only the bedrock to carry lateral loads.

If a clear spacing of three pier diameters is not attainable due to loading requirements, piers must be placed as follows. Excavation should not be performed within a radius of 6 m nor additional caissons drilled within a clear distance of 1 m of concrete that has not attained a compressive strength of at least 10.3 Mpa. Adjacent piers should not be placed consecutively. Initially, every other pier should be placed. Then, after these piers have attained appropriate strength, the remaining piers may be placed. This methodology is used to avoid caving of the surficial soils and non-engineered fills during pier installation. URS/Dames & Moore should be contacted if additional design information is required.

6.1.1 Upper Twin Bridge

The foundation materials on which the proposed bridge abutments will be founded are generally surficial soils and fill overlying limestone bedrock. The foundation conditions at the western embankment were characterized by Boring LC-S-1, and consist of 4.3 m of fill overlying moderately weak to weak limestone bedrock. The foundation conditions at the eastern embankment were characterized by Boring LC-S-2, and consist of 1.7 m of boulders overlying moderately strong limestone bedrock. Section 4.3 provides a general description of subsurface conditions. The overburden materials at the location of the proposed Upper Twin Bridge structure are classified as A-1 with the exception of a thin layer of A-6 soils in Boring LC-S-1. Soil parameters used for design can be found in Sections 5.0 through 5.5. Drilled pier capacities for the Upper Twin Bridge are presented in the following table.

Table 12
Drilled Pier Capacities – Upper Twin Bridge

Location	Pier Diameter (m (ft))	Socket Length (m (ft))	Allowable Skin Friction (kN (kips))	Allowable End Bearing (kN (kips))	Allowable Total Capacity (kN (kips))
West Abutment	0.9 (3.0)	1.5 (5.0)	0	1,060 (240)	1,060 (240)
West Abutment	1.2 (4.0)	1.5 (5.0)	0	1,910 (430)	1,910 (430)
East Abutment	0.9 (3.0)	1.5 (5.0)	0	2,000 (400)	2,000 (400)
East Abutment	1.2 (4.0)	1.5 (5.0)	0	3,515 (790)	3,515 (790)

6.1.2 Beaver Creek Bridge at Franklin Basin

The foundation materials on which the proposed bridge abutments will be founded were defined by Boring LC-S-3. Subsurface materials in boring LC-S-3 consisted of 4.5 m of surficial soils overlying moderately strong limestone bedrock. Surficial soils consisted of 0.5 m of fill (AASHTO classification A-1-b) over 4.5 m of silty clay with cobbles, boulders, gravel, sand, and trace organics (AASHTO classification A-4). Drilled pier capacities for the Beaver Creek Bridge at Franklin Basin are presented in the following table.

Table 13
Drilled Pier Capacities – Beaver Creek Bridge at Franklin Basin

Location	Pier Diameter (m (ft))	Socket Length (m (ft))	Allowable Skin Friction (kN (kips))	Allowable End Bearing (kN (kips))	Allowable Total Capacity (kN (kips))
West Abutment	0.9 (3.0)	3.0 (10.0)	75 (20)	815 (180)	890 (200)
West Abutment	1.4 (4.0)	3.0 (10.0)	111 (25)	1,224 (275)	1,335 (300)
East Abutment	0.9 (3.0)	3.0 (10.0)	75 (20)	815 (180)	890 (200)
East Abutment	1.4 (4.0)	3.0 (10.0)	111 (25)	1,224 (275)	1,335 (300)

6.1.3 Red Banks Bridge

The foundation materials on which the proposed bridge abutments will be founded were defined by Borings LC-S-4 and LC-S-5. Soil conditions generally consisted of clayey sand and boulders in a clay matrix (AASHTO classification A-4) overlying conglomerate with sandy clay layers. Drilled pier capacities for the Red Banks Bridge are presented below.

Table 14
Drilled Pier Capacities – Red Banks Bridge

Location	Pier Diameter (m (ft))	Socket Length (m (ft))	Allowable Skin Friction (kN (kips))	Allowable End Bearing (kN (kips))	Allowable Total Capacity (kN (kips))
West Abutment	0.9 (3.0)	1.5 (5.0)	0	1020 (230)	1020 (230)
West Abutment	1.4 (4.0)	1.5 (5.0)	0	1780 (400)	1780 (400)
East Abutment	0.9 (3.0)	1.5 (5.0)	0	1020 (230)	1020 (230)
East Abutment	1.4 (4.0)	1.5 (5.0)	0	1780 (400)	1780 (400)

6.1.4 Seismic Criteria And Estimated Ground Acceleration

The site is located within the Intermountain Seismic Belt, which extends from southern Nevada northward through Utah and eastern Idaho into Western Montana. The Intermountain Seismic Belt is characterized by moderate-to-large magnitude earthquakes with shallow focal depths. Based upon the USGS National Seismic Hazard Maps, the peak ground acceleration with a 2% probability of exceedance in 50 years is approximately 0.4g. The site is located within a "Zone 3 Area" as defined by the seismic risk map of the United States in the Uniform Building Code (UBC) 1997 Edition. As a minimum, the criteria stated in the 1997 edition of the UBC for Zone 3 seismic areas should be incorporated into the design of the proposed facility.

6.1.5 Installation

Drilled piers should be installed only by qualified and experienced contractors. Proper cleanout of drilled pier excavations is essential. Under no circumstances should drilled piers be established upon soft, loose, or disturbed natural soils or in standing water. Casing of the excavation may be required to minimize sidewall sloughing, particularly within the existing fill at Upper Twin Bridge. Any accumulation of water should be pumped from the excavation to facilitate inspection and placement of concrete. If water cannot be pumped from the excavation, tremie methods should be used to place concrete. Placement methods should assure that voids are not created and segregation of the concrete is not allowed.

6.1.6 Concrete Corrosion Protection

Values of water-soluble sulfate (as SO_4) contents were less than 80 mg/kg for the samples tested (see Section 5.0). This concentration of water soluble sulfates represents a negligible degree of sulfate attack on concrete exposed to these materials. Use of a Type II cement is recommended for foundation elements in contact with site soils.

6.2 BURIED PIPES

Resistivity tests were performed on selected soil samples to evaluate whether site soils will react detrimentally with steel or other ferrous materials. Minimum resistivity values ranged from 800 to 4,000 ohm-cm, with an average value of 1,900 ohm-cm. These values range from corrosive to very corrosive, with the average value showing the soils to be corrosive. Because the resistivity values are indicative of corrosive to very corrosive environments, we recommend that Class B Pipe, as defined by UDOT's pipe class guidelines, be used for buried pipes.

6.3 BEAVER CREEK BOX CULVERT

The UDOT Geotechnical Section has recommended the use of free draining granular backfill material (UDOT 1994 Metric Standard Specification, Section 220) for use in foundation preparation for the Beaver Creek Box Culvert.

6.4 CUT SLOPES

Based on the results of stability analyses, URS/Dames & Moore recommends the use of ¼H: 1V cut slopes in competent bedrock and 1.5H: 1V to 2H: 1V cut slopes in overburden (soil and highly weathered bedrock). Based on observations and verification of subsurface conditions by qualified personnel during construction, cut slopes of 1H: 1V may be permitted in moderately weathered bedrock. Table 15 presents our recommendations for cut slopes by approximate stations. Cuts have been numbered from 1 to 23 and are differentiated as to left or right of centerline (cuts C5aL and C23aL were so numbered for convenience). Table 15 also includes the approximate cut length and maximum cut height as presented on the plans and cross-sections dated August 8 and August 9, 2000. The anticipated depth of overburden is included where sufficient information data were available to make a reasonable estimation. Table 15 also includes comments on whether bedrock may be expected.

For each cut number, boring and geophysical lines completed at or in the vicinity of the cut are identified. The relative locations of the borings and geophysical lines are presented on the plan sheets in Appendix A. It should be noted that these plan sheets, dated July 6 and 7, 2000, show cut slopes that were evaluated in our preliminary geotechnical analyses. These plan sheets do not represent the cut slopes identified in Table 15, which were revised in August, 2000. The plan sheets in Appendix A are included solely for the purpose of showing the locations of the borings and geophysical lines relative to the existing alignment.

Table 15
Cut Slope Recommendations[1]

Cut No.	Approximate Cut Limits[2]		Approx Cut Length (m)	Max Cut Height[3] (m)	Estimated Depth of Overburden[4] (m)	Recommended Maximum Cut Slope in Overburden	Anticipate Bedrock?	Recommended Cut Slope in Bedrock (if encountered)	Boring Number	Geo-physics Line
	Start	Finish								
C1L	22755	22820	65	7	0 to >5	1.5H:1V	Yes	¼H:1V?	LC-RC-1	-
C1R	22740	22840	100	9	0 to >5	1.5H:1V	Yes	¼H:1V?	LC-RC-1	-
C2R	22895	2300	105	2	Unknown	1.5H:1V	Unlikely	¼H:1V?	-	-
C2L	23070	23110	40	2	2 – 4	1.5H:1V	Unlikely	¼H:1V?	LC-S-2	G2
C3L	23130	23530	400	7	3 – 6	1.5H:1V	Yes	¼H:1V?	LC-RC-2	G3
C4L	29735	30260	525	6	0 to >8	1.5H:1V	Unlikely	¼H:1V?	LC-RC-3	-
C5L	30260	30940	680	10	6 to >13	1.5H:1V	Unlikely	¼H:1V?	LC-RC-4	G4
C5aL	31200	31530	330	2	Unknown	1.5H:1V	Unlikely	¼H:1V?	-	-
C6L	31740	31900	160	2	Unknown	1.5H:1V	Unlikely	¼H:1V?	-	-
C7L	32090	32250	160	3.5	Unknown	1.5H:1V	Unknown	¼H:1V?	-	-
C8L	32300	32740	440	9	Unknown	1.5H:1V	Unknown	¼H:1V?	-	-
C9R	33000	33730	730	6	Unknown	1.5H:1V	Unknown	¼H:1V?	-	-
C10R	33820	34100	280	17	3 to >12	2H:1V	Yes	¼H:1V?	LC-RC-13	G15
C10L	33860	33920	60	1	Unknown	1.5H:1V	Unknown	¼H:1V?	-	-
C11R	34170	34400	230	29	7 to >22	2H:1V	Unlikely	¼H:1V?	LC-RC-12	G14
C12R	34500	34570	70	3	Unknown	2H:1V	Unknown	¼H:1V?	-	-
C13R	34630	34720	90	2	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C14R	34780	34930	150	18	5 to >24	1.7H:1V	Unlikely	¼H:1V?	LC-RC-5	G5
C15R	35000	35150	150	8	1 – 4	2H:1V	Yes	¼H:1V?	LC-RC-6	G6
C16L	35200	35440	240	2	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C16R	35360	35480	120	1.5	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C17R	35590	35660	70	2	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C18L	35680	35830	150	1	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C18R	35750	35870	120	2	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C19R	35970	36160	190	6.5	10 to >15	2H:1V	Unlikely	¼H:1V?	LC-RC-7	G7

Cut No.	Approximate Cut Limits[2]		Approx Cut Length (m)	Max Cut Height [3] (m)	Estimated Depth of Overburden[4] (m)	Recommended Maximum Cut Slope in Overburden	Anticipate Bedrock?	Recommended Cut Slope in Bedrock (if encountered)	Boring Number	Geo-physics Line
	Start	Finish								
C20R	36200	36370	170	2	Unknown	2H:1V	Unlikely	¼H:1V?	-	-
C21R	36480	36630	150	9	0 – 8	1.5H:1V	Yes	¼H:1V?	LC-S-3 & LC-RC-11	G8
C22L	36740	37120	380	15	2 – 9	1.7H:1V	Yes	¼H:1V?	LC-RC-8 - & 9	G9, 10, 11, & 12
C23L	37120	37250	130	11	0 – 6	1.5H:1V	Yes	¼H:1V?	LC-RC-9	G12
C23aL	37320	37590	270	4.5	Unknown	2H:1V	Unknown	¼H:1V?	-	-
C23R	37640	37795	155	7	3 – 7	1.5H:1V	Yes	¼H:1V?	LC-RC-10	G13

[1] The above recommendations are based on data obtained from a limited number of exploratory borings and geophysical surveys. Subsurface conditions may vary from those generalized in the geotechnical analyses, and will require field verification during construction.

[2] The approximate cut limits are based on UDOT's revised plan sheets dated 08/08/00 and 08/09/00.

[3] The maximum cut height is based on cross-sections associated with UDOT's revised plan sheets dated 08/08/00 and 08/09/00.

[4] The estimated depth of overburden is based upon the subsurface materials encountered at the specific locations of borings and/or geophysical surveys, together with limited field observations. For cuts without an associated boring or geophysical survey, the estimated depth of overburden is unknown.

6.4.1 Slope Stability

Soil and rock strength parameters to be used in stability analyses of the slopes above and below US 89 were estimated based upon available field and laboratory test data. These strength parameters were used to analyze the stability of existing slopes and slopes with proposed improvements in place.

Stability analyses were completed using a combination of stereonet analyses for rock slopes and the computer codes SLOPE/W and PCStabl6H, limit equilibrium stability programs. Analysis with PCStabl6H utilized Bishop's modified method to determine the factor of safety against failure for potentially circular failure surfaces. For each circular failure surface, a search routine was employed that equally spaced twenty initiation points along a specified interval. From each of the initiation points, several potential failure surfaces were evaluated, and the failure surfaces with the minimum factors of safety were identified. Analysis with SLOPE/W utilized Spencer's method to determine the factor of safety against failure for potentially circular failure surfaces. A search routine was used that employed a grid of rotation centers and a range of radii to model circular and composite slip surfaces. From each of the initiation points within the grid of rotation centers, several potential failure surfaces were evaluated and the failure surfaces with the minimum factors of safety were identified.

Stability analyses were run for selected slopes and generalized slope profiles based on topography provided by UDOT. Selected cross-sections were chosen based on the combination of steepness and height of slope and

the quality of rock and soil making up the slope. Slope geometries were developed to achieve a minimum factor of safety of 1.3 for global stability based upon soil and rock parameters inferred from the nearest boring and its associated laboratory results. Because of the limited subsurface information available, field verification of the inferred soil and rock conditions must be completed during construction to assure that the analyses completed are adequately conservative.

6.4.2 Rock Discontinuity Analyses

Discontinuity mapping and analysis was performed to help characterize the rock mass and conduct failure mode analysis to determine the potential for adverse discontinuity sets that may effect the stability of the proposed new rock cuts. Eight transects (T1-T8) were surveyed along exposed rock outcrops. The location of transects are shown on the plan sheets and approximate station locations are provided on Table 16. The scope of work consisted of collecting discontinuity data in the field, tabulating and analyzing the data using stereographic projection methods, graphically portraying the data using Rockware's Rockworks99™ stereonet software, and providing recommendations.

6.4.2.1 Rock Strength

Relative rock surface-hardness measurements were collected using an L-9 Schmidt rock test hammer. The Schmidt hammer provides a good field test for determining relative rebound-hardness values for rock. Hammer readings were converted to approximate compressive strength (Table 16).

Figures 5a and 5b present plots of relative outcrop rock strength by station along transects. The mean outcrop rock strength for all values is 48.2 kPa ± 23.4 kPa for one standard deviation. This compares favorably with the mean uniaxial compressive strength results of 40.2 kPa ± 35.2 kPa from lab testing of rock core. Outcrop strength ranged from a low in the shaley limestone of 37.2 kPa ± 15.5 kPa (Transect 4) to a high of 88.3 kPa ± 23.7 kPa (Transect 3). Based on the Schmidt hammer and lab results a mean value of 40.2-48.2 kPa appears to be a reasonable value for rock cut design in limestone. No uniaxial compressive strength lab tests were conducted on the shaley units because of the difficulty obtaining intact core from these more friable units. However, the outcrop test results suggest a value of 37.2 kPa ± 15.5 kPa may be appropriate for design in these sections. These values are based on outcrop surface hardness and may be somewhat less than unweathered intact bedrock

6.4.2.2 Rock Discontinuities

Discontinuity mapping was conducted along exposed bedrock outcrops in the existing cuts. Discontinuity parameters collected at selected stations along each transect included: discontinuity type, orientation, tightness

(open or closed), filling type and thickness, roughness, length, spacing, and moisture. A summary of the discontinuity data is presented in Table 16. Table 16 also identifies the transect location by station and the related cuts included in the failure mode analysis (see Section 6.4.2.3).

Table 16
Discontinuity Data Summary

	Rock Type	Discont Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
Transect 1 Approx. STA 36480-36630 (see plan sheets for transect location) – Cut C21R															
1	Limestone	B	202	21						Dry	36	39	11.5	79.3	69
2	Limestone	J	161	84	S	NF	7	0.2		Dry	38	38	11.0	75.8	6
3	Limestone	J	27	86	S	NF	8	0.1		Dry	32	32	8.1	55.8	4
4	Limestone	J	294	75	S	NF	9	0 2		Dry	36	36	10.0	68 9	15
5	Limestone	B	205	22						Dry	42	45	15.5	106.9	68
6	Limestone	J	208	89	S	NF	7	0.1	0 2	Dry	24	24	5 2	35 9	1
7	Limestone	J	209	87	S	NF	9	0.7	0.2	Dry	16	16	3 4	23 4	3
8	Limestone	J	159	86	S	NF	8	0.3		Dry	32	32	8 1	55.8	4
9	Limestone	B	186	19						Dry	38	41	12.5	86.2	71
10	Limestone	J	170	78	S	NF	7	0.5		Dry	24	24	5 2	35 9	
11	Limestone	J	114	71	S	NF	6	0 1		Dry	40	40	12 0	82.7	19
12	Limestone	J	218	89	S	NF	6	0.3		Dry	18	18	4.0	27.6	1
13	Limestone	B	175	7	S	NF				Dry	28	31	7.9	54.5	83
14	Limestone	J	223	87	S	NF	6	0 6		Dry	36	36	10.0	68.9	3
15	Limestone	J	329	80	S	NF	6	0 6		Dry	40	40	12.0	82.7	10
16	Limestone	B	196	15	S					Dry	44	47	16.5	113.8	75
17	Limestone	J	223	89	S	NF	6	0.5		Dry	32	32	8.1	55.8	1
18	Limestone	J	335	86	S	NF	6	0.2		Dry	34	34	8 8	60.7	4
						Mean:	***7.0***	***0.3***	***0.2***				***9.4***	***65.0***	
						Std Dev:	***1.2***	***0.2***	***0.0***				***3.7***	***25.2***	
Transect 2 Approx. STA 36760-37200 (see plan sheets for transect location) – Cuts C22L and C23L															
19	Limestone	J	322	62	S	NF	10	0.4	0.2	Dry	16	19	4 1	28 3	28
20	Limestone	J	355	72	0-2	calcite	7	0.4	0.1	Dry	14	14	3.1	21.4	18
21	Limestone	J	338	67	closed	NF	7	0.4	0 1	Dry	18	21	4.4	30.3	23
22	Limestone	J	344	70	S	calcite	7	0.5	0.1	Dry	26	26	5 8	40 0	20
23	Limestone	J	204	79	S	NF	10	0.3		Dry	20	20	4.2	29.0	11
24	Limestone	J	234	63	S	NF	10	0.2							27
25	Limestone	J	132	81	closed	NF	8	0.5	0 1	Dry	16	16	3.4	23.4	9

	Rock Type	Discont. Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
26	Limestone	J	125	81	closed	NF	8	0.5	0.1	Dry	14	14	3.1	21.4	9
27	Limestone	B	316	9						Dry	28	31	7.9	54.5	81
28	Limestone	J	129	85	S	NF	11	0.3	0.1	Dry	16	16	3.4	23.4	5
29	Limestone	J	214	71	0-2	NF	10	1.2	0.2	Dry	16	16	3.4	23.4	19
30	Limestone	J	223	84	S	NF	11	1.0	0.2	Dry	16	16	3.4	23.4	6
31	Limestone	J	146	74	S	NF	11	0.2	0.1	Dry	14	14	3.1	21 4	16
32	Limestone	J	127	74	closed	NF	8	0.6	0.1	Dry	16	16	3.4	23 4	16
33	Limestone	J	144	76	S	NF	10	0.8	0.1	Dry	22	22	4.1	28.3	14
34	Limestone	B	314	17						Dry	26	29	6.9	47.6	73
35	Limestone	J	142	74	0-6	NF	8	0.7	0.2	Dry	26	26	5.8	40.0	16
36	Limestone	J	211	86	S	calcite	10	0.6	0.1	Dry	28	28	6.5	44.8	4
37	Limestone	J	145	71	S	NF	10	0.2	0.2	Dry	18	18	4.0	27.6	19
38	Limestone	B	270	7							26	29	6.9	47.6	83
39	Limestone	J	122	68	S	NF	11	0.3		Dry	26	26	5.8	40 0	22
40	Limestone	J	35	77	S	NF	12	1.1		Dry	24	24	5 2	35.9	13
41	Limestone	J	11	85	S	NF	12	0.6		Dry	18	18	4.0	27.6	5
42	Limestone	B	273	10							42	45	15.5	106.9	80
43	Limestone	J	136	78	0-1	C	8	0.9	0.1		16	16	3.4	23.4	12
44	Limestone	J	135	76	S	NF	12	0.4	0.1	Dry	24	24	5.2	35.9	14
45	Limestone	J	190	84	S	C	11	0.4	0.3	Dry	20	20	4.2	29.0	6
46	Limestone	J	11	81	S	NF	9	0.6	0.2	Dry	26	26	5.8	40.0	9
47	Limestone	J	115	78	S	NF	9	0.6	0.1	Dry	32	32	8.1	55.8	12
48	Limestone	J	220	82	S	C	9	0.2		Dry	14	14	3.1	21.4	8
49	Limestone	J	87	72	S	NF	9	0.2		Dry	24	24	5.2	35.9	18
50	Limestone	B	240	6							26	29	6.9	47.6	84
51	Limestone	J	7	85	S	NF	10	1.1	0.4	Dry	26	26	5.8	40.0	5
52	Limestone	J	115	81	S	NF	11	0.6	0.2	Dry	34	34	8.8	60.7	9
53	Limestone	J	79	77	S	NF	11	0.5	0.1	Dry	16	16	3.4	23.4	13
54	Limestone	J	135	87	C	NF	9	1 1	0.1	Dry	36	36	10.0	68.9	3
55	Limestone	J	31	89	S	NF	9	0.9	0.2	Dry	28	28	6.5	44.8	1
56	Limestone	J	110	73	S	NF	11	0.7	0.2	Dry	36	36	10.0	68.9	17
57	Limestone	J	123	80	C	NF	8	0.7	0.3	Dry	22	22	4.1	28.3	10
58	Limestone	B	255	5							28	21	4.4	30.3	85
						Mean:	***9.6***	***0.6***	***0.1***				***5.4***	***37.5***	
						Std Dev:	***1.5***	***0.3***	***0.1***				***2.5***	***17.4***	

Transect 3 Approx. STA 37660-37795 (see plan sheets for transect location) - Cut C23R

	Rock Type	Discont. Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
59	Limestone	B	48	3							42	45	15.5	106.9	87
60	Limestone	J	217	85	S	NF	9	0.6		Dry	48	48	19.0	131.0	5
61	Limestone	J	126	89	S	NF	8	0.7	0.7	Dry	44	44	15.0	103.4	1
62	Limestone	J	204	73	S	NF	8	0.8		Dry	44	44	15.0	103.4	17
63	Limestone	J	119	85	C	NF	7	0.4	0.6	Dry	40	40	12.0	82.7	5
64	Limestone	J	115	85	S	NF	9	0.7	0.8	Dry	40	40	12.0	82.7	5
65	Limestone	B	42	3						Dry	42	45	15.5	106.9	87
66	Limestone	J	215	86	S	NF	11	0.2	0.2	Dry	42	42	13.2	91.0	4
67	Limestone	J	231	86	S	NF	11	0.8	0.2	Dry	44	44	15.0	103.4	4
68	Limestone	J	114	77	S	NF	11	0.2	0.4	Dry					13
69	Shaley LS	J	223	85	S	NF	11	0.3		Dry	32	32	8.1	55.8	5
70	Shaley LS	B	147	7							30	33	8.5	58.6	83
71	Shaley LS	J	257	80	S	NF	12	0.3	0.8	Dry	34	34	8.8	60.7	10
72	Shaley LS	J	185	62	S	NF	9	0.3	0.9	Dry	32	34	8.8	60.7	28
73	Shale	J	126	80	S	NF	10	0.9	0.2	Damp					10
74	Shale	J	202	85	S	NF	8	1.5	0.1	Damp					5
75	Shale	J	218	85	S	NF	8	1.7	0.1	Damp					5
76	Shale	J	217	89	S	NF	8	0.4	0.1	Damp					1
77	Shale	J	122	73	C	NF	7	0.2	0.0	Damp					17
						Mean:	***9.2***	***0.6***	***0.4***				***12.8***	***88.3***	
						Std Dev:	***1.6***	***0.5***	***0.3***				***3.4***	***23.7***	

Transect 4 Approx. STA 37660-37795 (see plan sheets for transect location) - Cut C23R

78	Shaley LS	J	227	89	S	NF	11	0.3		seep	22	22	4.1	28.3	1
79	Shale	J	157	69	S	NF	9		0.1	seep					21
80	Shale	B	248	11											79
81	Shale	J	204	89	S	NF	8	0.3	0.1	Dry	16	16	3.4	23.4	1
82	Shale	J	117	81	C	NF	10	0.4	0.1	Wet		23	4.9	33.8	9
83	Shale	J	0	80	S	NF	11	0.4	0.4	Dry	12	12	2.8	19.3	10
84	Shale	J	255	79	S	NF	12	0.6	0.1	Dry	34	34	8.8	60.7	11
85	Limestone	B	260	3											87
86	Limestone	J	111	89	S	NF	9	0 6		Dry	28	28	6.5	44.8	1
87	Limestone	J	185	84	S	NF	9	0.5		Dry	26	26	5.8	40.0	6
88	Limestone	B	206	4							16	19	4.1	28.3	86
89	Limestone	J	193	89	S	NF	8	0.8		Dry	22	23	4.9	33.8	1
90	Limestone	J	233	86	S	NF	8	0.2		Dry	18	18	4.0	27.6	4

	Rock Type	Discont. Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
91	Limestone	J	117	75	S	NF	8	0.6		Dry	36	36	10.0	68.9	15
						Mean:	***9.4***	***0.5***	***0.2***				***5.4***	***37.2***	
						Std Dev:	***1.4***	***0.2***	***0.1***				***2.3***	***15.5***	

Transect 5 Approx. STA T5-8 22760-23420 (see plan sheets for transect location) - Cuts C1L, C1R, C2L & C3L

92	Limestone	J	172	88	C	NF	11	0.3		Dry	24	24	5.2	35.9	2
93	Limestone	B	90	8							32	35	9.4	64.8	82
94	Limestone	J	259	86	S	calcite	11	0.1	0.2	Dry	26	26	5.8	40.0	4
95	Limestone	J	195	87	S	NF	9	0.1	0.5	Dry	40	40	12.0	82.7	3
96	Limestone	J	180	78	S	calcite	11	0.2	0.5	Dry	18	18	4.0	27.6	12
97	Limestone	J	176	75	0-3	NF	11	0.3	0.5	Dry	16	16	3.4	23.4	15
98	Limestone	J	82	84	S	NF	12	0.4	0.1	Dry	16	16	3.4	23.4	6
99	Limestone	B	100	6							16	19	4.1	28.3	84
100	Limestone	J	194	75	0-4	NF	11	0.3	0.5	Dry	24	29	6.9	47.6	15
101	Limestone	J	161	80	0-1	NF	11	0.2	0.4	Dry	16	16	3.4	23.4	10
102	Limestone	J	68	78	S	NF	13	0.5	0.1	Dry	16	33	8.5	58.6	12
103	Limestone	J	164	74	0-4	NF	12	0.5	0.9	Dry	20	33	8.5	58.6	16
104	Limestone	B	120	3							24	27	6.1	42.1	87
105	Limestone	J	179	76	S	NF	11	0.2	0.9	Dry	26	29	6.9	47.6	14
106	Limestone	J	74	78	S	NF	11	0.2	0.1	Dry	28	29	6.9	47.6	12
107	Limestone	J	300	85	C	NF	9	0.6	0.4	Dry	22	22	4.1	28.3	5
108	Limestone	J	182	78	0-1	NF	10	0.4	0.5	Dry	22	22	4.1	28.3	12
109	Limestone	J	175	72	0-2	NF	11	0.4	0.9	Dry	16	28	6.5	44.8	18
110	Limestone	J	93	85	S	NF	13	0.5	0.1	Dry	22	22	4.1	28.3	5
111	Limestone	J	174	76	S	NF	13	0.5	0.9	Dry	16	16	3.4	23.4	14
112	Limestone	J	120	83	S	NF	13	0.5		Dry	28	28	6.5	44.8	7
113	Limestone	J	100	90	S	NF	13	0.6	0.1	Dry	16	16	3.4	23.4	0
114	Limestone	J	184	76	S	NF	10	0.5	0.9	Dry	30	30	7.2	49.6	14
115	Limestone	B	91	10							40	43	14.0	96.5	80
116	Limestone	J	175	73	0-5	NF	11	0.2	0.6	Dry	14	14	3.1	21.4	17
117	Limestone	J	93	87	S	NF	13	0.3	0.1	Dry	22	22	4.1	28.3	3
118	Limestone	J	180	77	S	calcite	13	0.3	0.4	Dry	24	24	5.2	35.9	13
119	Limestone	J	107	78	S	NF	13	0.3	0.4	Dry	22	22	4.1	28.3	12
120	Limestone	J	187	75	S	NF	11	0.3	0.4	Dry	22	22	4.1	28.3	15
						Mean:	***11.5***	***0.3***	***0.5***				***5.8***	***40.0***	
						Std Dev:	***1.3***	***0.1***	***0.3***				***2.7***	***18.4***	

Transect 6 Approx. STA T5-8 22760-23420 (see plan sheets for transect location) - Cuts C1L, C1R, C2L & C3L

	Rock Type	Discont. Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
121	Limestone	J	111	86	S	NF	9	0.4	0.3	Dry	28	28	6 5	44.8	4
122	Limestone	J	118	86	S	NF	8	0.7	0.3	Dry	36	36	10.0	68.9	4
123	Limestone	J	20	88	C	NF	7	0.3	1.2	Dry	40	40	12.0	82.7	2
124	Limestone	J	85	90	C	NF	8	0.6		Dry	28	28	6.5	44.8	0
125	Limestone	J	201	85	0-3	NF	9	0.4	0.3	Dry	24	24	5.2	35.9	5
126	Limestone	J	120	86	S	NF	9	0.4	0.3	Dry	28	28	6.5	44.8	4
127	Limestone	J	185	73	S	NF	10	2.4	0.8	Dry	24	24	5.2	35.9	17
128	Limestone	J	106	78	0-5	NF	10	0.6	0.3	Dry	20	20	4.2	29.0	12
129	Limestone	J	200	83	0-3	NF	9	0.9	1.2	Dry					7
130	Limestone	J	114	85	S	NF	10	2.7	0.3	Dry	20	20	4.2	29.0	5
131	Limestone	B	142	10						Dry					80
132	Limestone	J	225	86	S	NF	11	0.3	0.2	Dry	24	24	5.2	35.9	4
133	Limestone	J	268	70	S	calcite	9	1.5		Dry	30	30	7.2	49.6	20
134	Limestone	J	161	79	S	NF	7	1.5	0.9	Dry	32	32	8.1	55.8	11
135	Limestone	J	180	63	0-3	NF	11	1.2	1.2	Dry	28	30	7.2	49.6	27
136	Limestone	J	175	68	S	NF	9	1.3	0.6	Dry	30	30	7.2	49.6	22
137	Limestone	J	367	83	S	NF	9	1.8	0.2	Dry	30	30	7.2	49.6	7
138	Limestone	J	141	87	C	calcite	8	0.9	0.6	Dry	20	20	4.2	29.0	3
139	Limestone	J	269	72	S	NF	7	0.9	0.1	Dry	36	36	10.0	68.9	18
140	Limestone	J	183	84	S	NF	7	0.2	0.9	Dry	30	30	7.2	49.6	6
141	Limestone	J	135	90	0-8	NF	7	0.7	1.2	Dry	16	16	3.4	23.4	0
142	Limestone	B	120	9						Dry	30	33	8.5	58.6	81
143	Limestone	J	259	78	S	NF	7	0.9		Dry	42	42	13.2	91.0	12
144	Limestone	J	150	89	0-4	NF	7	0.4	0.9	Dry	32	32	8.1	55.8	1
145	Limestone	J	158	83	0-1	NF	9	0.9	1.1	Dry	14	14	3.1	21.4	7
146	Limestone	J	173	75	0-2	NF	11	1.1	0.8	Dry	16	16	3.4	23.4	15
147	Limestone	J	270	82	S	NF	9	0.9	0.1	Dry	32	32	8.1	55.8	8
148	Limestone	B	145	6	S	NF				Dry	28	31	7.9	54.5	84
149	Limestone	J	186	79	0-1	NF	7	1.0	0.1	Dry	24	41	12.5	86.2	11
150	Limestone	J	98	89	S	NF	7	0.9	0.1	Dry	28	28	6.5	44.8	1
151	Limestone	J	280	85	S	calcite	6	0.9	0.1	Dry	34	34	8.8	60.7	5
152	Limestone	J	180	82	C	NF	9	0.9	1.2	Dry	32	32	8.1	55.8	8
						Mean:	***8.5***	***1.0***	***0.6***				***7.2***	***49.5***	
						Std Dev:	***1.4***	***0.6***	***0.4***				***2.6***	***18.0***	

	Rock Type	Discont. Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
Transect 7 Approx. STA T5-8 22760-23420 (see plan sheets for transect location) - Cuts C1L, C1R, C2L & C3L															
153	Limestone	B	145	7							24	27	6.1	42.1	83
154	Limestone	J	333	87	S	calcite	10	0.7	1.2	Dry	24	24	5.2	35.9	3
155	Limestone	J	338	87	S	calcite	10	0.6		Dry	14	14	3.1	21.4	3
156	Limestone	J	284	86	0-1	NF	8	0.7	0.4	Dry	14	14	3.1	21.4	4
157	Limestone	J	354	85	S		11	0.8		Dry	20	20	4.2	29.0	5
158	Limestone	J	344	80	S	NF	8	0.2	0.1	Dry	30	30	7.2	49.6	10
159	Limestone	J	62	73	C	NF	9	1.4		Dry	20	20	4.2	29.0	17
160	Limestone	J	320	72	S	NF	9	1.5		Dry	34	36	10.0	68.9	18
161	Limestone	J	14	67	C	NF	11	0.9	0.7	Dry	36	36	10.0	68.9	23
162	Limestone	J	62	88	C	NF	10	0.6	0.3	Dry	20	20	4.2	29.0	2
163	Limestone	J	65	85	C	NF	10	0.9	0.3	Dry	30	30	7.2	49.6	5
164	Limestone	J	310	65	S	calcite	8	2.4		Dry	32	33	8.5	58.6	25
165	Limestone	J	322	66	S	calcite	8	1.8		Dry	30	32	8.1	55.8	24
166	Limestone	J	340	72	S	NF	8	0.6		Dry	20	30	7.2	49.6	18
167	Limestone	J	111	87	S	NF	9	0.4		Dry	22	22	4.1	28.3	3
168	Limestone	J	230	84	C	NF	8	0.9		Dry	10	10	2.5	17.2	6
169	Limestone	J	270	73	S	calcite	10	0.9		Dry	38	38	11.0	75.8	17
170	Limestone	J	335	77	S	NF	8	0.6		Dry	22	22	4.1	28.3	13
171	Limestone	J	220	83	S	NF	9	1.0		Dry	24	24	5.2	35.9	7
172	Limestone	J	220	60							30	32	8.1	55.8	30
						Mean:	***9.1***	***0.9***	***0.5***				***6.2***	***42.5***	
						Std Dev:	***1.1***	***0.5***	***0.4***				***2.5***	***17.6***	
Transect 8 Approx. STA T5-8 22760-23420 (see plan sheets for transect location) - Cuts C1L, C1R, C2L & C3L															
173	Limestone	B	159	7							38	41	12.5	86.2	83
174	Limestone	J	35	86	C	NF	10	0.6		Dry	22	22	4.1	28.3	4
175	Limestone	J	351	90	S	NF	10	0.3		Dry	28	28	6.5	44.8	0
176	Limestone	B	170	11		NF					40	43	14.0	96.5	79
177	Limestone	J	355	75	S	NF	10	0.2		Dry	22	22	4.1	28.3	15
178	Limestone	J	4	72	S	NF	10	0.7		Dry	12	12	2.8	19.3	18
179	Limestone	J	50	65	S	NF	9	0.1		Dry	34	36	10.0	68.9	25
180	Limestone	J	335	80	S	NF	10	0.6		Dry	30	30	7.2	49.6	10
181	Limestone	J	333	82	S	NF	10	1.2	0.1	Dry	34	34	8.8	60.7	8
182	Limestone	B	127	5							12	15	3.2	22.1	85
183	Limestone	J	328	83	S	NF	9	0.6		Dry	34	34	8.8	60.7	7
184	Limestone	J	355	88	C	NF	9	0.8	0.3	Dry	34	34	8.8	60.7	2

	Rock Type	Discont. Type[1]	Azimuth (strike)[2]	Azimuth (dip)[2]	Open or Closed? (mm)[3]	Type of Filling[4]	Roughness[5]	Length (m)	Typical Distance Between Parallel Joints	Moisture	Average Schmidt Hardness	Corrected Schmidt Hardness	Compressive Strength (psi x10^3)	Compressive Strength (kPa) x10^3	Impact Angle (-)
185	Limestone	J	356	86	C	NF	10	0.7	0.3	Dry	22	22	4.1	28.3	4
186	Limestone	B	143	5							30	33	8.5	58.6	85
187	Limestone	B	157	5							36	39	11.5	79.3	85
188	Limestone	J	350	74	S	NF	11	0.9		Dry	24	24	5.2	35.9	16
189	Limestone	J	62	70	C	NF	9	0.2	1.3	Dry					20
190	Limestone	J	50	78	C	NF	9	0.1	0.1	Dry					12
191	Limestone	J	47	78	C	NF	9	0.3	0.1	Dry					12
192	Limestone	J	319	86	S	NF	9	0.6	0 1	Dry	26	26	5.8	40.0	4
193	Limestone	J	320	90	S	NF	8	0.4	0.1	Dry	22	22	4.1	28.3	0
194	Limestone	J	243	76	S	NF	9	0 2	0.2	Dry	18	18	4.0	27.6	14
195	Limestone	J	238	66	S	NF	9	0.3	0.2	Dry	18	21	4.4	30.3	24
196	Limestone	J	240	75	S	NF	9	0 3	0.2	Dry	18	18	4.0	27.6	15
197	Limestone	J	156	71	S	NF	10	0.3	0.3	Dry	34	34	8.8	60.7	19
198	Limestone	J	150	85	S	NF	8	0.7	0.3	Dry	36	36	10.0	68.9	5
199	Limestone	J	317	82	S	NF	9	4.3	0.2	Dry	32	32	8 1	55.8	8
200	Limestone	J	317	85	S	NF	10	3.4	0.2	Dry	30	30	7.2	49.6	5
201	Limestone	B	154	1							34	37	10 5	72.4	89
202	Limestone	J	56	88	0-2	NF	8	0.5	0.4	Dry					2
203	Limestone	J	50	89	0-1	NF	11	0.6	0.4	Dry					1
204	Limestone	J	48	88	C	NF	8	0.2	0.4	Dry					2
205	Limestone	J	56	79	0-2	NF	8	0.4		Dry	26	26	5.8	40.0	11
206	Limestone	B	145	4											86
207	Limestone	J	227	65	C	NF	8	1.1	0.3	Dry					25
208	Limestone	J	220	68	C	NF	8	1.2	0.3	Dry					22
209	Limestone	J	227	69	C	NF	9	1.3	0.3	Dry					21
210	Limestone	J	160	76	S	NF	8	0.4		Dry	38	38	11.0	75.8	14
211	Limestone	J	221	72	0-5	NF	10	1.5		Dry	20	20	4.2	29.0	18
212	Limestone	J	220	70	C	NF	8	1.2		Dry	20	20	4.2	29.0	20
						mean:	***9.2***	***0.8***	***0.3***				***7.1***	***48.8***	
						std dev.	***0.9***	***0.9***	***0.2***				***3.1***	***21.2***	
					ALL DATA	***mean:***	***9.3***	***0.7***	***0.4***				***7.0***	***48.2***	
						std dev.	***1.7***	***0.6***	***0.3***				***3.4***	***23.4***	

Notes: 1: J = joint, B = bedding, F = fault; V = vein; 2: right-hand rule format; 3: C = closed, O = open; S = Surface
4: NF = no filling; Qtz = quartz; 5: On a scale of 1 to 10, with 1 being the smoothest and 10 the roughest.

The results of the discontinuity survey indicate that the average spacing between joints is about 0.4 m ± 0.3m and the apparent extent is about 0.7 m ± 0.6. Discontinuity roughness was reported as very rough with a mean (on a scale of 1 very smooth to 10 very rough) of 9.3 ± 1.7m. Most discontinuities appeared to be clean (no filling), only 9% of outcrop discontinuities were observed to have an infilling of calcite (up to 6 mm in thickness). The only evidence of groundwater seepage in May and June was noted in areas of Transects 3 and 4 and is perhaps related to water perched on the less permeable shale zones. These areas of potential groundwater seepage should be noted and field observations made during construction to identify specific groundwater zones for cut slope design modification. Seepage is likely to vary seasonally with snowmelt and runoff.

Contour plots of the orientation of outcrop discontinuities are shown in Figures 6a through 6l. No significant difference in discontinuity orientation was noted between bedrock types (limestone, shale, or shaley limestone). The contour plot was used to determine the average orientation for major discontinuity sets. Typically two or three major joint sets (J1, J2 and J3) and one bedding set (B1) were identified. The average orientation for each of these sets was used in the failure mode analysis and is summarized in Table 17 below.

Table 17
Discontinuity Orientation Summary

Transect	Data Points	Bedding Strike	Bedding Dip	Joint Set Strike	Joint Set Dip	Joint Set Strike	Joint Set Dip	Joint Set Strike	Joint Set Dip
T 1	18	207	18	160	85	215	89	None	None
T 2	40	279	7	132	80	10	85	None	None
T 3	19	85	3	120	84	218	86	None	None
T 4	14	240	5	106	80	198	87	230	89
T 5	29	90	8	94	87	178	77	None	None
T 6	32	132	9	115	86	183	80	278	75
T 7	20	142	8	338	82	225	85	63	87
T 8	40	145	5	320	86	224	70	50	85
All	212	145	5	116	84	180	77	221	86

6.4.2.3 Failure Mode Analysis

The critical shear strength of a rock mass is determined primarily by its discontinuities. Stereographic analysis can be used to determine the areas along discontinuities where the rock is inherently weak and can show where rock failure is geodynamically possible.

Failure mode analysis will help to determine the possible mode of slope failure given the orientation of a cut slope and a set of discontinuities for a specific area, defined as a zone. The method used in this analysis makes

use of stereographic projection techniques. The method involves selecting the structure sets, in terms of strike and dip values, and projecting the orientation of these discontinuities together with the strike and dip of the slope as great circles on a stereographic projection produced by Rockware's Rockworks99™ stereonet software. The spatial relationship of the structures can then be viewed to determine possible slope failure modes through the cut slope.

An example of how several discontinuities and a cut slope may appear is shown in Figure 7. The curved lines (great circles) represent the orientation of planes (joint, bedding surface, fault, or cut surface) in space. The polar stereonet projection background (an apparent 90-degree rotation) is a program error according to Rockware technicians. However, data plotted on Figures 6a through 6l, 7, and 8a through 8i are accurate according to a Schmidt stereonet projection. A vertically dipping surface would be represented on the diagram by a straight line passing through the center of the stereonet. A horizontal plane would be represented by a curved line coincident with the rim of the stereonet.

The potential for certain modes of slope failure exists whenever a structure (planar failure), or the line of intersection of two or more structures (wedge failure), dips at an angle less than the angle of the slope and undercuts the slope. Undercutting, or daylighting, is easily determined by visually examining the stereographic projection. As an example, Figure 7 illustrates two failure modes. The intersection of bedding and a joint along line A create a potential geometry for wedge failures and the daylighting of bedding in the cut slope along line B creates a potential for a planar failure. In the case of wedge failures it is assumed that failure may only occur directly down the line of intersection of the structures involved, represented by lines A, C, and D in the figure. In the case of failure along a plane, it is assumed that failure may only take place directly down the dip direction of the structure represented by lines B, E, and F. The geometry for potential toppling failures can also be discerned from the stereographic projection.

The potential for slope failure from adverse discontinuities may be assessed by evaluating the possibility and degree of undercutting of the potential failure surface through the slope. This is done by evaluating the stereographic projection for lines which are outside of the slope line in the direction of slope dip. The figure shows that lines A and B are the only discontinuities that dip at lesser angles than the cut slope creating a potential mode for failure of the slope.

Figures 8a through 8i present the failure mode analyses for the proposed roadway cut sections in rock (cuts C1L, C1R, C2L, C3L, C15R, C21R, C22L, C23L, and C23R). The discontinuity orientations from transect data nearest the cut slope, or in some instances the combination of the nearest transects, were used in the failure mode analysis. In some cases, such as for cut C15R, there was no outcrop transect data so the orientations from all the combined transect data was used in the failure mode analysis. A rock-cut slope angle of ¼H: 1V (about 76°) was used in this analysis. Data for this analysis was collected from the outcrop at road

level. Given the fairly tight grouping of joint sets observed in the contour plot it is likely that these discontinuities represent regional trends.

The failure mode analysis indicates that there are a number of adverse joint-joint and joint-bedding combinations formed but the resulting failure surface is at such a low angle that failure is unlikely. There is one instance in the failure mode analysis for proposed cut slope C15R where a wedge geometry may undercut the proposed ¼H: 1V (76°) planned cut slope face by a few degrees. Based on the failure mode analysis, a reduction of the cut slope to 70° for C15R should avoid exposing the potential wedge. Should a potential wedge failure be observed in the face of C15R, a field call can then be made whether to cut back the slope a few degrees to the base of the block exposed or perhaps use spot rock bolts to anchor the block in the steeper cut. There are other orientations where the primary joint sets and bedding combine to form the geometry for possible failure, however the orientation of the cut slopes would not "daylight" these wedges.

Based on this analysis, it appears that ¼H: 1V rock cuts would not be affected by the major discontinuity sets identified in this study. Random discontinuities could create the potential for localized adverse conditions and would need to be identified during construction. It is expected that natural variations in the bedding and joint orientations will be encountered and field adjustments may be required. UDOT's Plans and Specifications for the contractor should include some contingency for field observation-based modification of cuts due to natural variation in the rock.

6.4.2.4 Conclusions

Rock strength varies somewhat across the outcrops based primarily on rock type. The mean outcrop rock strength for all values is 48.2 kPa ± 23.4 kPa compared to a mean uniaxial compressive strength results of 40.2 kPa ± 35.2 kPa from lab testing of rock core. Based on the Schmidt hammer and lab results a mean value of 40.2-48.2 kPa appears to be a reasonable value for rock cut design in limestone and a value on the order of 37.2 kPa ± 15.5 kPa may be appropriate for design in shaley limestone sections.

Two to three primary joints (J1-3) and one bedding (B1) discontinuity set were identified. Failure mode analysis suggests there is a low potential for planar or wedge failures along the major joint sets identified for ¼H: 1V rock cuts except in cut C15R, where the potential is higher.

6.4.2.5 Recommendations

Discontinuities exposed in new rock cuts should be carefully monitored during construction by adequately trained personnel. Spot rock bolting could be used to help stabilize discrete zones should larger adverse joint sets be discovered during construction.

Cuts in highly weathered bedrock or unconsolidated materials should be evaluated separately. The failure mode analysis used does not model circular failures cutting through the intact rock mass. Table 15 presents cut slope recommendations for both soil and rock cuts.

Generally no moisture was encountered during the field mapping, performed during May and June, 1999, except in areas of Transects 3 and 4 (Appendix A, sheet 7K). Saturated conditions can significantly impact slope stability so drainage above the cut slopes must be considered in design.

6.4.3 Erosion Control Measures

We understand that temporary erosion control measures are being addressed by UDOT's environmental consultant.

6.5 EMBANKMENT FILLS

Embankment fills proposed as part of the roadway expansion involve both extensions of existing embankment fills and roadway grade changes. Table 18 details the locations and maximum heights of proposed embankment fills, based on review of plans and cross-sections dated July 6 and July 7, 2000. The fills are also identified on the plan sheets in Appendix A. With the exception of fills F1, F2, F5, and F9, fill heights do not exceed 3 m.

Table 18
Embankment Fills

Fill Number	Approximate Fill Limits[1]		Maximum Height[2] (m)	Approx Length[1] (m)	Boring Number
	Start (m)	Finish (m)			
F1	22+820	22+960	11	140	LC-RF-1
F2	23+080	23+300	7	220	-
F3	29+920	30+460	2	540	-
F4	30+460	30+660	1.5	200	-
F5	30+800	31+590	3.5	790	-
F6	31+860	32+640	2.5	780	-
F7	32+900	33+360	3	460	-
F8	33+525	33+730	2.5	205	-
F9	33+800	34+000	10[3]	200	-
F10	34+150	34+250	5.5	100	-
F11	34+700	34+800	1	100	-

Fill Number	Approximate Fill Limits[1]		Maximum Height[2] (m)	Approx Length[1] (m)	Boring Number
	Start (m)	Finish (m)			
F12	35+200	35+360	1.5	160	-
F13	35+460	35+600	2.5	140	-
F14	35+830	35+883	2	53	-
F15	35+991	36+170	3	179	-
F16	36+200	36+390	2.5	190	-
F17	36+390	36+509	1.5	119	-
F18	36+720	37+590	2.5	870	-

[1] The approximate fill limits and lengths are based on UDOT's plan sheets dated 07/06/00 and 07/07/00.

[2] The maximum fill height is based on cross-sections associated with UDOT's plan sheets dated 07/06/00 and 07/07/00.

[3] With the exception of a sliver fill from 33+940 to 34+000, F9 has a maximum height of 2 m

6.5.1 Estimated Settlement

Information on subsurface conditions was not available for most fill locations. Based on review of the plans dated July 6 and July 7, 2000, boring LC-RF-1 was the only boring drilled in the location of a proposed fill (fill F1). Boring LC-RF-1 encountered 0.9 m (3 feet) of silt underlain by 1.8 m (6 feet) of gravels, cobbles, and boulders. Limestone bedrock was encountered beneath the gravels, cobbles, and boulders to the maximum depth explored, 9.4 m. Depth to groundwater at the time of field investigation was 8.6 m (28.2 feet) in boring LC-RF-1.

We anticipate that suitable site materials, consisting of gravels, cobbles, boulders and/or intact bedrock, will be present at the bearing level in some proposed embankment fill locations. Based on materials encountered in the exploratory borings drilled along the alignment, we suspect that silts and clays will be present at the bearing level in other fill locations. A review of both fill and retaining wall borings indicates that depths of clayey soils were generally on the order of 1.5 m (5 feet). Results of laboratory testing indicate that on-site clays will be relatively compressible. Based upon our experience with similar materials, we anticipate that near-surface silts will also be compressible.

Because sufficient information is not available to properly characterize settlement behavior of embankments, we recommend overexcavation and replacement of silt and clay site soils with granular borrow (UDOT Standard Metric Specification, '94). We expect that areas of compressible site soils will be limited in extent laterally. We estimate that total settlement of embankments bearing on granular borrow or suitable site soils will be less than 1 inch.

6.5.2 External Stability

Slope stability analyses were performed with the SLOPE/W and PCStabl6H computer programs, described in Section 6.4.1. Stability analyses with SLOPE/W and PCStabl6H utilized Spencer's method and the modified Bishop method, respectively, to determine the factor of safety against failure for potentially circular failure surfaces. Based on the input slope geometries and estimated soil parameters, the minimum factor of safety for the fill slopes was determined to be greater than 1.25 for the static analyses.

Pseudo-static analysis was performed using a seismic coefficient of approximately ½ of the peak ground (horizontal) acceleration determined for 10 percent probability of exceedance in 50 years. From Section 4.2.2.2, the peak acceleration at the project site for 10% probability of exceedance in 50 years was estimated at 0.15 to 0.20g for NEHRP B-C boundary (firm rock) sites (Frankel et al., 1996). The pseudo-static analysis, with a seismic coefficient of 0.1g, yielded a factor of safety of 1.0 or greater.

6.6 RETAINING WALLS

Table 19 details the locations and maximum heights of proposed MSE and gabion walls for the project. With the exception of the walls identified by bolded structure numbers, the approximate wall limits, approximate length, and maximum height was based on plan sheets and associated cross-sections dated July 6 and July 7, 2000. Copies of these plan sheets are included in Appendix A. For the walls with bolded structure numbers, the information was based on review of plans and associated cross-sections dated August 8 and August 9, 2000. The wall number refers to the designation shown on the plan sheets in Appendix A. With the exception of walls M1, M6, M9, and M11, wall heights do not exceed 3 m.

Table 19
MSE and Gabion Walls

Wall Number	Structure Number[1]	Approx. Wall Limits		Approx. Length (m)		Maximum Height (m)	Boring Number	Wall Type
		Start (m)	Finish (m)	Left	Right			
M1	**R-376A**	22+962	23+016	69[2]		8.5	LC-RR-1 LC-S-2	MSE
	R-376B	23+056	23+065		25[2]	6.5		
M1A	R-376C	23+400	23+530		130			MSE
M2	R-376D	31+587	31+656		69	1.5		MSE
	R-376E	31+661	31+740		79			
M3	R-377A	32+640	32+710		70	2.5	LC-S-4 LC-S-5	Gabion
	R-376F	32+725	32+839		114			MSE
	R-376G	32+808	32+847	39				

Wall Number	Structure Number[1]	Approx. Wall Limits		Approx. Length (m)		Maximum Height (m)	Boring Number	Wall Type
		Start (m)	Finish (m)	Left	Right			
	R-376H	32+875	32+899	24				
M4	R-376I	33+360	33+525	165		3		MSE
M5	R-377B	33+730	33+800	70		3		Gabion
	R-377C	33+730	33+800		70			
M6	R-376J	34+000	34+211	211		3.5		MSE
	R-377D	34+120	34+150		30			Gabion
M7	R-377E	34+345	34+500		155	3		Gabion
M8	**R-376L**	35+882	35+992	110		4		MSE
	R-377F	34+560	34+630		70	1		Gabion
M9	R-377G	35+883	35+991	108		4	LC-RR-2	Gabion
M10	R-377H	36+170	36+200	30		2		Gabion
	R-377I	36+170	36+195		25			
M11	R-376M	36+509	36+643	134		3.5	LC-S-3	MSE
	R-376N	36+663	36+700	37				
	R-376O	36+672	36+720		48			
M12	R-376P	37+590	37+618		28	1		MSE
	R-376Q	37+611	37+618	7				
	R-376R	37+623	37+628		5			
	R-376S	37+625	37+628	3				

[1] For structure numbers highlighted in bold, the approximate wall limits, approximate length, and maximum height are based on review of plan sheets and associated cross-sections dated 08/08/00 and 08/09/00. Otherwise, this information was based on review of plan sheets and associated cross-sections dated 07/06/00 and 07/07/00.

[2] Total length includes portion of wall which wraps around bridge abutment.

The plan sheets dated July 6 and 7, 2000 show wall R-376J (M6) starting at STA 34+000. This will require the construction of a very thin sliver fill at the end of fill F9. It may be appropriate to start the wall at approximately STA 33+950 to avoid construction problems associated with this type of fill.

Sufficient information was available to evaluate the bearing capacity, settlement, and global stability of five of the proposed MSE walls: R-376A, R-376B, R-376G, R-376H and R-376L. Analyses of the remaining retaining walls were performed by UDOT and are included in Appendix G.

6.6.1 Bearing Capacity of MSE Walls

We evaluated the foundation bearing capacity of the following MSE walls: R-376A, R-376B, R-376G, R-376H and R-376L. A discussion of each wall is presented below. Design information and wall locations were based

on drawings sent via facsimile to URS on September 13, 2000, and subsurface information is based on the boring logs presented in Appendix B.

Allowable bearing pressures and recommendations regarding overexcavation are based on information presented in boring logs. Borings were widely spaced and may not be indicative of conditions existing between them. Variations in these conditions may be sufficient to necessitate modifications in wall designs. Therefore, we recommend that a qualified geotechnical engineer be present to observe subsurface conditions exposed in excavations to take advantage of all opportunities to recognize differing conditions and reduce the risk of having undetected conditions that could affect the performance of the MSE walls.

Frost depth must be considered in evaluation of embedment depth of the leveling pad. Also, provisions for erosion or scour protection at the base of the MSE walls may be required for those walls that are along the river (R-376A, R-376B and R-376G).

MSE Wall R-376A -- STA 22+962 to 23+016

Two borings were drilled in the vicinity of wall R-376A. Boring LC-RR-01 at STA 22+962 was drilled near the end of R-376B. Approximately 1.4 m of topsoil and silty clay were encountered, underlain by an approximately 2.7 meter thick layer of very dense boulders in a clay matrix with gravel and cobbles. Limestone bedrock was encountered beneath the boulders.

Boring LC-S-01 at STA 23+026 was drilled in the vicinity of R-376B, about 10 m outside the extent of the wall. Approximately 1.5 m of sandy and clayey gravel fill material was encountered, underlain by an approximately 2.7 m thick layer of loose bouldery fill material. Limestone bedrock was encountered beneath the bouldery fill. The results of one SPT test (N=4 blows/0.15 m) within this bouldery fill indicated that the boulders were placed loosely.

It is anticipated that this wall will be founded at an approximate depth of 0.6 m, based on the minimum leveling pad embedment depth and thickness specified in the MSE wall typical section. However, due to the apparent presence of either silty clay or loose fill at this depth, it is recommended that any silty clay or loose fill material beneath the leveling pad be overexcavated and replaced with compacted granular borrow. Therefore, it is expected that this wall will be founded on compacted granular borrow overlying either boulders in a clay matrix with gravel and cobbles or limestone bedrock. We estimate an allowable bearing pressure for this material of 285 kPa (6 ksf).

MSE Wall R-376B -- STA 23+056 to 23+065

Boring LC-S-02 at STA 23+067 was drilled in the vicinity of R-376B, about 2 m outside the extent of the proposed wall. Approximately 0.2 m of topsoil underlain by an approximately 1.7 m thick layer of dense boulders was encountered. Limestone bedrock was encountered beneath the boulders.

It is anticipated that this wall will be founded at an approximate depth of 0.6 m, based on the minimum leveling pad embedment depth and thickness specified in the MSE wall typical section. Therefore, it is expected that this wall will be founded on dense boulder material. We estimate an allowable bearing pressure for this material of 285 kPa (6 ksf).

MSE Wall R-376G -- STA 32+808 to 32+847

Boring LC-S-05 at STA 32+842 was drilled near R-376G. Approximately 2.5 m of glacial till consisting of very dense boulders in a clay matrix was encountered, underlain by moderately strong to strong conglomerate. Groundwater was encountered at an approximate depth of 1 m.

It is anticipated that this wall will be founded at an approximate depth of 0.6 m, based on the minimum leveling pad embedment depth and thickness specified in the MSE wall typical section. The drawings indicate that there is a concern that the foundation material at this depth may be softened due to saturation, and it has been recommended that an additional minimum 0.3 m of material be overexcavated beneath the leveling pad and replaced with compacted stabilization rock. Therefore, it is expected that this wall will be founded on compacted stabilization rock overlying glacial till consisting of very dense boulders in a clay matrix. We estimate an allowable bearing pressure for this material of 285 kPa (6 ksf).

MSE Wall R-376H -- STA 32+875 to 32+889

Boring LC-S-04 at STA 32+866 was drilled in the vicinity of R-376H, about 9 m outside the extent of the proposed wall. Approximately 0.5 m of clayey sand underlain by an approximately 1.3 m thick layer of glacial till consisting of very dense boulders in a clay matrix with gravel and cobbles was encountered. Moderately strong conglomerate was encountered beneath the glacial till. Groundwater was encountered at an approximate depth of 0.5 m.

It is anticipated that this wall will be founded at an approximate depth of 0.6 m, based on the minimum leveling pad embedment depth and thickness specified in the MSE wall typical section. Therefore, it is expected that this wall will be founded on glacial till consisting of very dense boulders in a clay matrix with gravel and cobbles. We estimate an allowable bearing pressure for this material of 380 kPa (8 ksf). If clayey sand is encountered beneath the anticipated leveling pad depth, it should be overexcavated and replaced with compacted granular borrow.

MSE Wall R-376L -- STA 35+882 to 35+992

Boring LC-RR-02 at STA 35+957 was drilled near R-376L. Approximately 1.4 m of sandy silt and silty clay was encountered, underlain by an approximately 5.9 m thick layer of glacial till consisting of dense boulders in a clay matrix with gravel and cobbles. Hard sandy clay was encountered beneath the glacial till. Groundwater was encountered near the ground surface.

It is anticipated that this wall will be founded at an approximate depth of 0.6 m, based on the minimum leveling pad embedment depth and thickness specified in the MSE wall typical section. However, due to the apparent presence of silty clay at this depth, it is recommended that any sandy silt or silty clay material beneath the leveling pad be overexcavated and replaced with compacted granular borrow. Therefore, it is expected that this wall will be founded on compacted granular borrow overlying glacial till. We estimate an allowable bearing pressure for this material of 285 kPa (6 ksf).

6.6.2 Estimated Settlement

Estimated settlement of the MSE walls R-376A, R-376B, R-376G, R-376H, and R-376L, bearing on suitable site soils or properly compacted granular borrow, is estimated to be less than 1 inch. Differential settlement is estimated to be ½ to ¾ of total settlement. Information on subsurface conditions was not available for other wall locations. For these walls, we recommend overexcavation and replacement of silt and clay site soils with granular borrow. We expect that areas of compressible site soils will be limited in extent laterally.

6.6.3 Global Stability

Slope stability analyses of the above five walls were performed with the slope stability computer program, SLOPE/W. The stability analyses utilized Spencer's method to determine the factor of safety against failure for potentially circular failure surfaces, as well as "block specified" failure surfaces. Circular failure surfaces were used for subsurface profiles consisting of soil and relatively soft, weathered bedrock to a substantial depth. Where shallow bedrock was encountered, and removal/replacement of overlying overburden was assumed, a "block specified" failure surface was assumed to occur at the interface of the bedrock and wall/embankment fill. Based on the input slope geometries, wall heights, and soil parameters, the minimum factor of safety for the MSE walls was determined to be greater than 1.3 for the static analysis.

The pseudo-static analysis was performed using a seismic coefficient of approximately ½ of the peak ground (horizontal) acceleration determined for 10 percent probability of exceedance in 50 years. From Section 4.2.2.2, the peak acceleration at the project site for 10% probability of exceedance in 50 years was estimated at 0.15 to 0.20g for NEHRP B-C boundary (firm rock) sites (Frankel et al., 1996). The pseudo-static analysis, with a seismic coefficient of 0.1g, yielded a factor of safety of 1.1 or greater.

7.0 CLOSURE

This final report provides geotechnical data for use in design of the reconstruction of the Logan Canyon Highway. This report focuses on presentation of data developed from soil and rock exploratory holes, geophysical lines, and laboratory test data. Settlement and stability analyses have been performed. Due to the limited extent of subsurface information, thorough review of excavations for cuts, fills, walls, and structures will be required to verify projected conditions. If conditions do not match those anticipated for the project, URS/Dames & Moore must be contacted to revise their recommendations.

8.0 LIMITATIONS

This report has been prepared for the exclusive use of the Utah Department of Transportation for specific application to the Logan Canyon Highway Project in accordance with generally accepted geotechnical engineering practice common to the local area. No other warranty, express or implied, is made.

The analyses and recommendations contained in this report are based on the data obtained from the referenced subsurface explorations in conjunction with design information available prior to the date of this report. The borings indicate subsurface conditions only at the specific locations and times, and only to the depths penetrated. They do not necessarily reflect strata variations that may exist between such locations. The validity of recommendations is based in part on assumptions about the stratigraphy made by the geotechnical engineer. Such assumptions may be confirmed only during earthwork and foundation construction. If subsurface conditions different from those described are noted during construction, recommendations in this report must be re-evaluated. It is advised that an experienced geotechnical engineer be retained to observe earthwork construction and foundation installation in order to confirm that our assumptions and preliminary recommendations are valid or to modify them accordingly. Due to the limited geotechnical information available for design and the variability in the site soil and rock conditions, cut slope adjustment and design modification decisions may need to be made in the field on a real time basis to provide compliance with design assumptions and to limit contractor standby time and other change order opportunities.

In the event that any changes in the nature, design, or location of the facilities are planned, the conclusions and recommendations contained in this report should be reviewed with respect to the changes. URS/Dames & Moore is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or engineering analyses.

The geotechnical design recommendations presented herein are subject to field verification of site conditions during construction. Observation of the geotechnical aspects of construction for the project by URS/Dames & Moore personnel is required. The on-site observations are intended to check compliance with design concepts, specifications, and recommendations, and to assist in development of design changes should subsurface conditions differ from those anticipated. All excavations must be observed by URS/Dames & Moore personnel to verify the projected site conditions, and to provide assurance that the installation and construction has been performed in accordance with the recommendations presented in this final report. Any variation from expected conditions should be immediately identified so that recommendations may be revised if necessary.

9.0 REFERENCES

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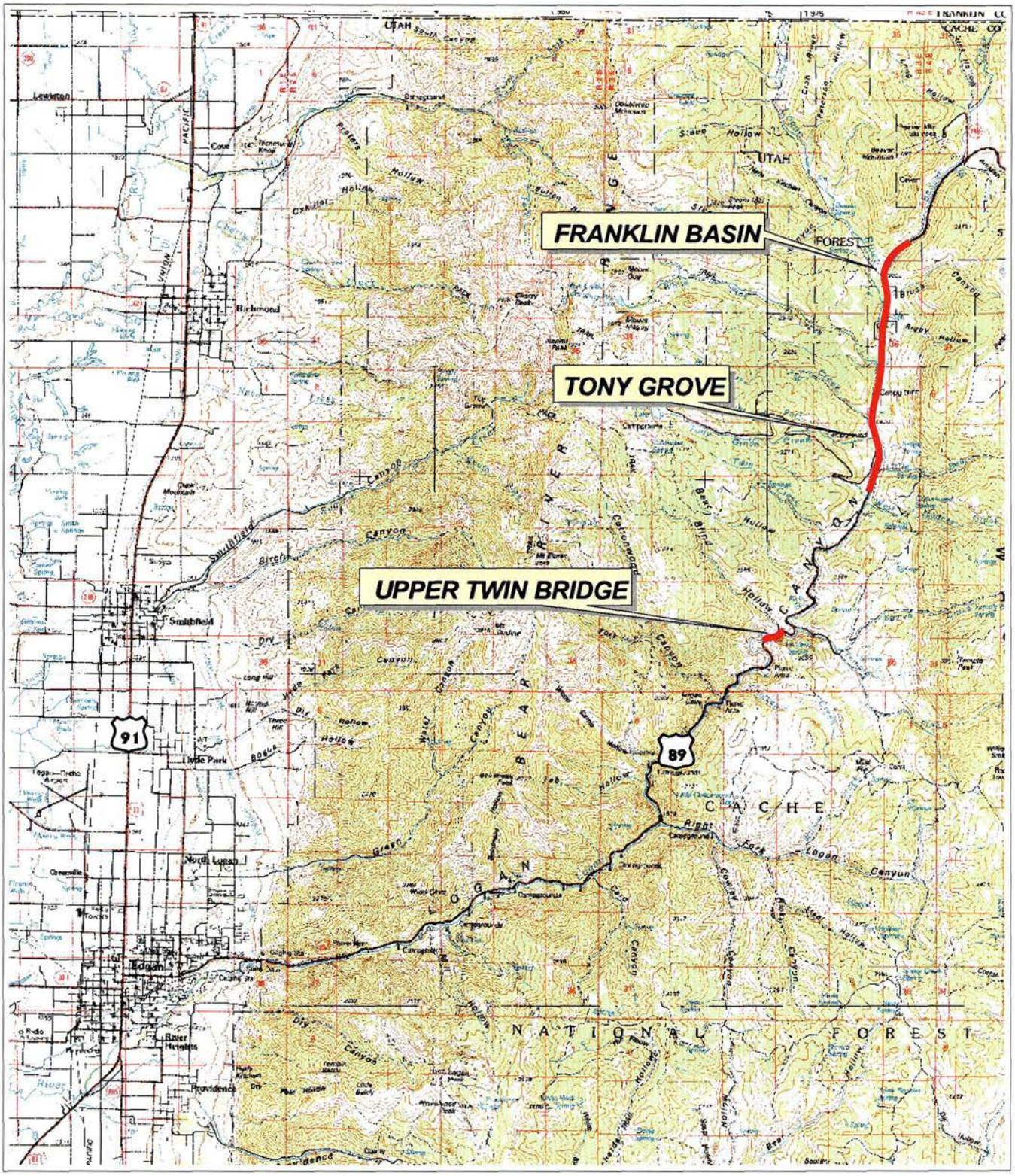
FIGURES



1 0 1 2 Miles

N
W E
S

VICINITY MAP

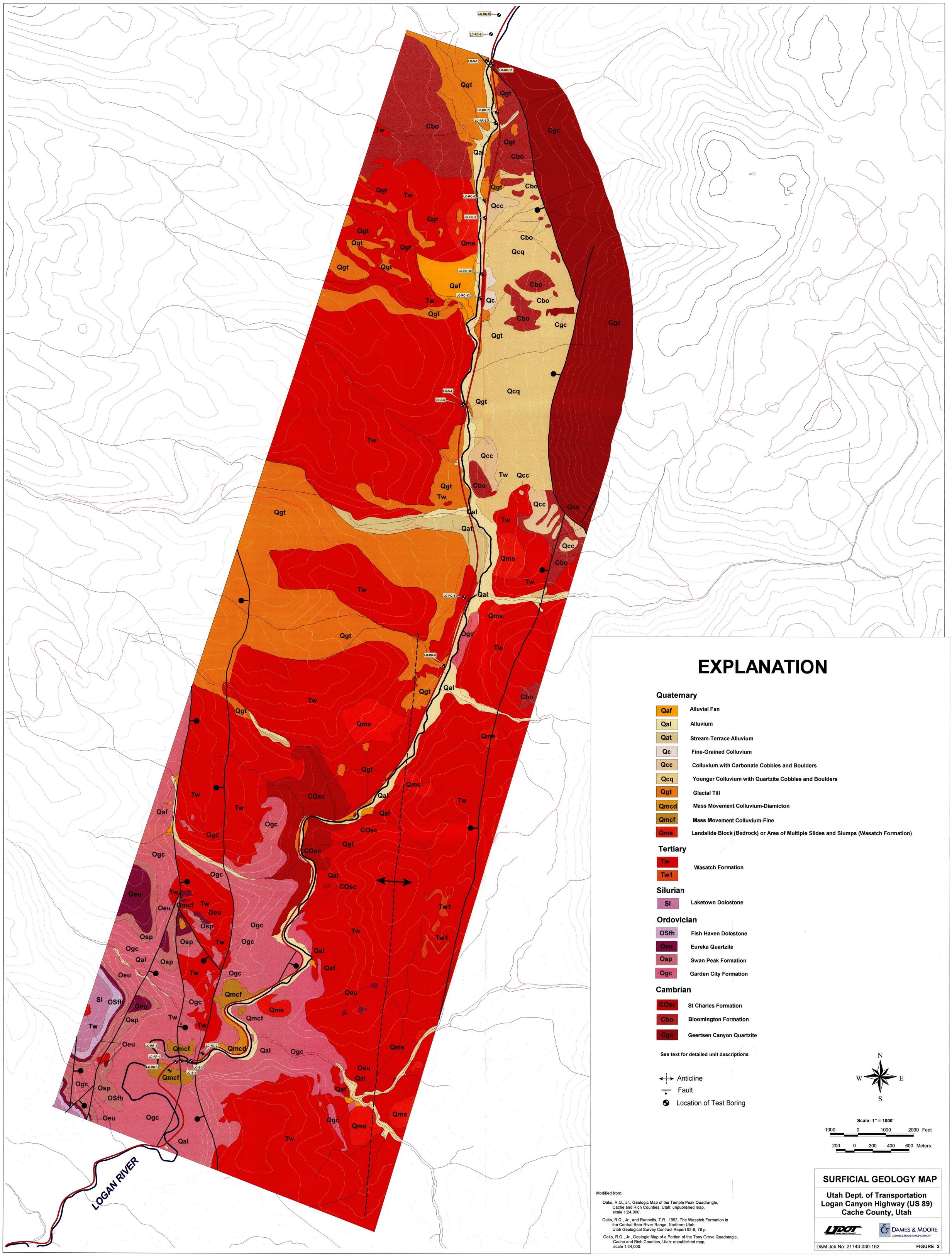
Utah Dept. of Transportation
Logan Canyon Highway (US 89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Source:
USGS 30 x 60 min 1:100.000 Quadrangle
"Logan, UT", 1984

JOB NO. 21743-030-162

FIGURE 1



EXPLANATION

Quaternary

- **Qaf** Alluvial Fan
- **Qal** Alluvium
- **Qat** Stream-Terrace Alluvium
- **Qc** Fine-Grained Colluvium
- **Qcc** Colluvium with Carbonate Cobbles and Boulders
- **Qcq** Younger Colluvium with Quartzite Cobbles and Boulders
- **Qgt** Glacial Till
- **Qmcd** Mass Movement Colluvium-Diamicton
- **Qmcf** Mass Movement Colluvium-Fine
- **Qms** Landslide Block (Bedrock) or Area of Multiple Slides and Slumps (Wasatch Formation)

Tertiary

- **Tw**, **Tw1** Wasatch Formation

Silurian

- **Sl** Laketown Dolostone

Ordovician

- **OSfh** Fish Haven Dolostone
- **Oeu** Eureka Quartzite
- **Osp** Swan Peak Formation
- **Ogc** Garden City Formation

Cambrian

- **COsc** St Charles Formation
- **Cbo** Bloomington Formation
- **Cgc** Geertsen Canyon Quartzite

See text for detailed unit descriptions

Anticline

Fault

Location of Test Boring

N W E S

Scale: 1" = 1000'

1000 0 1000 2000 Feet

200 0 200 400 600 Meters

Modified from:

Oaks, R.Q., Jr., Geologic Map of the Temple Peak Quadrangle, Cache and Rich Counties, Utah: unpublished map, scale 1:24,000.

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SURFICIAL GEOLOGY MAP

Utah Dept. of Transportation
Logan Canyon Highway (US 89)
Cache County, Utah

UDOT

DAMES & MOORE
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D&M Job No: 21743-030-162 **FIGURE 2**

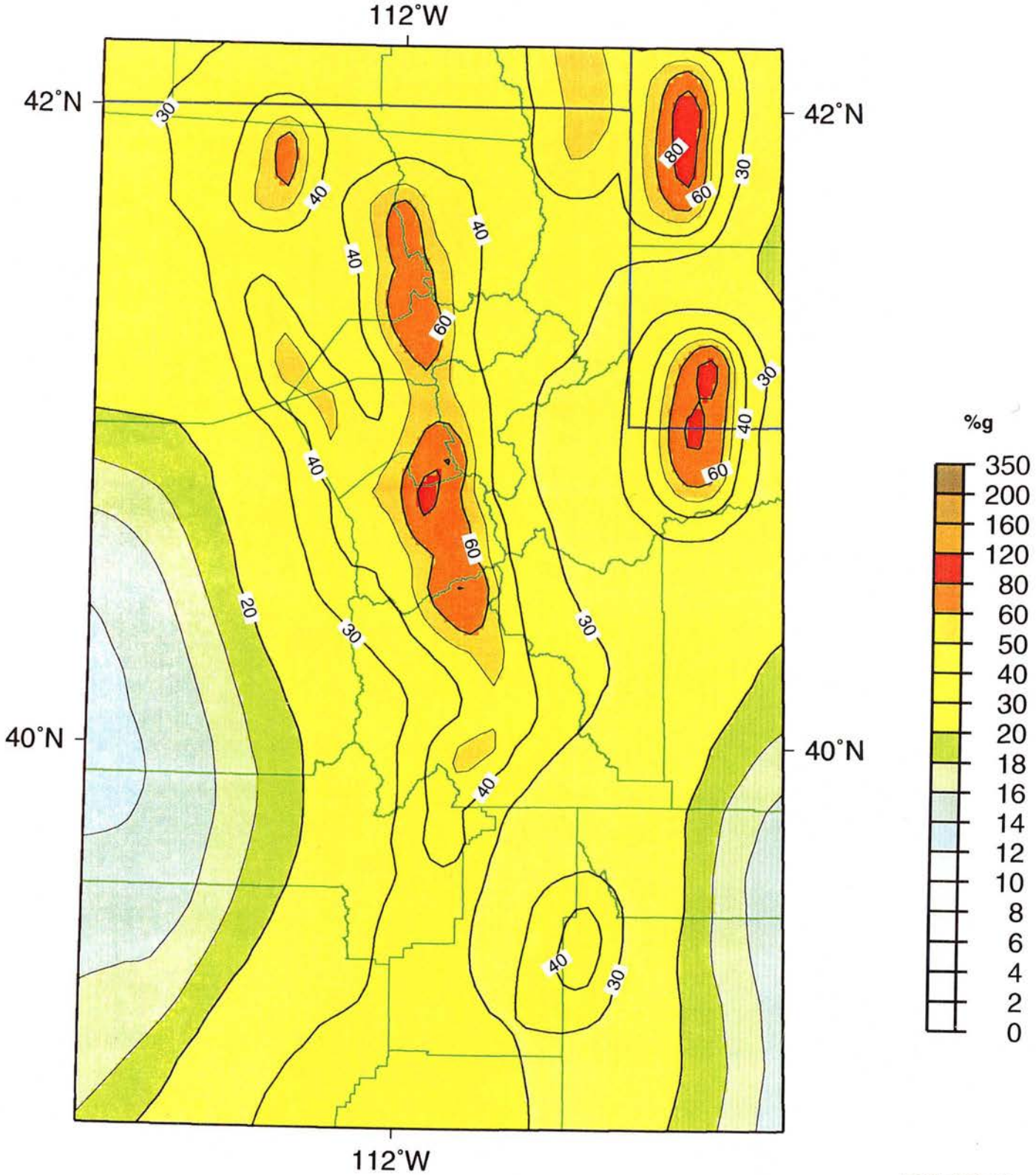


FIGURE 3

Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
site: NEHRP B-C boundary

miles
0 50

U.S. Geological Survey
National Seismic Hazard Mapping Project

Albers Conic Equal-Area Projection
Standard Parallels: 29.5 and 45.5 degrees

Upper Twin Bridge Area

Compressive Strength vs. Depth

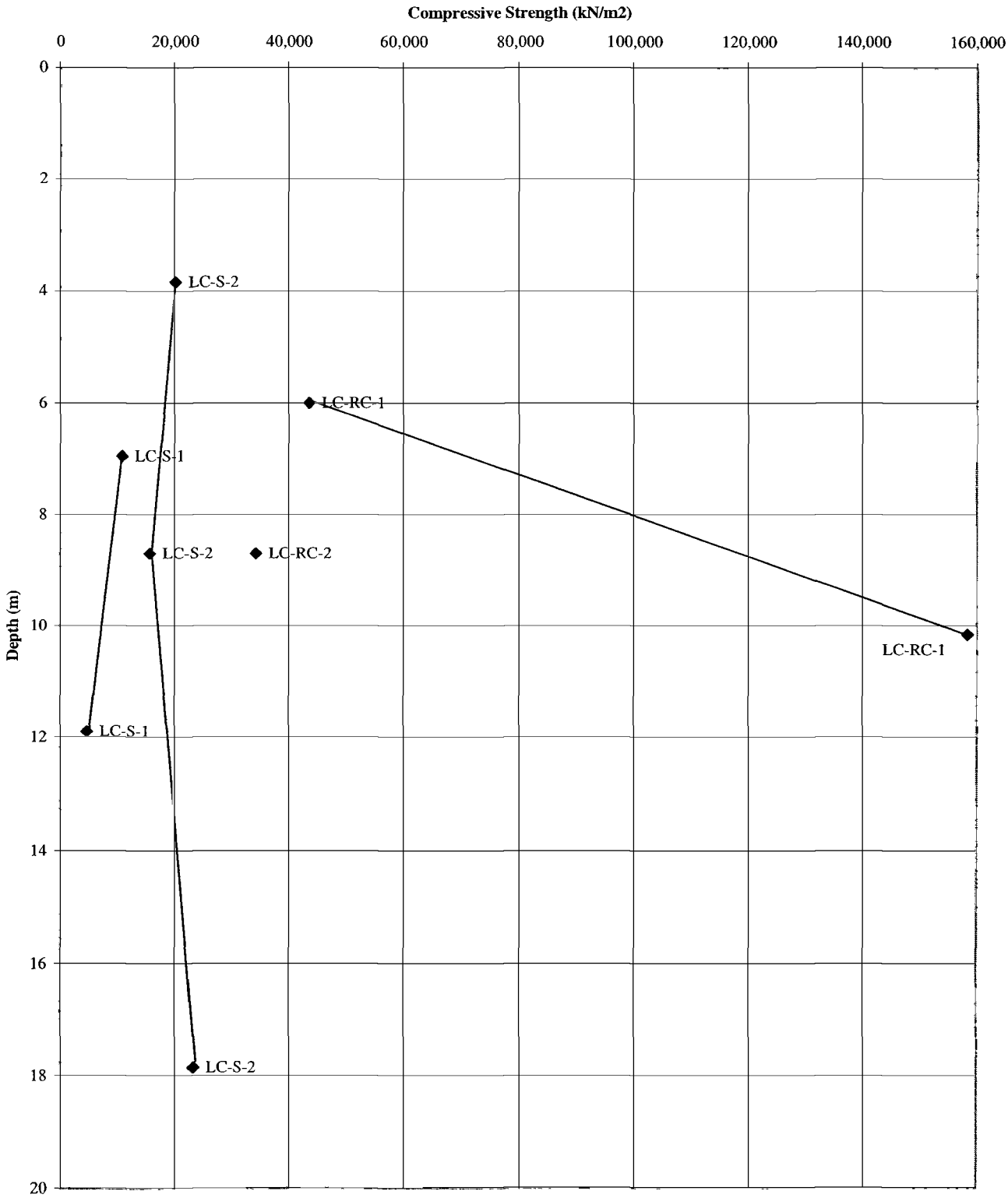


Figure 4a

Stations 29+735 to 37+795

Compressive Strength vs. Depth

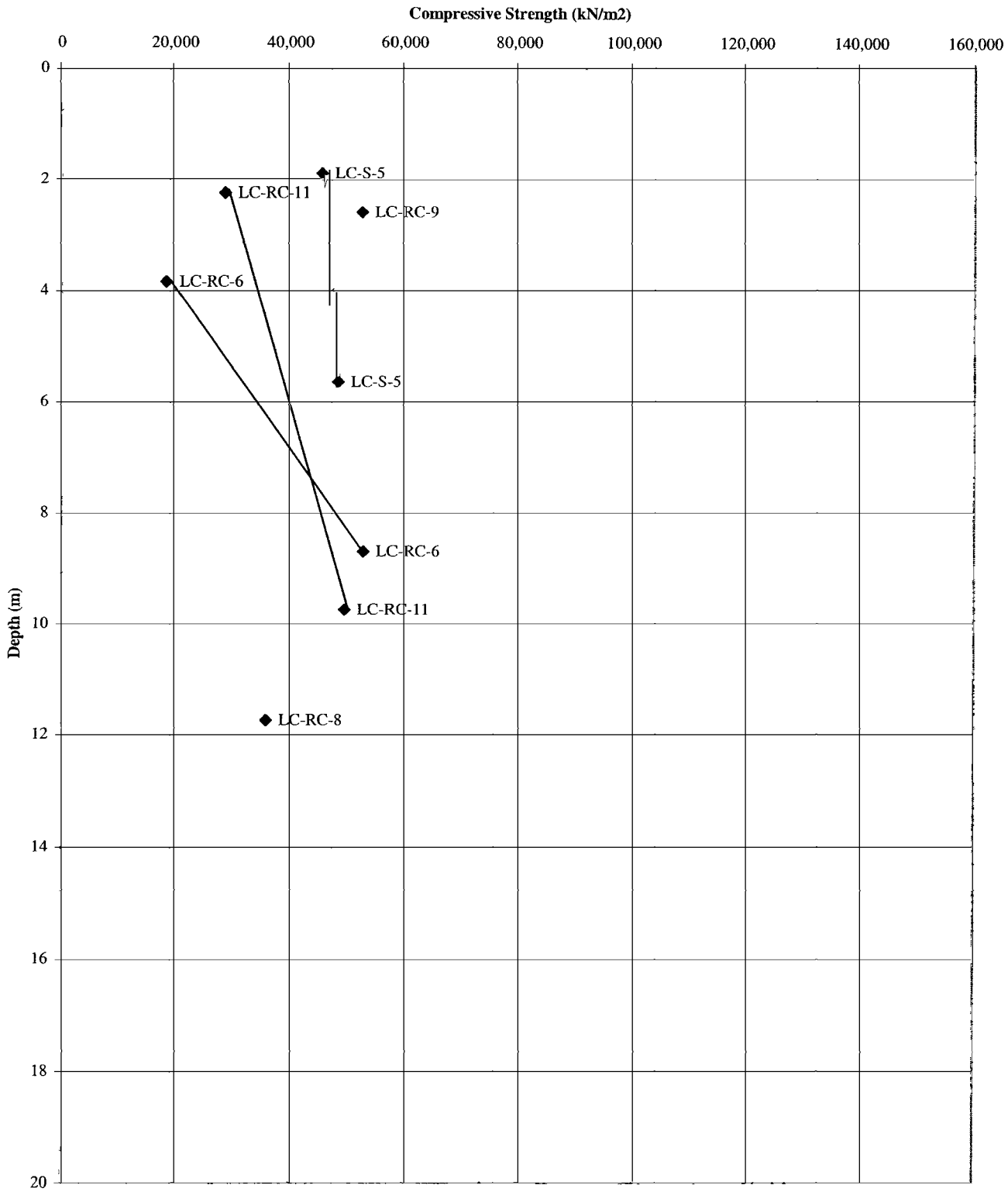


Figure 4b

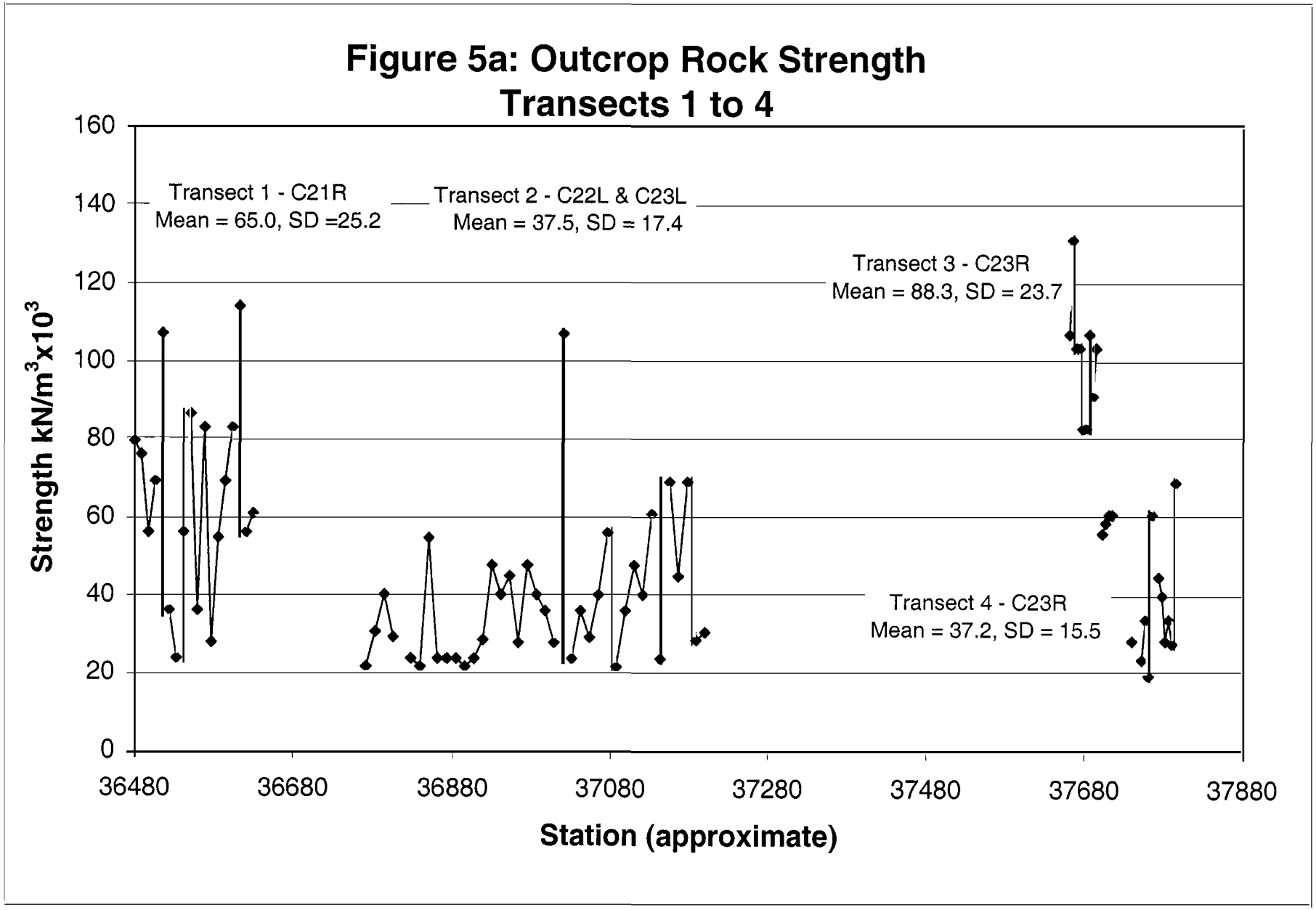


Figure 5a: Outcrop Rock Strength
Transects 1 to 4
Transect 1 - C21R
Mean = 65.0, SD =25.2
Transect 2 - C22L & C23L
Mean = 37.5, SD = 17.4
Transect 3 - C23R
Mean = 88.3, SD = 23.7
Transect 4 - C23R
Mean = 37.2, SD = 15.5
Strength kN/m3x10^3
0
20
40
60
80
100
120
140
160
36480
36680
36880
37080
37280
37480
37680
37880
Station (approximate)

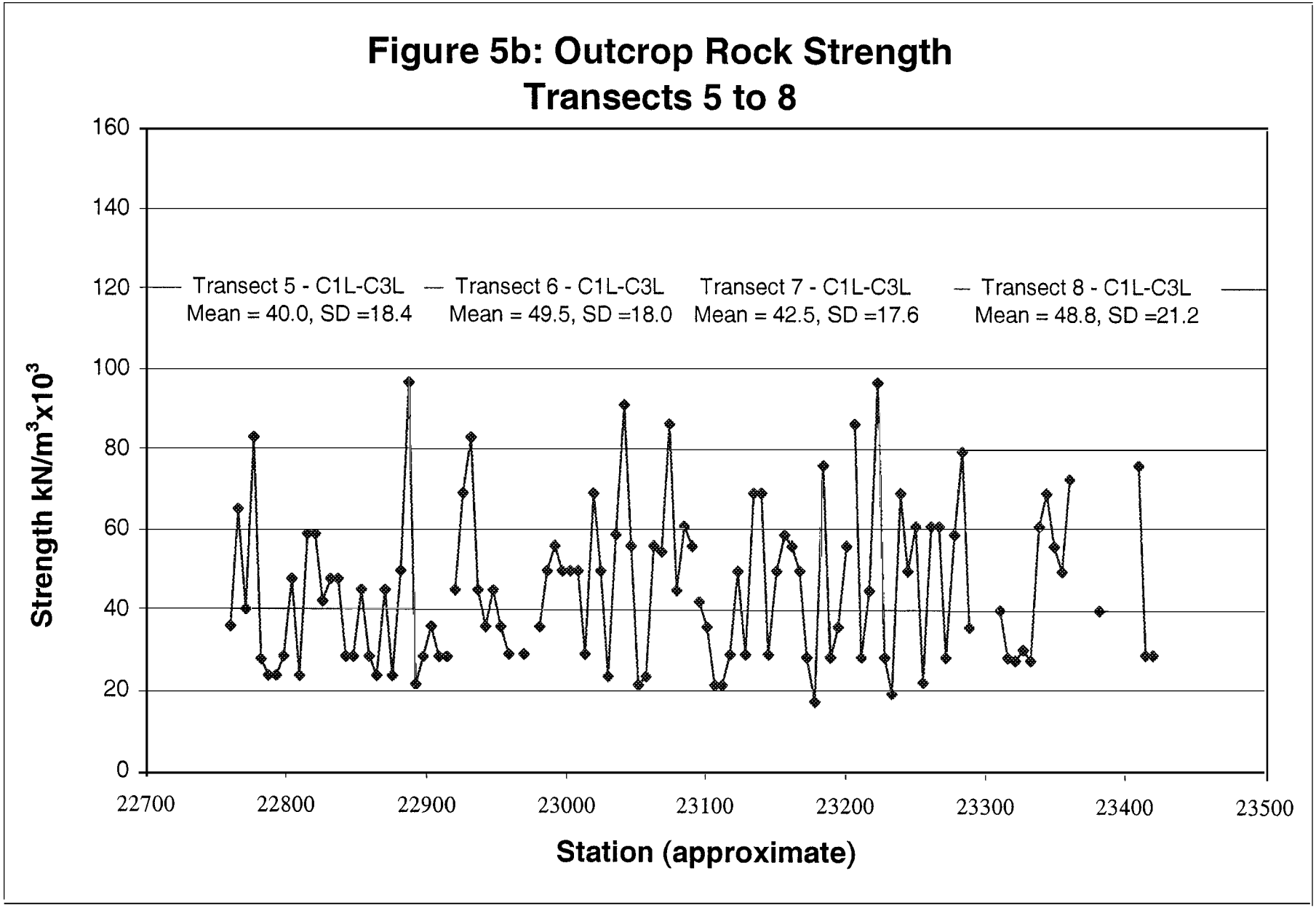
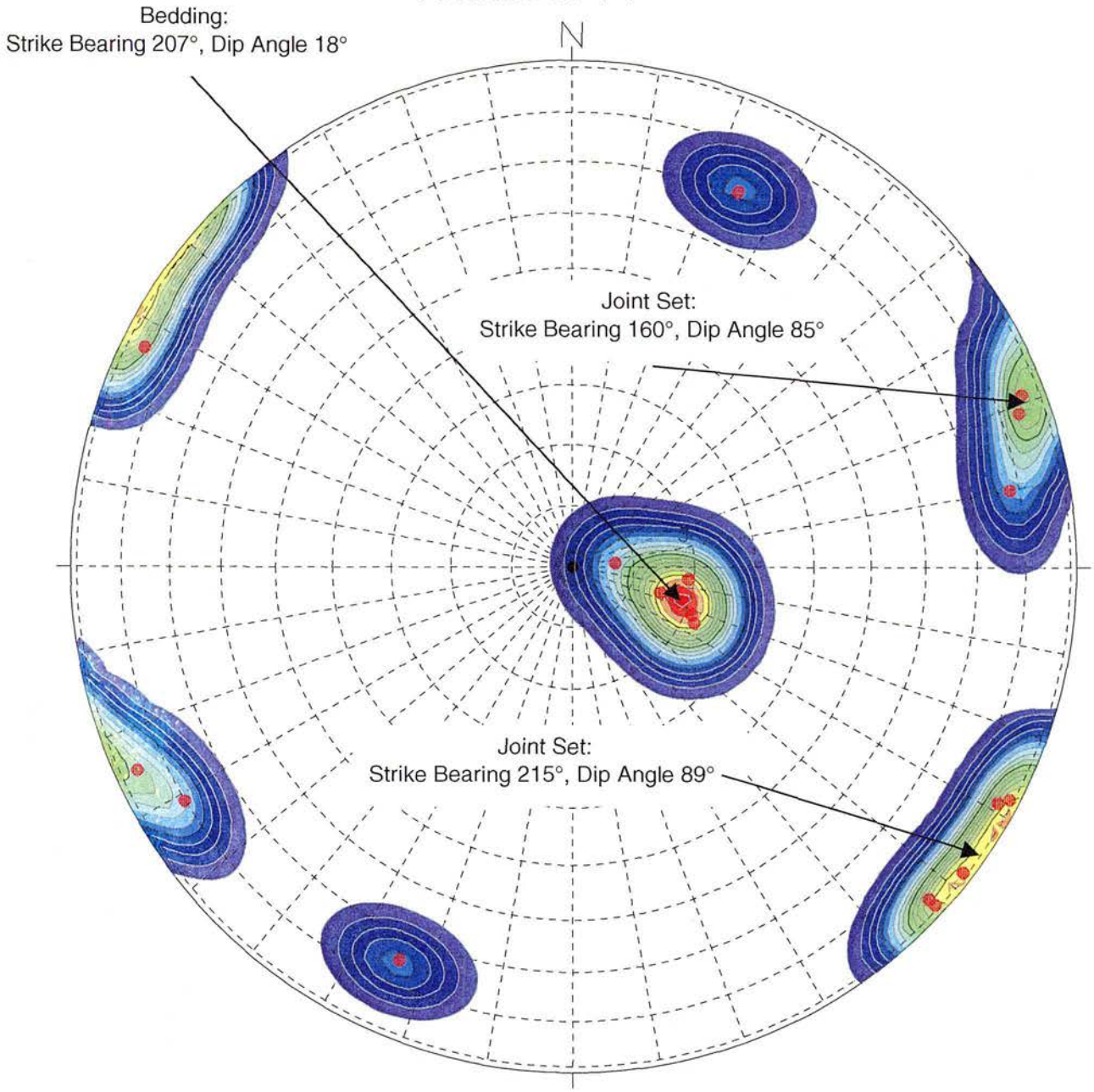


Figure 5b: Outcrop Rock Strength
Transects 5 to 8
Transect 5 - C1L-C3L
Mean = 40.0, SD =18.4
Transect 6 - C1L-C3L
Mean = 49.5, SD =18.0
Transect 7 - C1L-C3L
Mean = 42.5, SD =17.6
Transect 8 - C1L-C3L
Mean = 48.8, SD =21.2
Strength kN/m3x10^3
0
20
40
60
80
100
120
140
160
22700
22800
22900
23000
23100
23200
23300
23400
23500
Station (approximate)

Transect T1



18 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

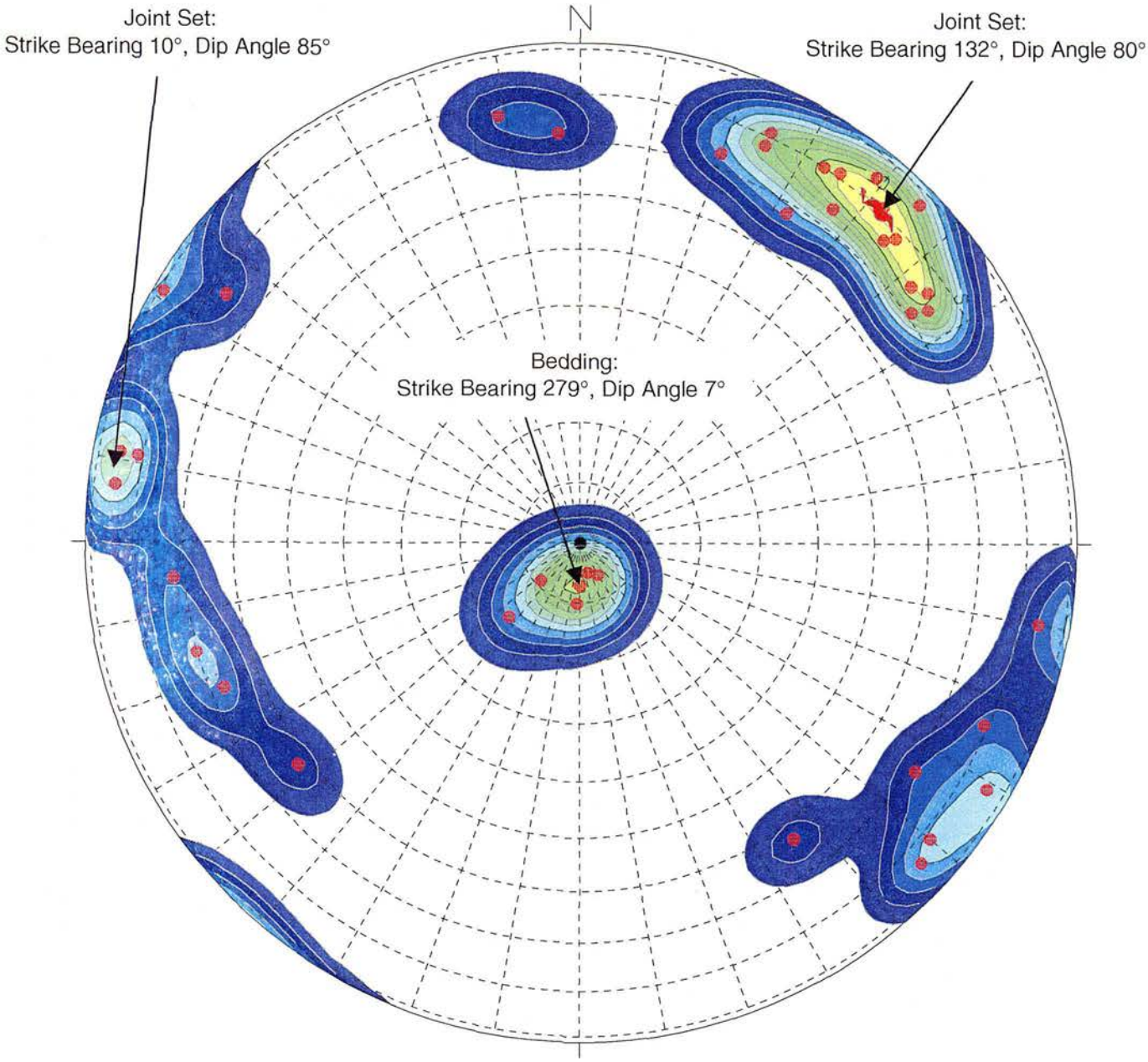
FIGURE 6a

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Transect T2



40 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6b

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
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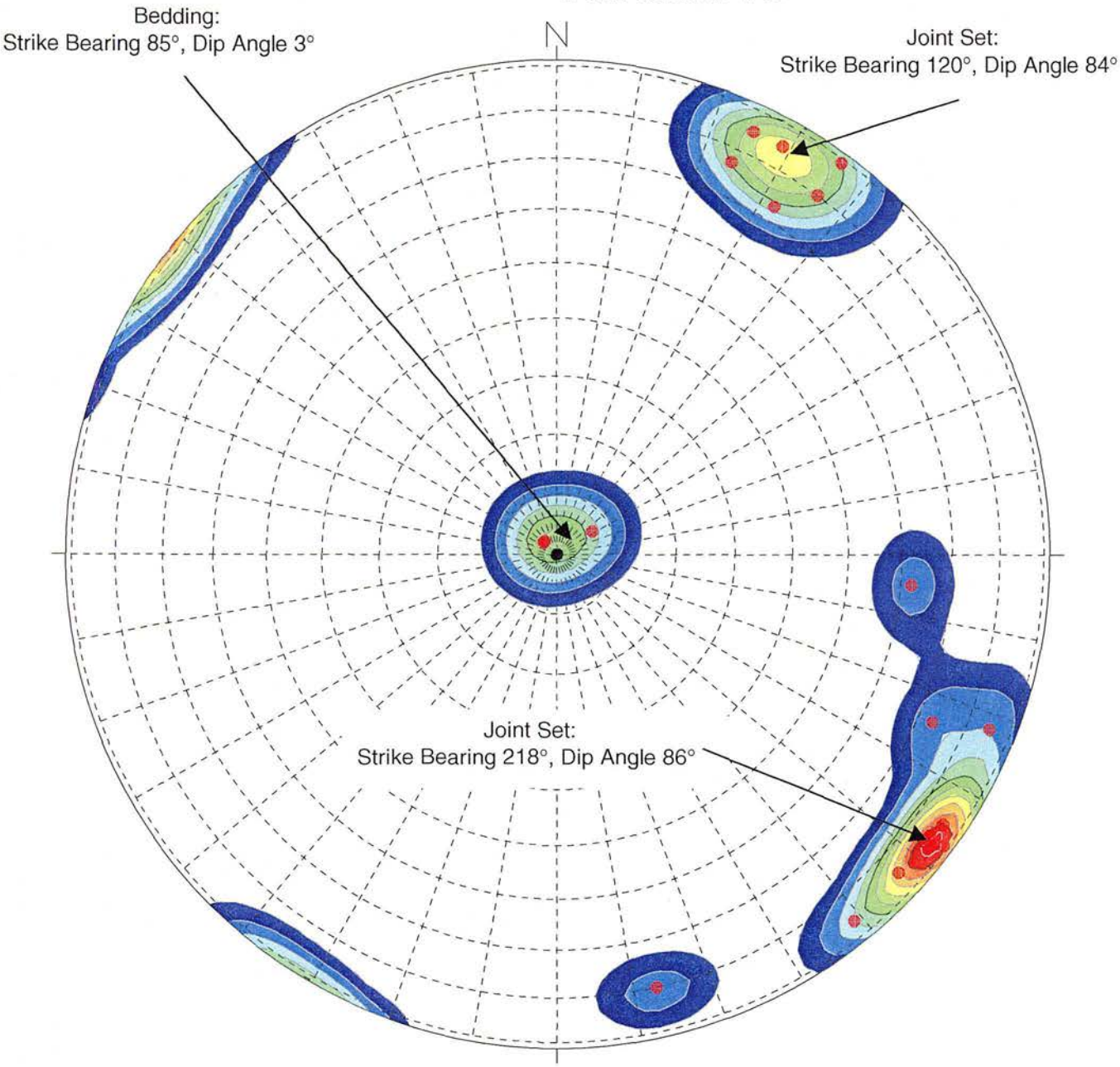
Transect T3



19 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6c

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
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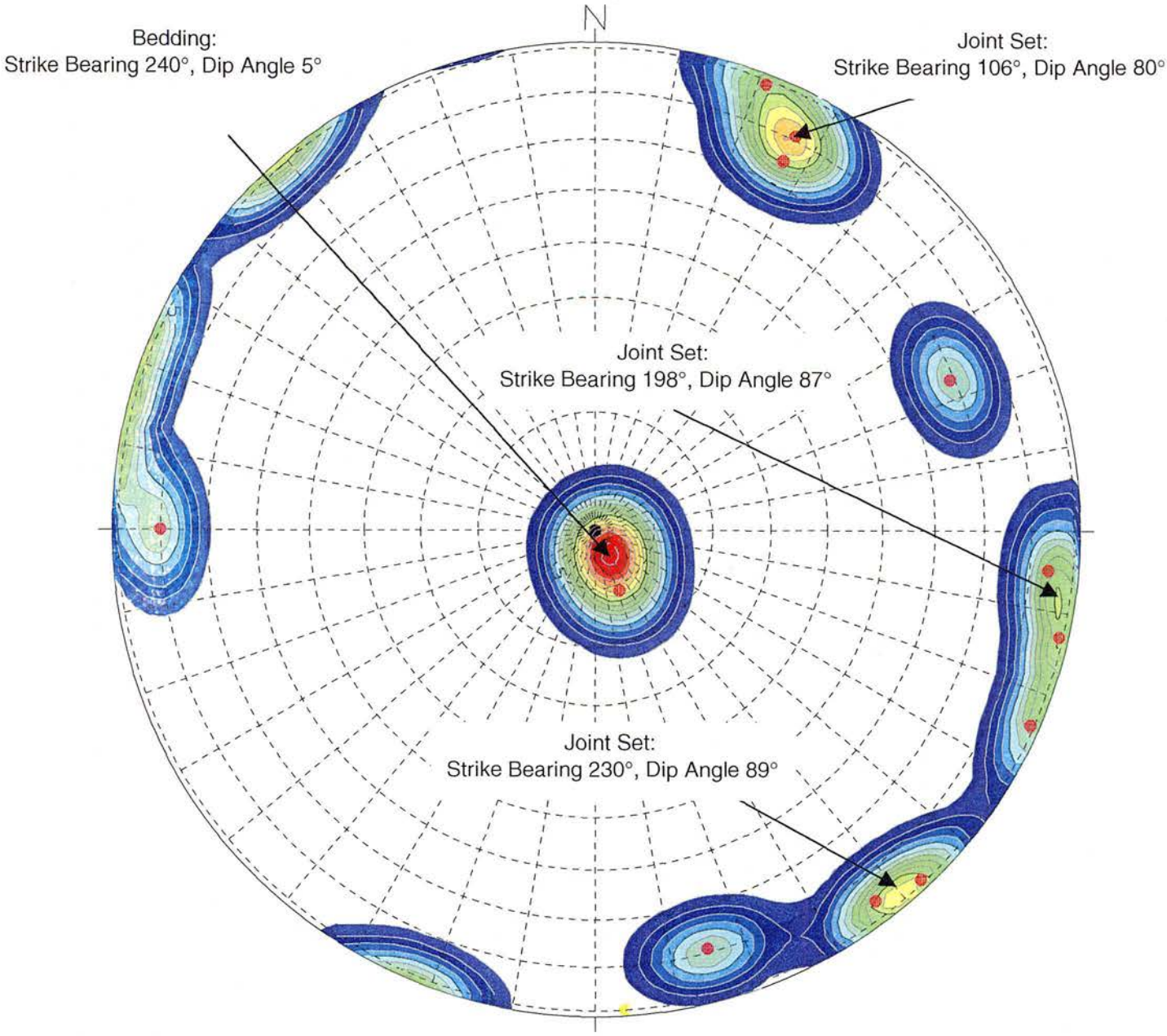
Transect T4



14 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6d

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
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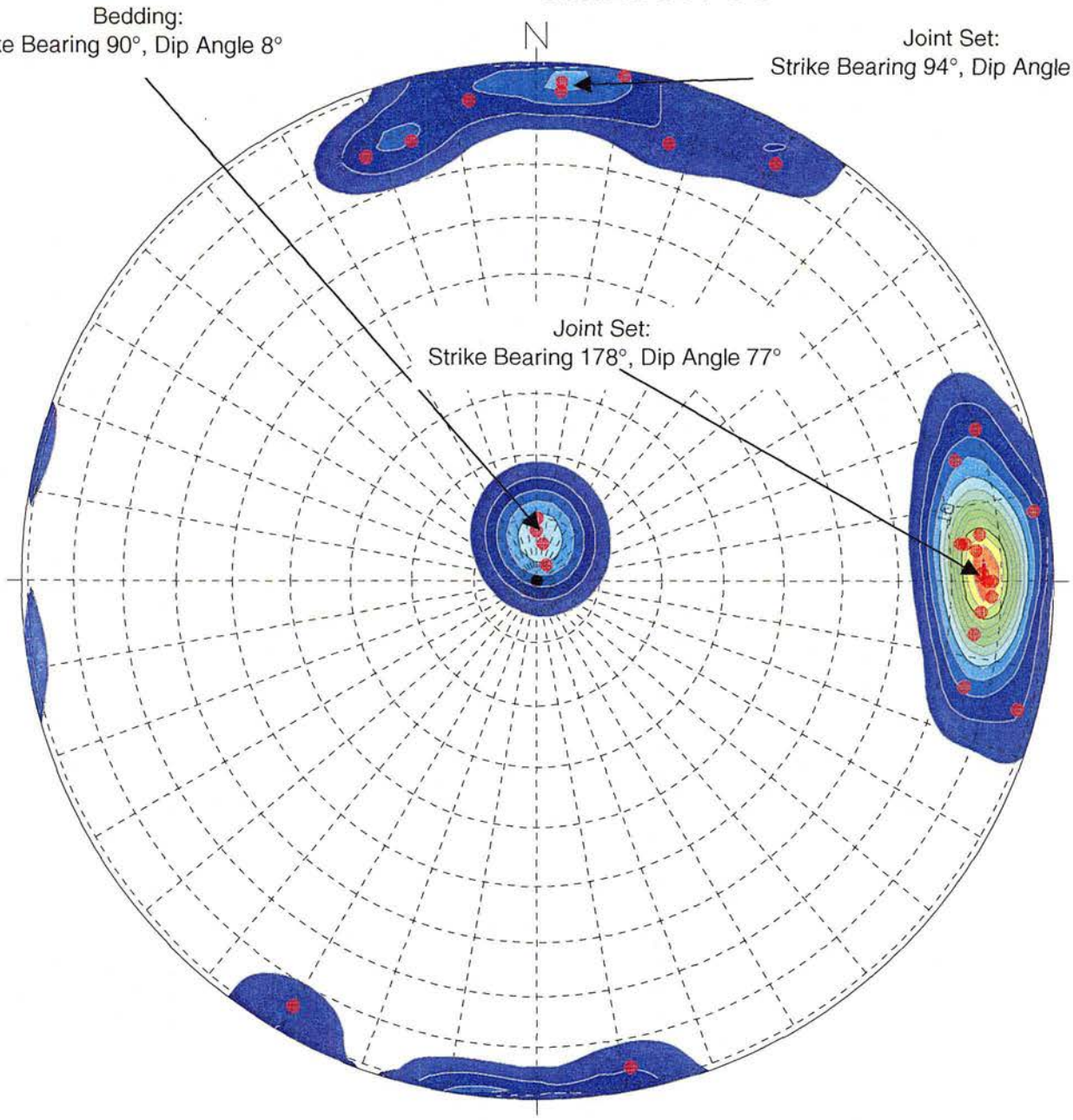
Transect T5



29 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6e

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
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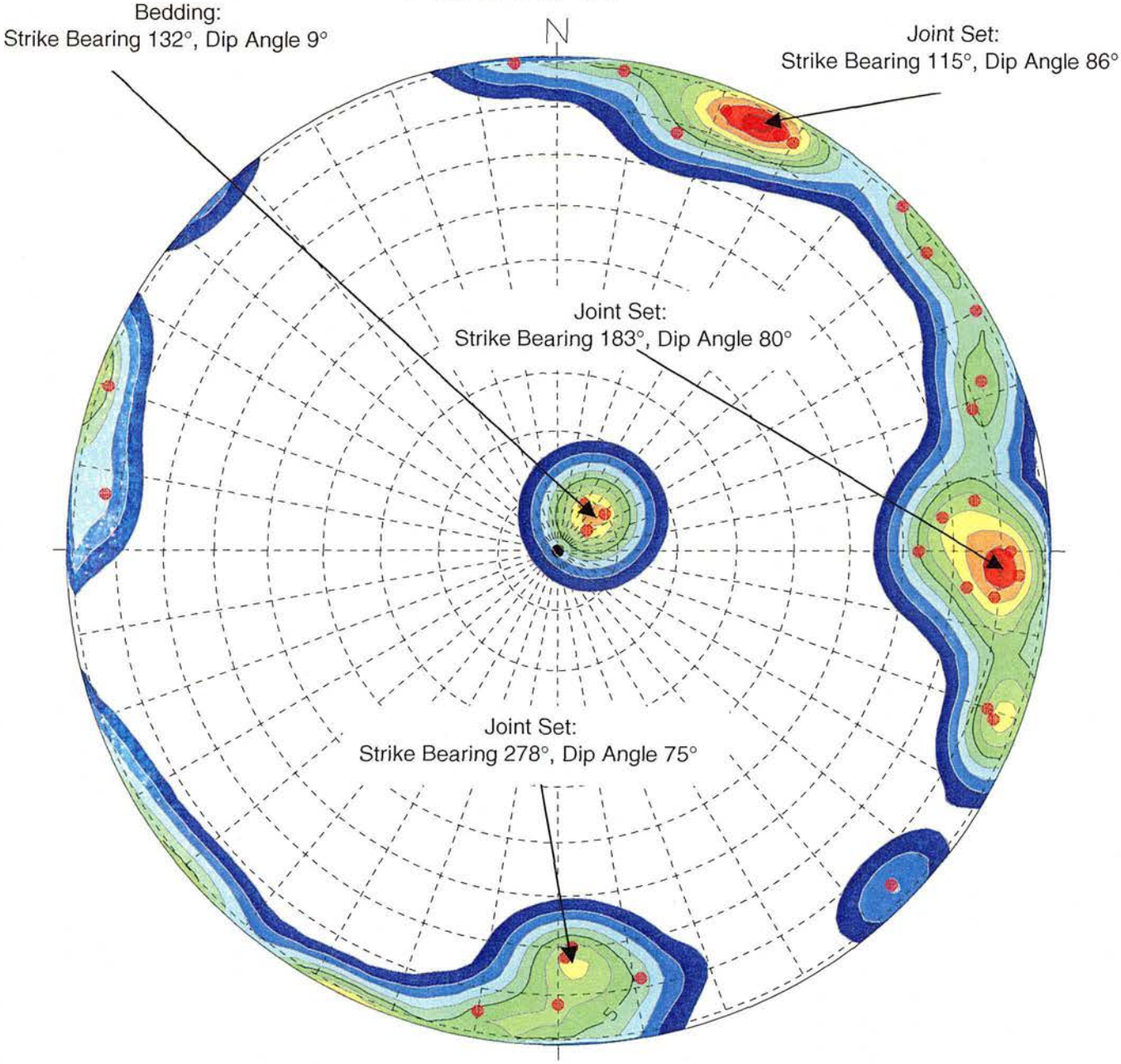
Transect T6



32 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6f

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
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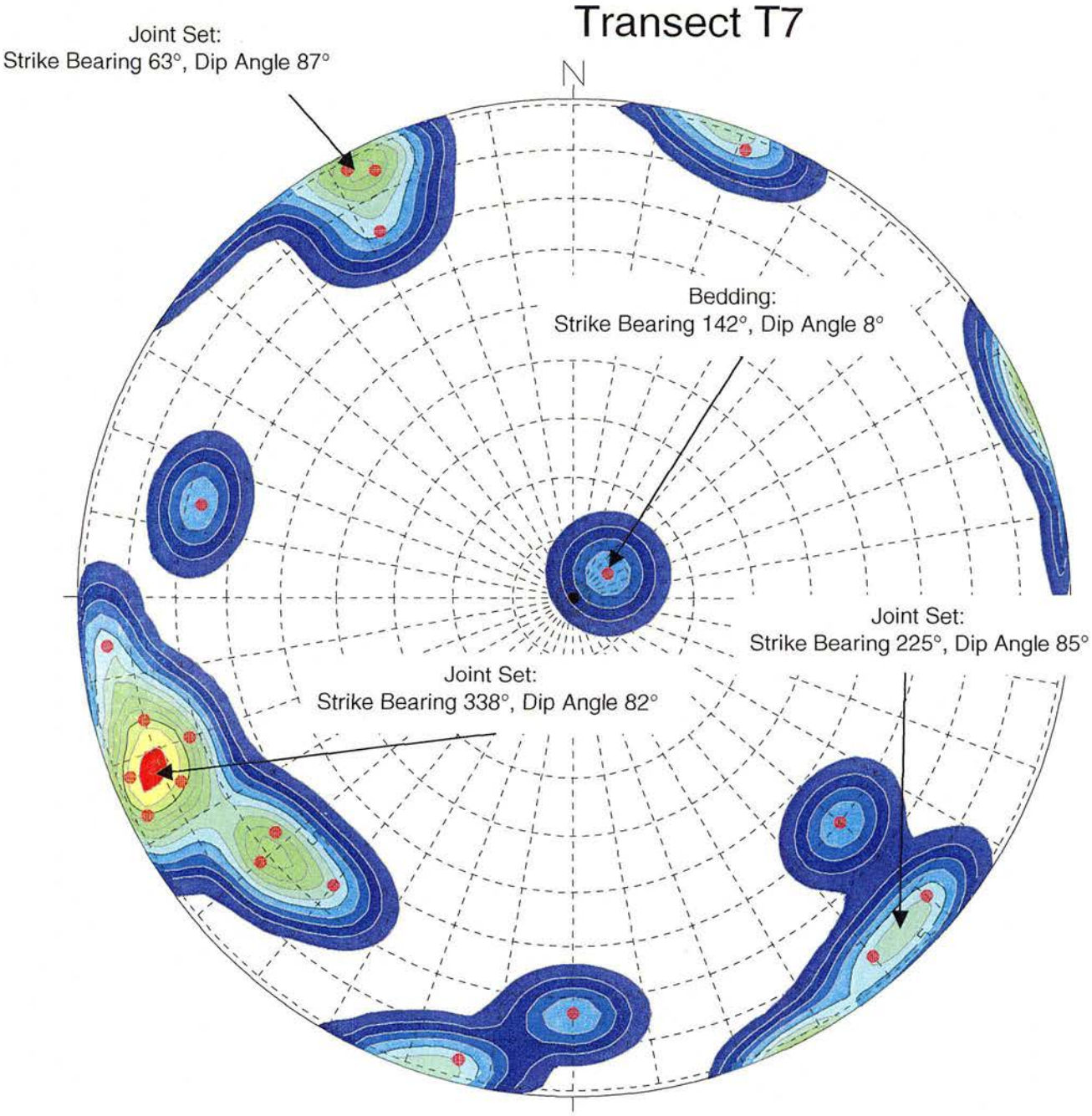

20 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6g

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Transect T8

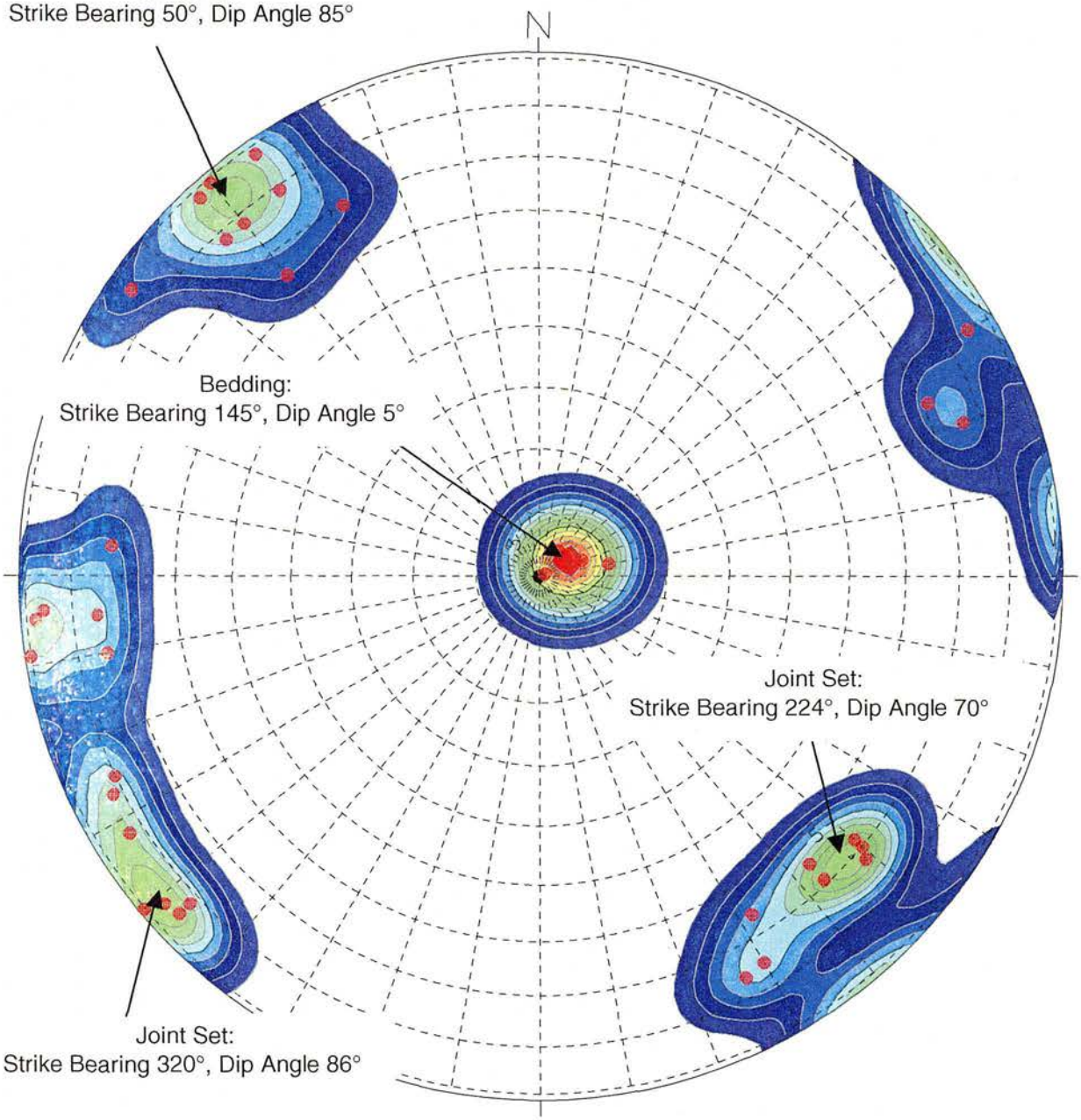

FIGURE 6h

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

40 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

DAMES & MOORE
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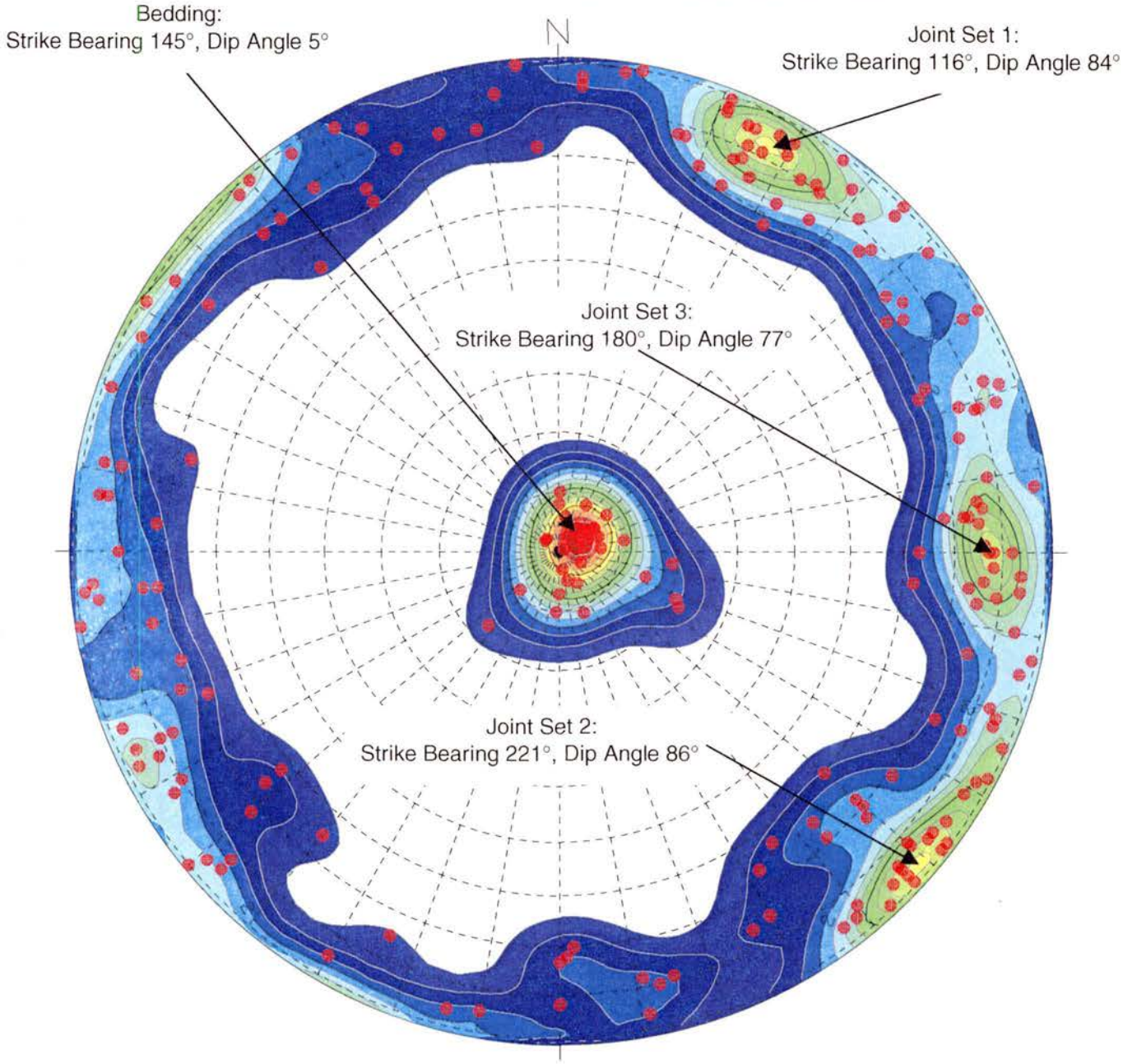
All Transect Data



212 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6i

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
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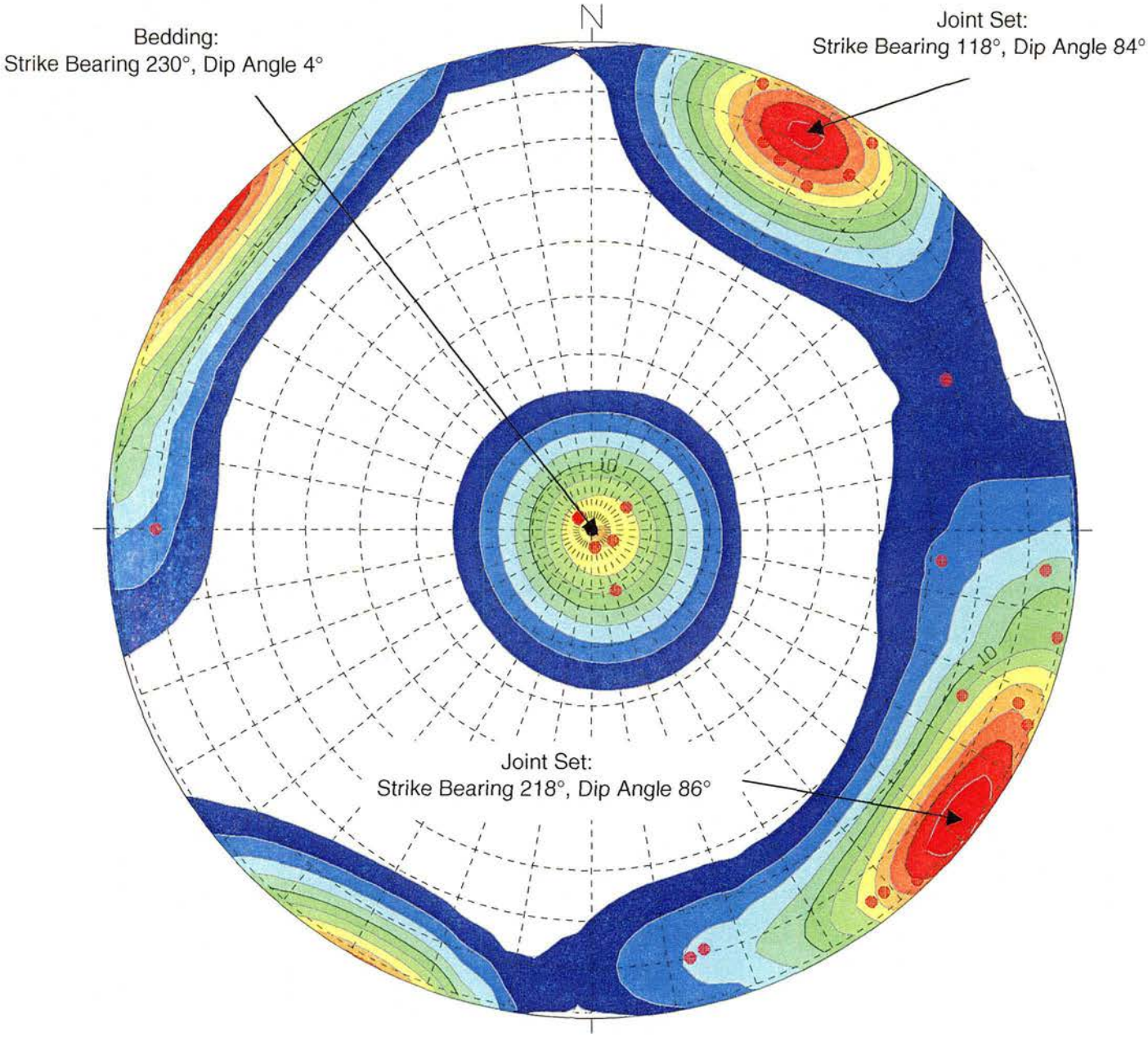
Transects 3 and 4



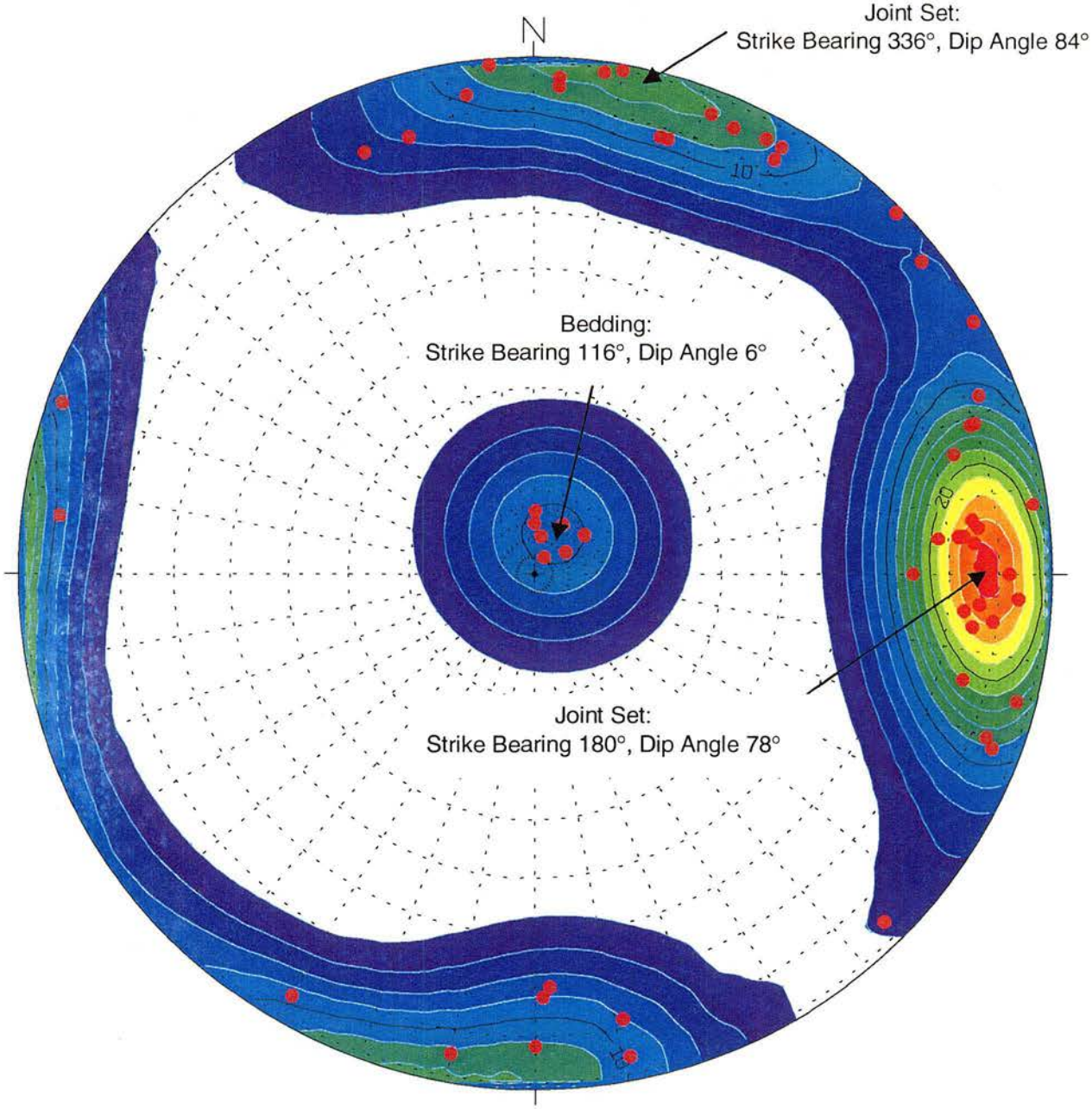
33 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

FIGURE 6j
Stereonet Analysis
Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Transects 5 and 6



61 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

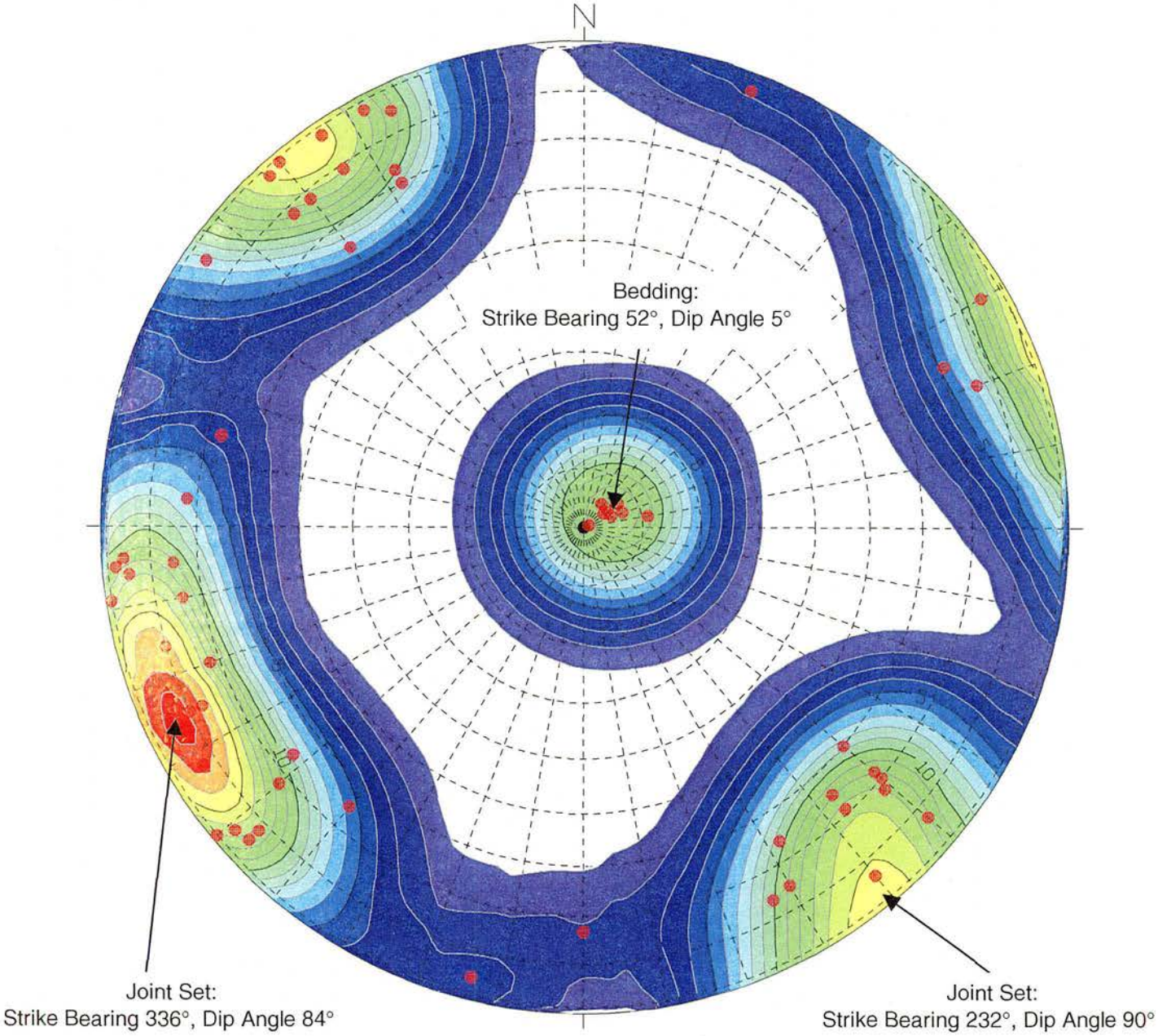
FIGURE 6k

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Transects 7 and 8



60 Sample Points
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format

Project No. 21743-030-162
September 1999

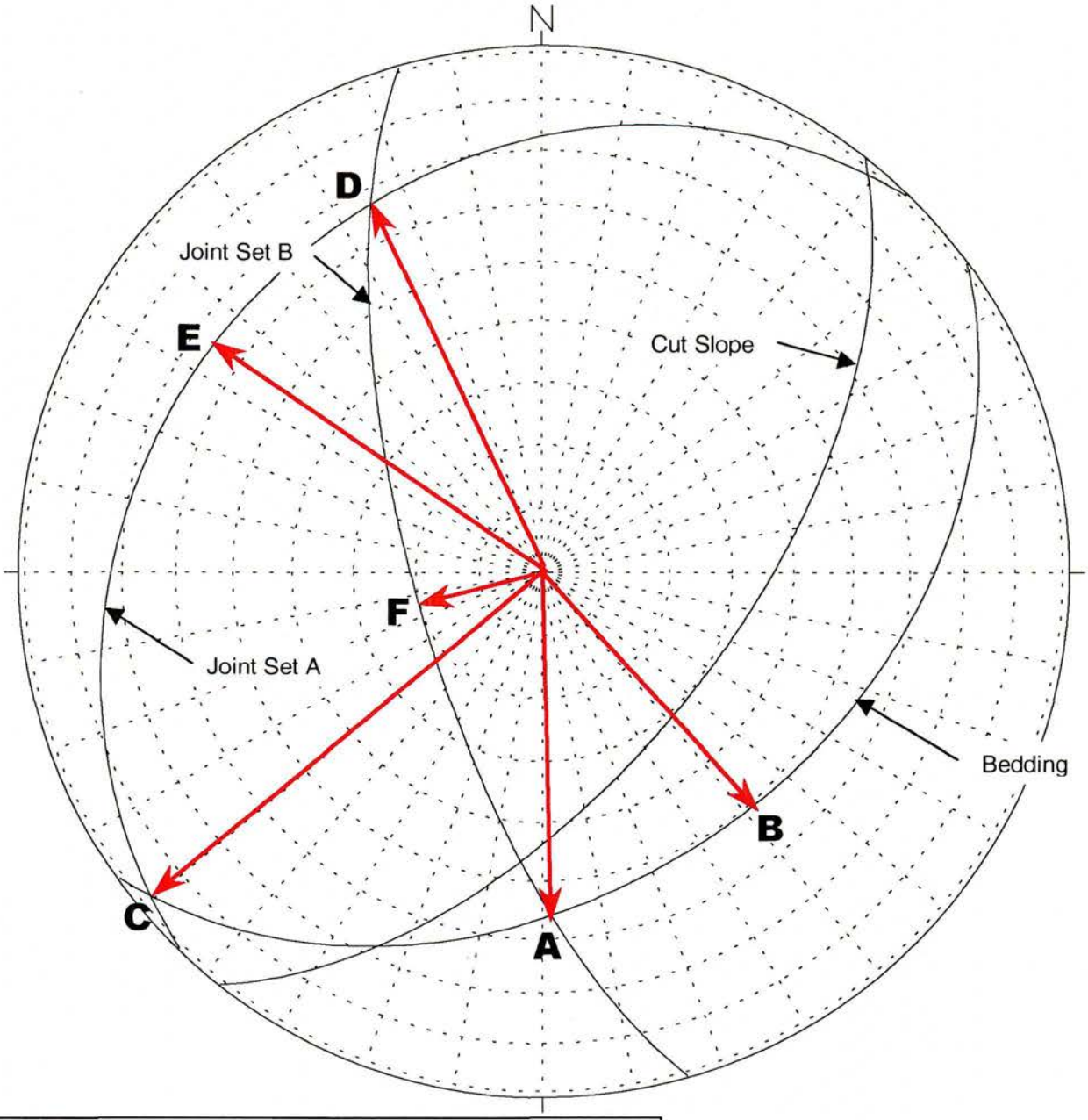
FIGURE 6I

Stereonet Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Example



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding & Joint B	Wedge	Yes
B	Bedding Plane	Plane	Yes
C	Bedding & Joint A	Wedge	No
D	Joint Sets A & B	Wedge	No
E	Joint Set A	Plane	No
F	Joint Set B	Plane	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

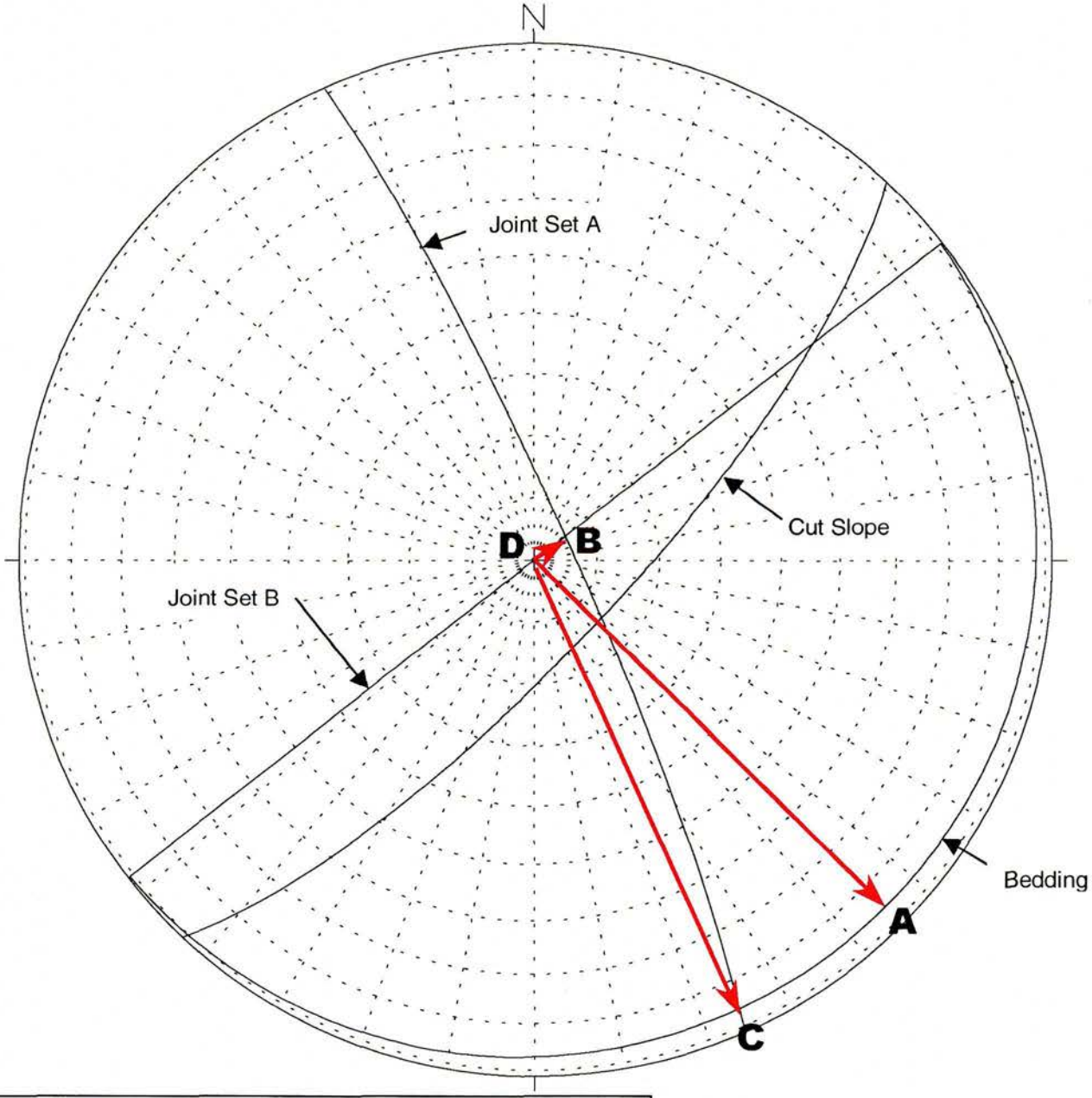
FIGURE 7

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C1L



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	Yes, but low angle
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	Yes, but low angle
D	Joint Set B	Plane	No, minor topple

FIGURE 8a

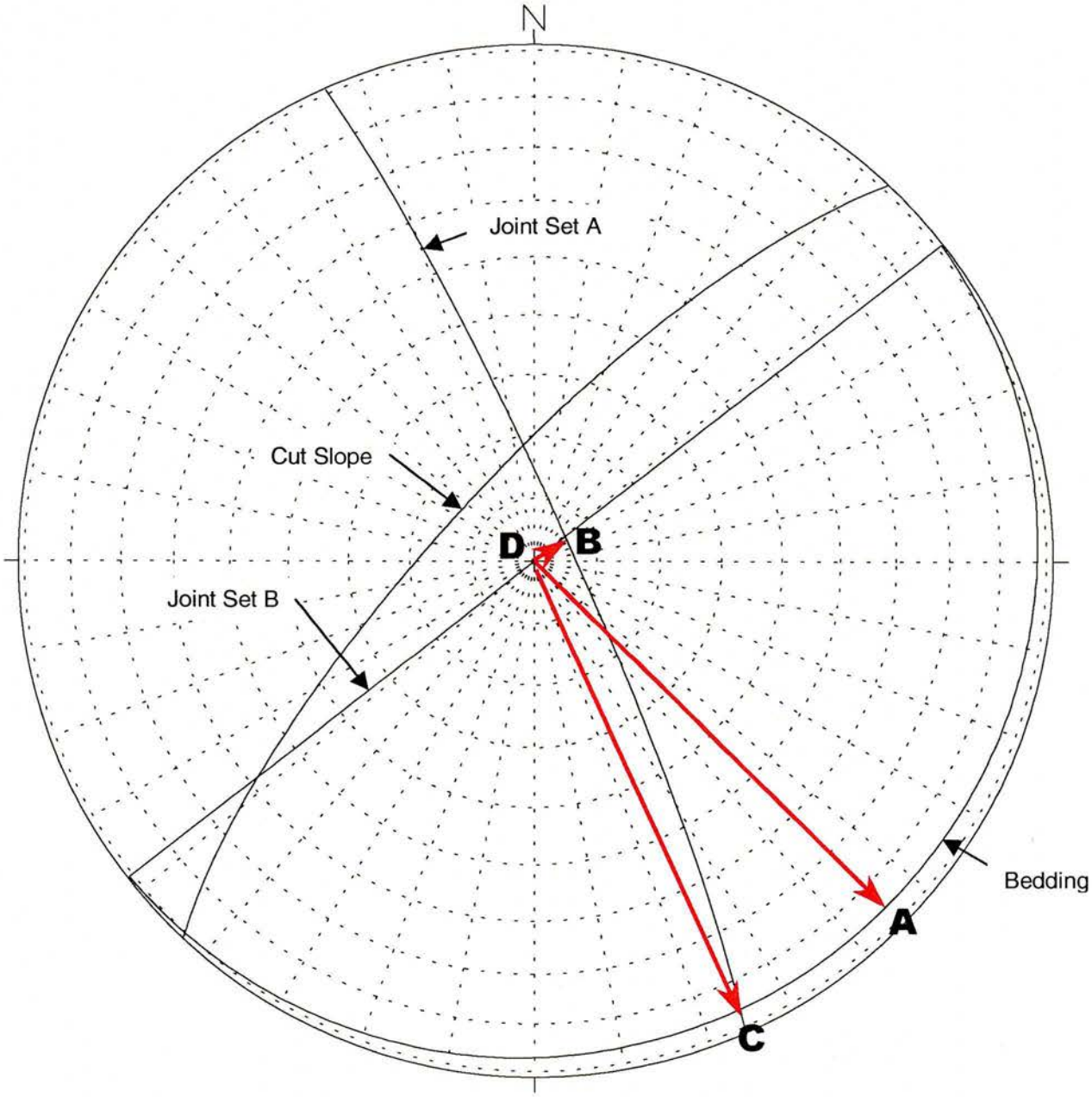
Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C1R



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	No
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	No
D	Joint Set B	Plane	No, minor topple

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

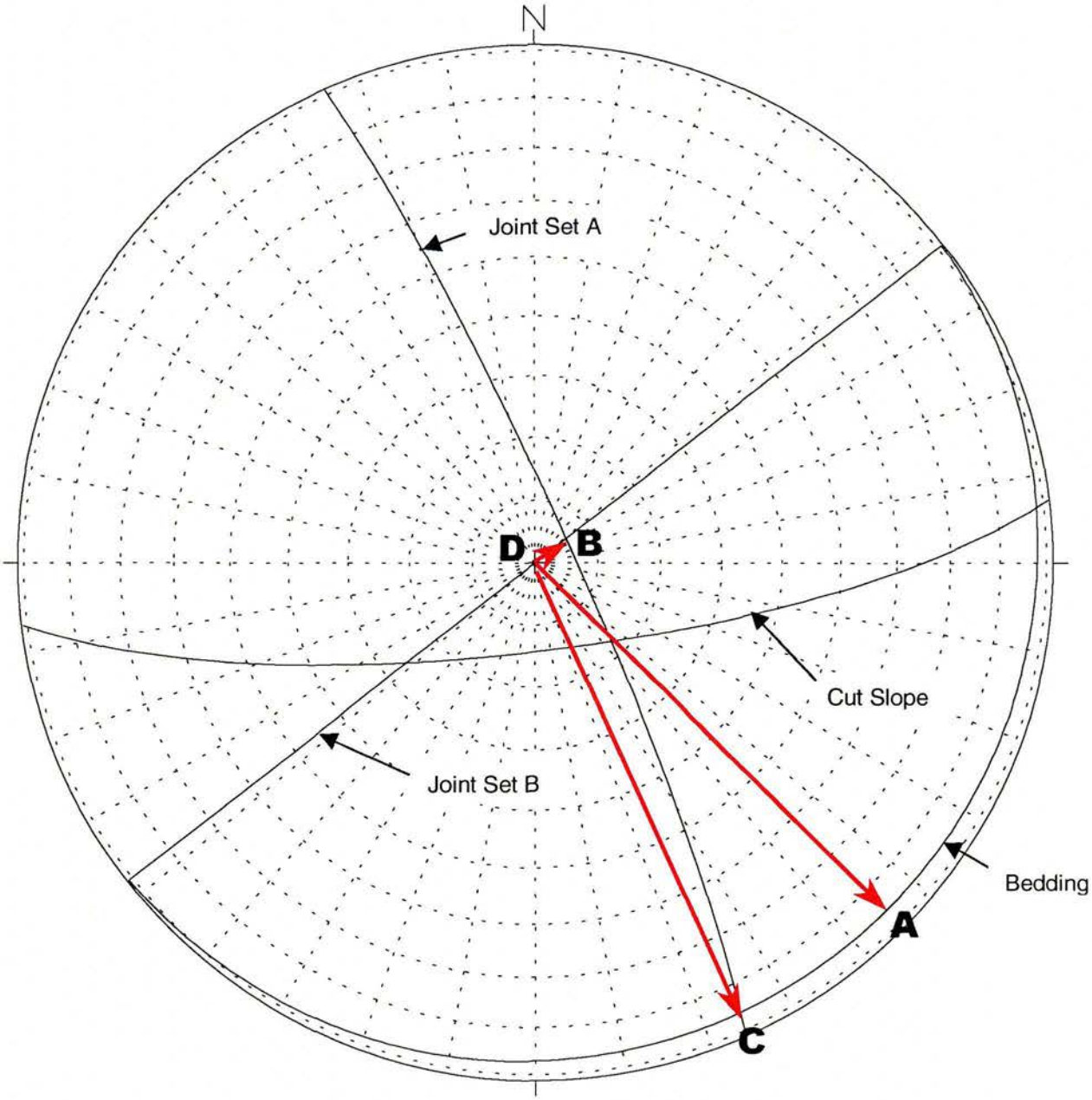
FIGURE 8b

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C2L



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	Yes, but low angle
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	Yes, but low angle
D	Joint Set B	Plane	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

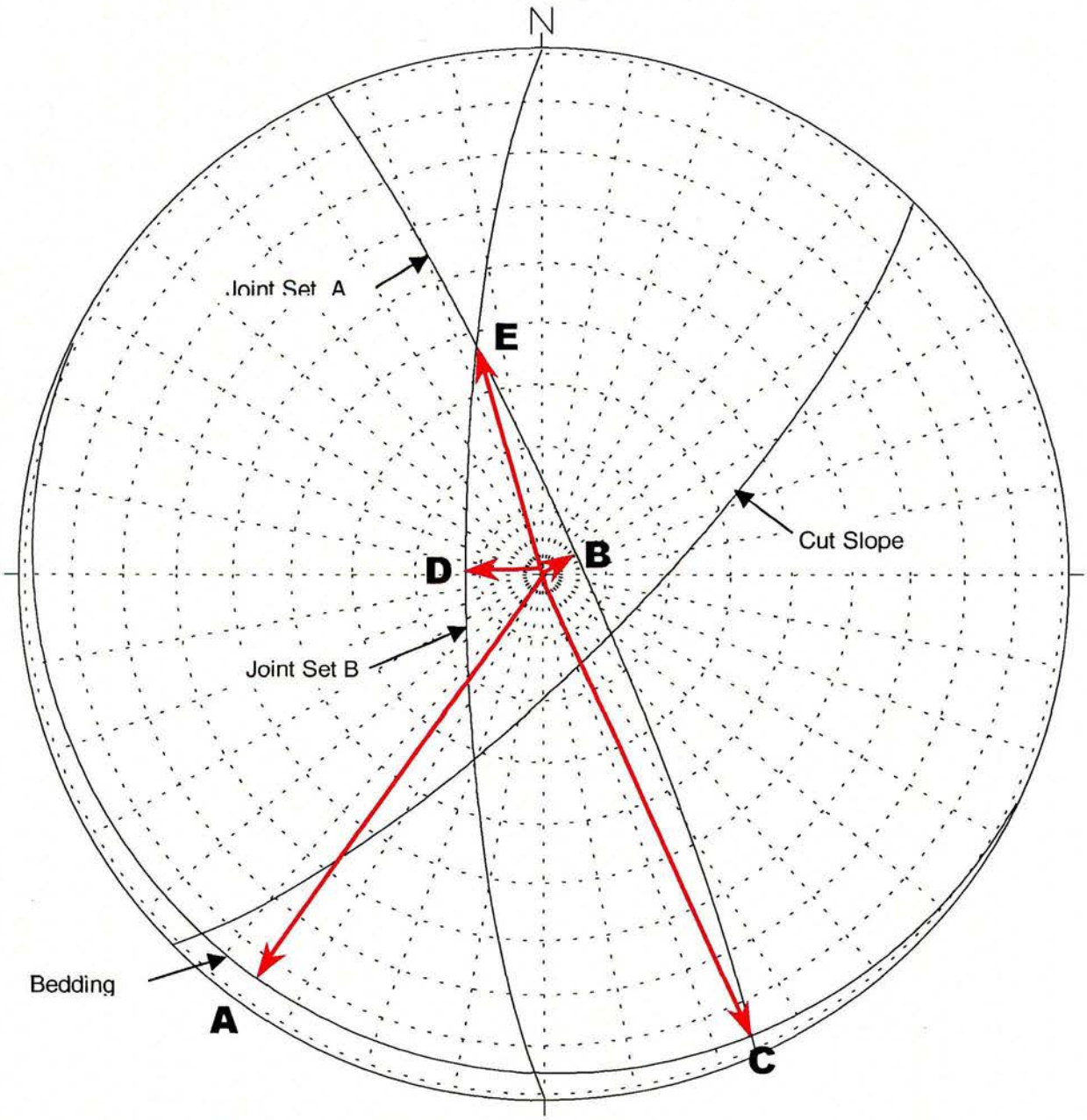
FIGURE 8c

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C3L



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	No
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	Yes, but low angle
D	Joint Set B	Plane	No
E	Joint Sets A & B	Wedge	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

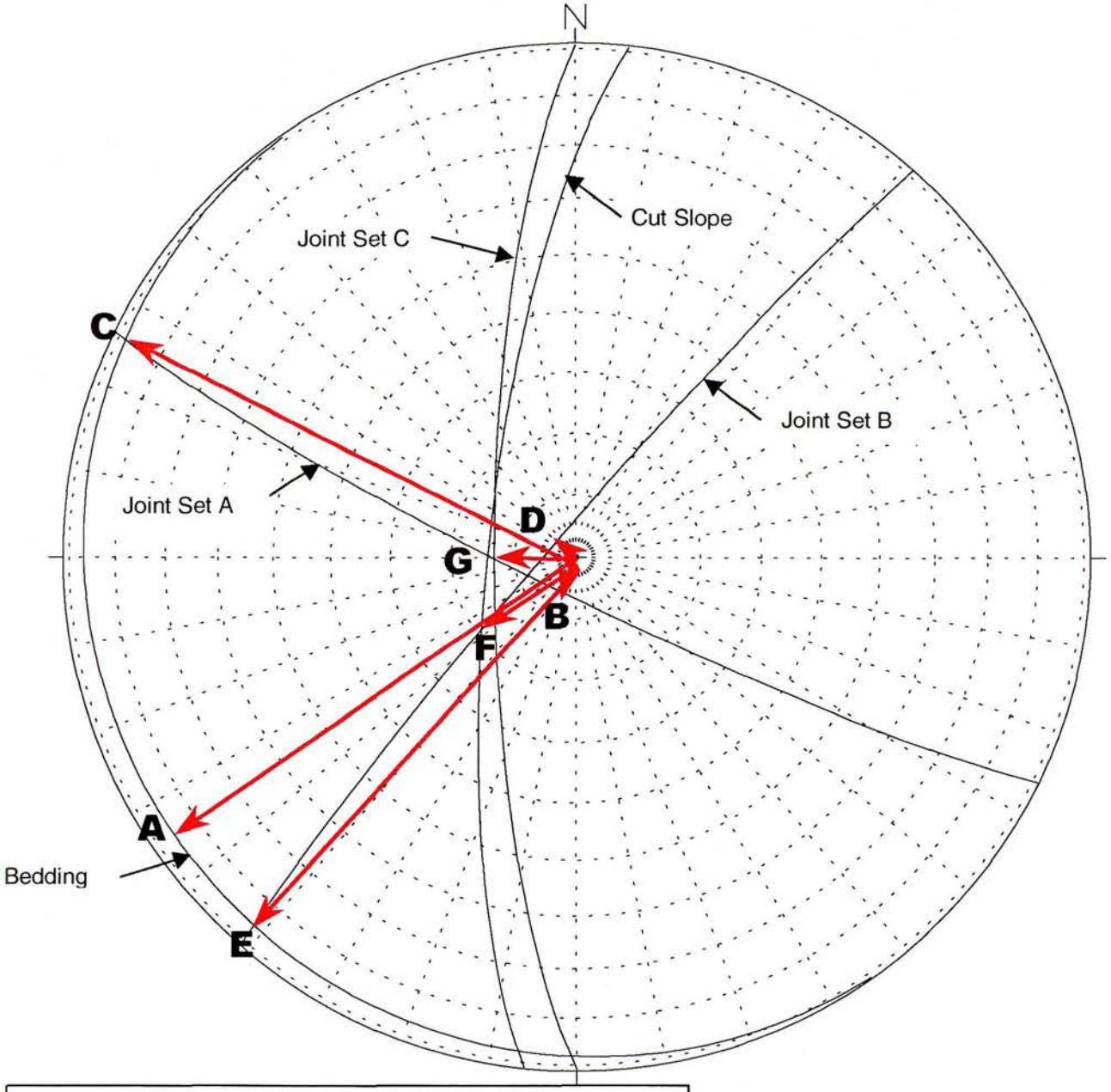
FIGURE 8d

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C15R



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	Yes, but low angle
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	Yes, but low angle
D	Joint Set B	Plane	No
E	Bedding & Joint Set B	Wedge	Yes, but low angle
F	Joint Sets A & B	Wedge	Yes
G	Joint Set C	Plane	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

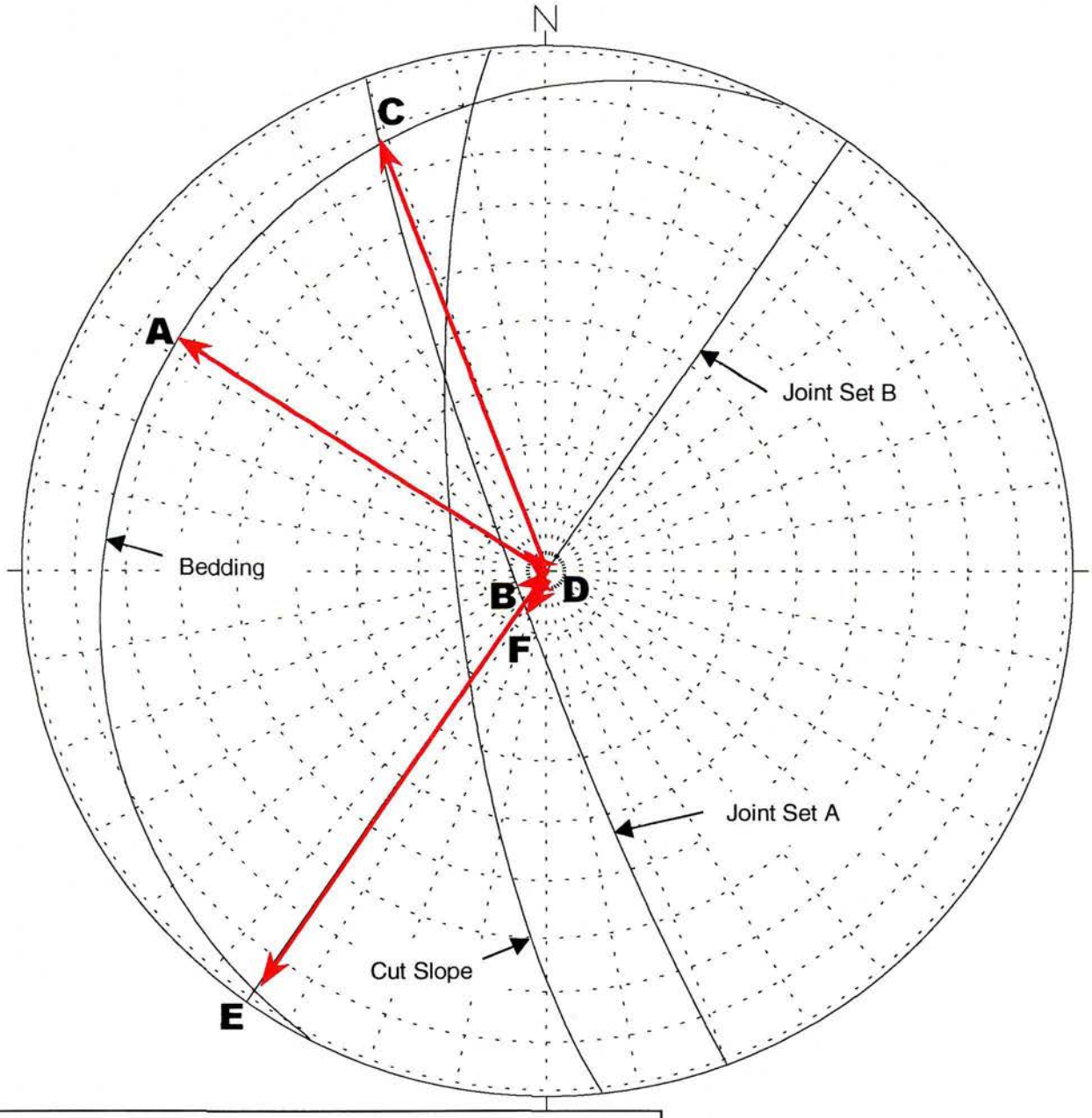
FIGURE 8e

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C21R



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	Yes, but low angle
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	Yes, but low angle
D	Joint Set B	Plane	No
E	Bedding & Joint Set B	Wedge	Yes, but low angle
F	Joint Sets A & B	Wedge	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

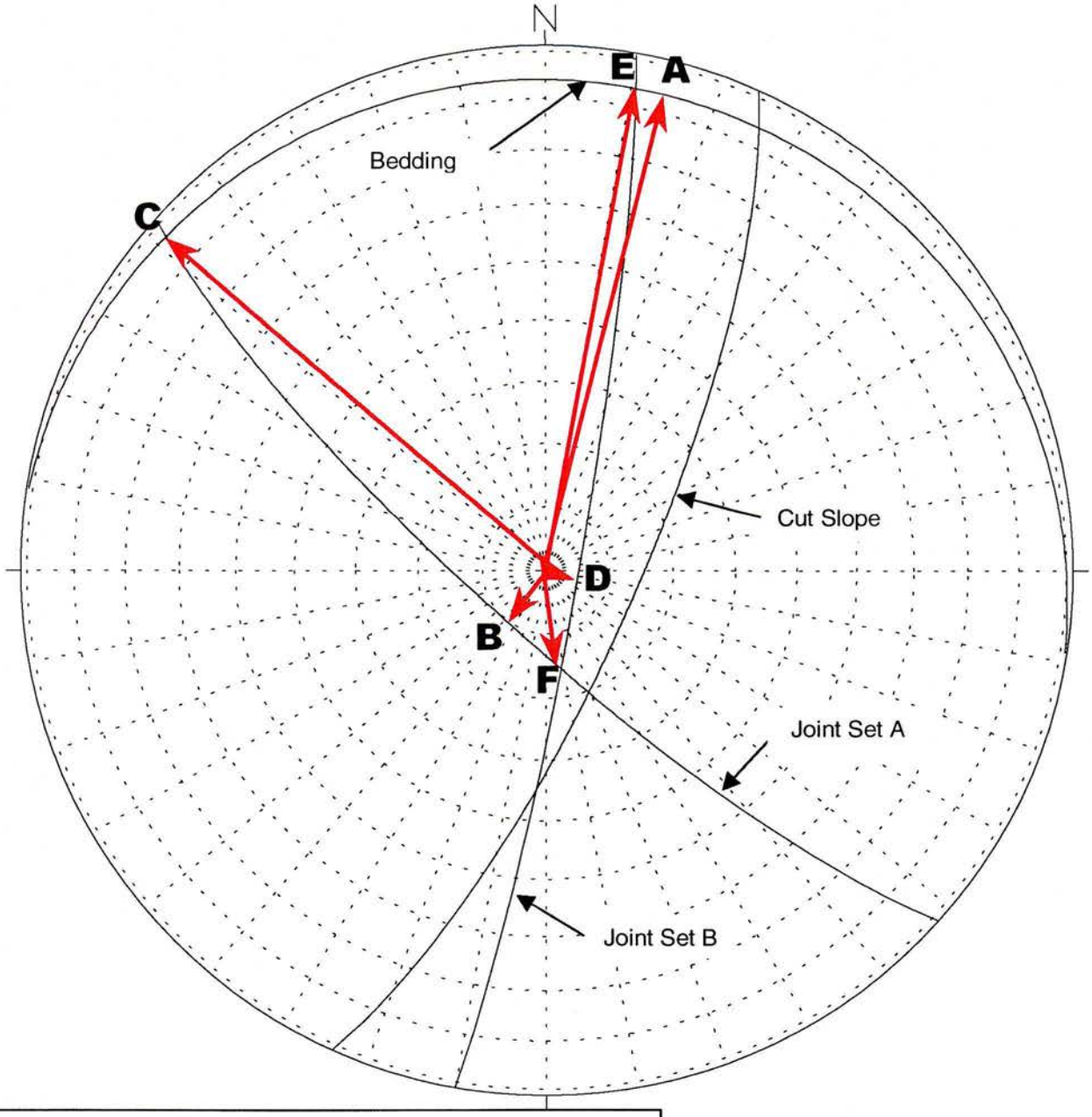
FIGURE 8f

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C22L



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	No
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	No
D	Joint Set B	Plane	No
E	Bedding & Joint Set B	Wedge	No
F	Joint Sets A & B	Wedge	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

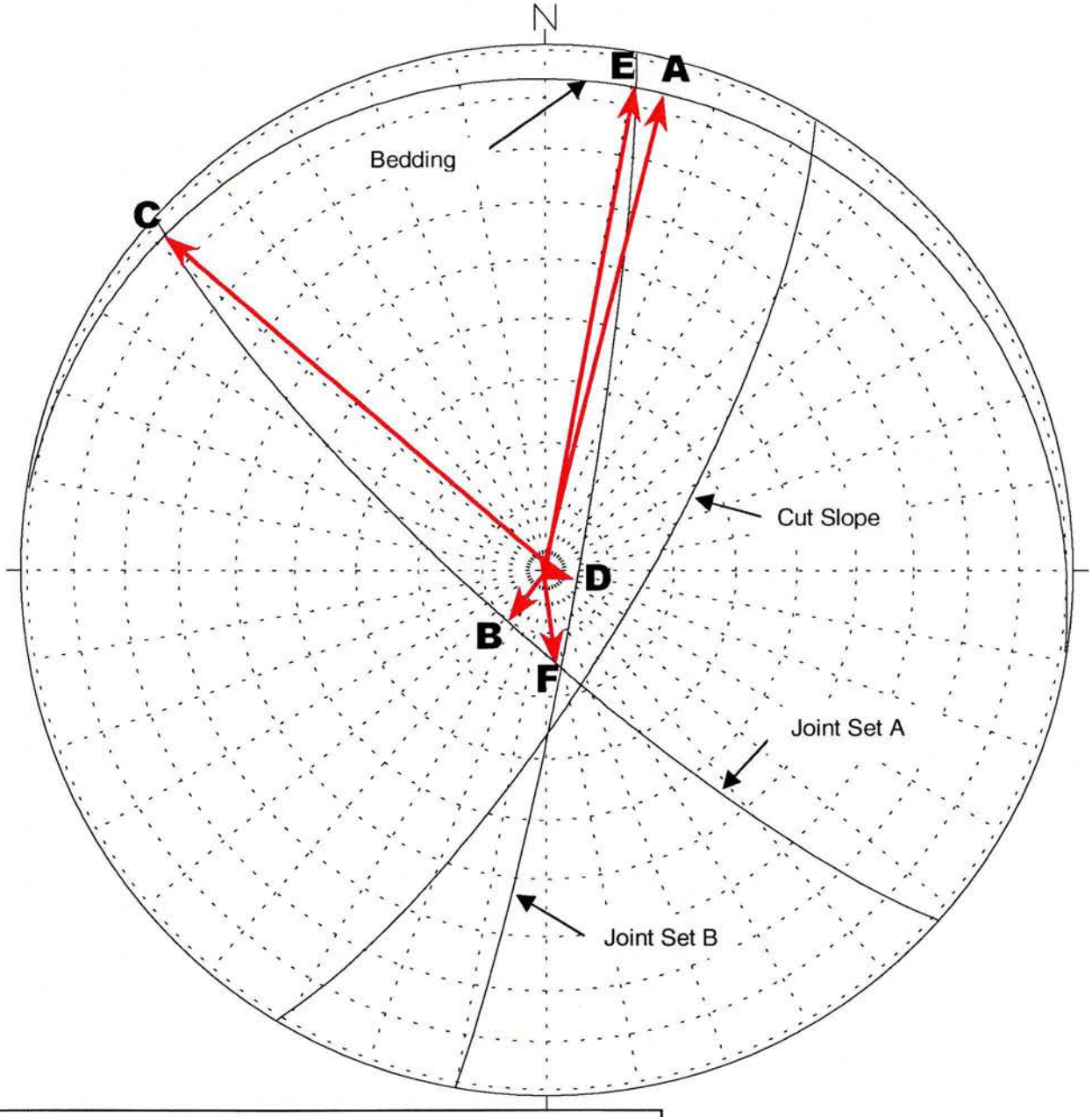
FIGURE 8g

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C23L



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	No
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	No
D	Joint Set B	Plane	No
E	Bedding & Joint Set B	Wedge	No
F	Joint Sets A & B	Wedge	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

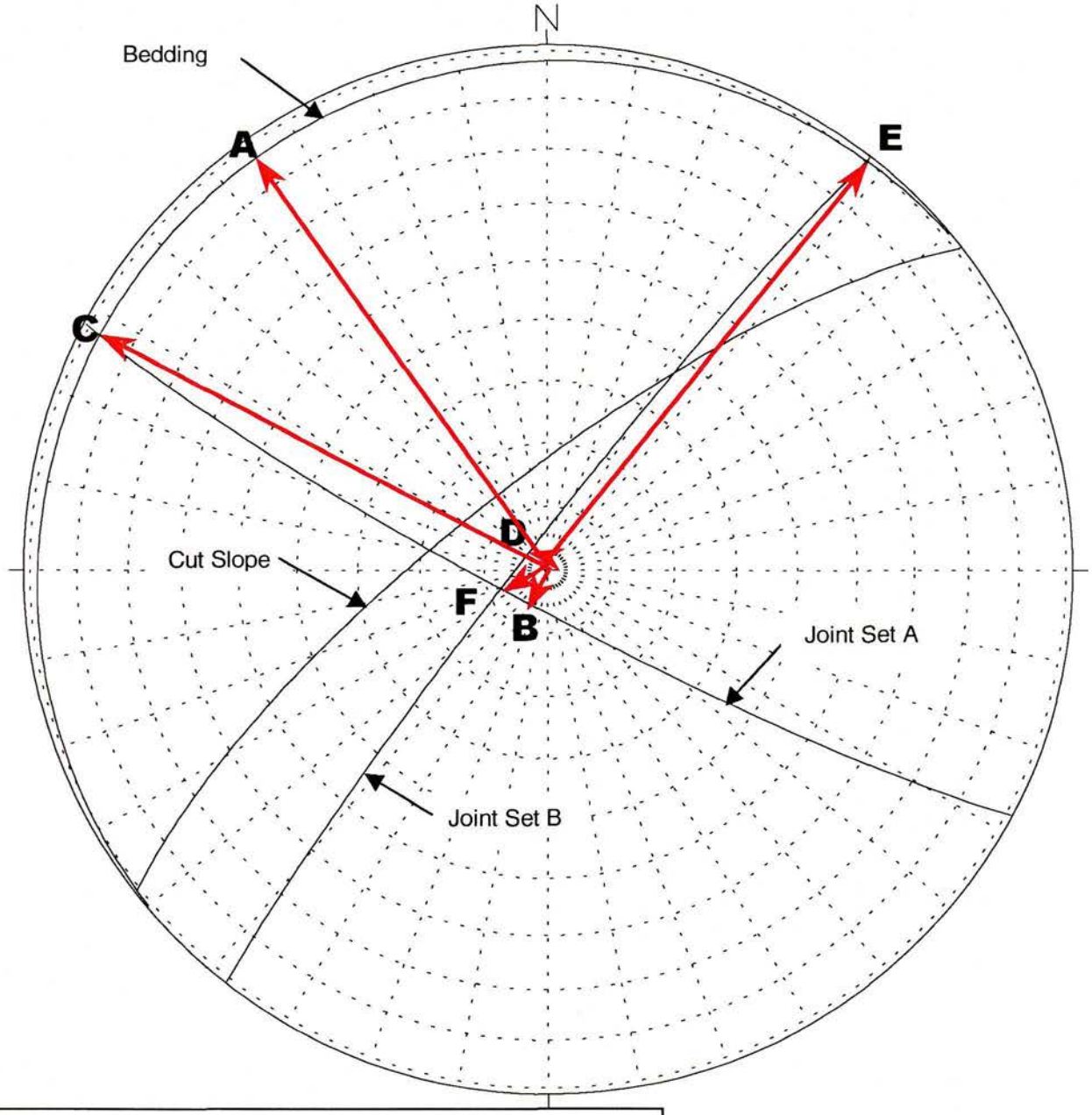
FIGURE 8h

Failure Mode Analysis

Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Failure Mode Analysis Cut C23R



Feature	Discontinuities	Failure Mode	Is Slope Undercut?
A	Bedding Plane	Plane	Yes, but low angle
B	Joint Set A	Plane	No
C	Bedding & Joint A	Wedge	No
D	Joint Set B	Plane	No
E	Bedding & Joint Set B	Wedge	Yes, but low angle
F	Joint Sets A & B	Wedge	No

Great Circle Representations
Schmidt (Equal Area) Projection
Lower Hemisphere
All Orientations Given in Right-Hand Rule Format
Project No. 21743-030-162
September 1999

FIGURE 8i

Failure Mode Analysis

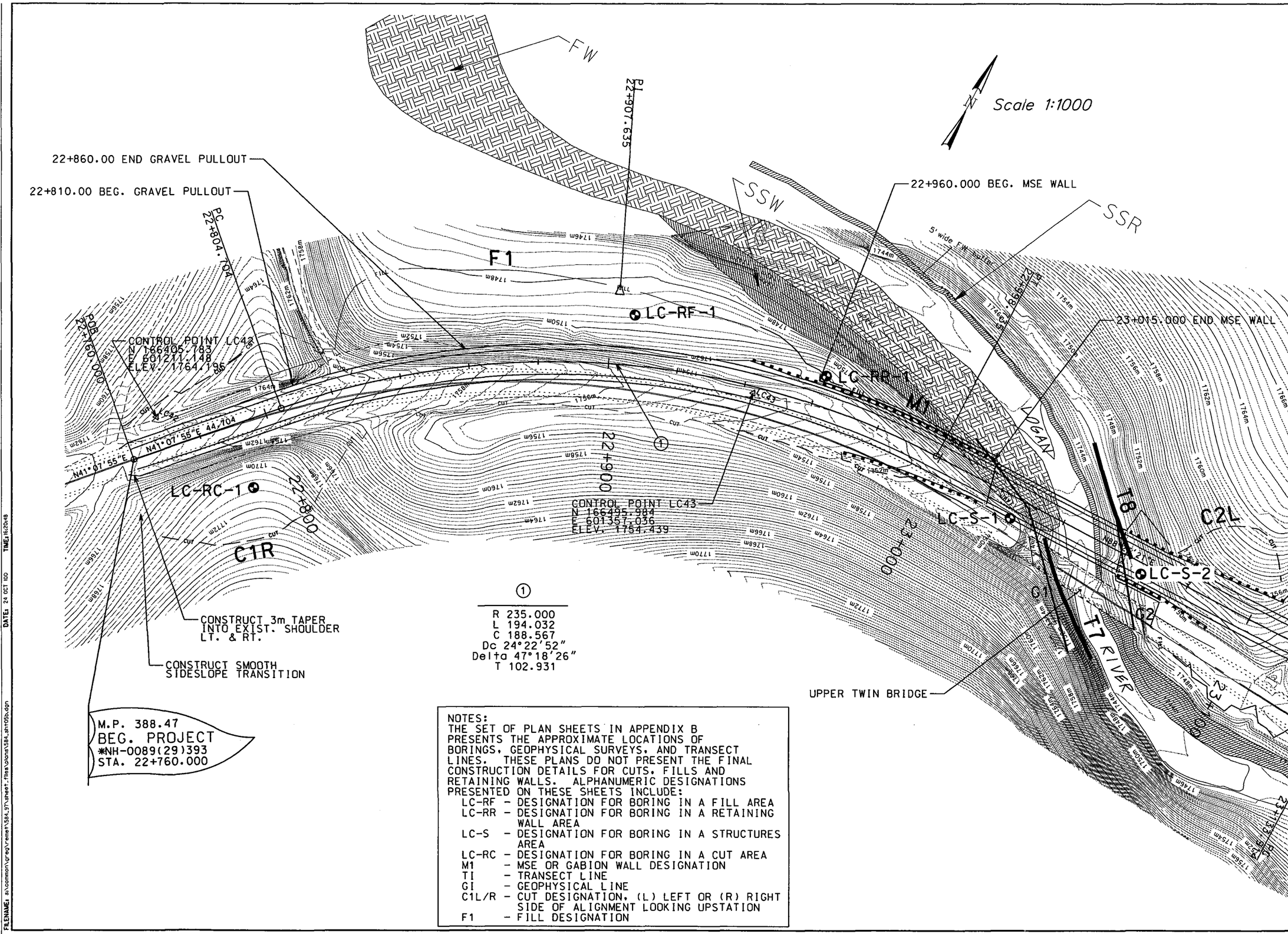
Rock Cut Slope Discontinuities
Utah Dept. of Transportation
Logan Canyon Highway (US-89)
Cache County, Utah

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

APPENDIX A

Appendix A

Plan Sheets, Originally Dated 07/06/00 and 07/07/00



①

R 235.000
L 194.032
C 188.567
Dc 24°22'52"
Delta 47°18'26"
T 102.931

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

- LC-RF - DESIGNATION FOR BORING IN A FILL AREA
- LC-RR - DESIGNATION FOR BORING IN A RETAINING WALL AREA
- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- M1 - MSE OR GABION WALL DESIGNATION
- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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DRAWN | CHECK
QUANT. | CHECK
DATE | BY

APPROVAL RECOMM. | DATE | PROJECT DESIGN ENGINEER
APPROVED | DATE | PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 5B

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NOTES:
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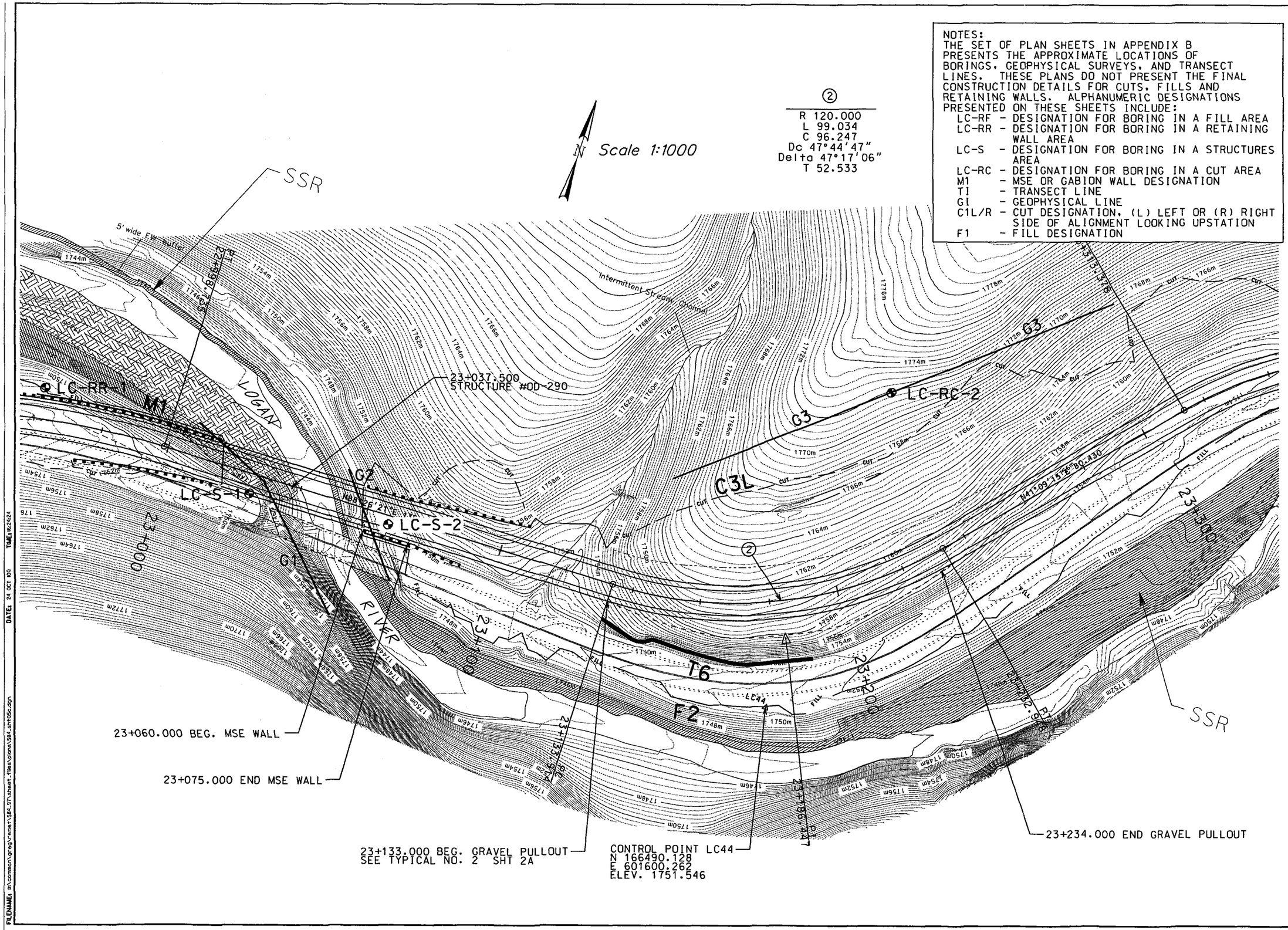
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 5C

REVISIONS

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PROJECT DESIGN ENGINEER
APPROVED
DATE
PLANS & ESTIMATES ENGINEER

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NOTES:
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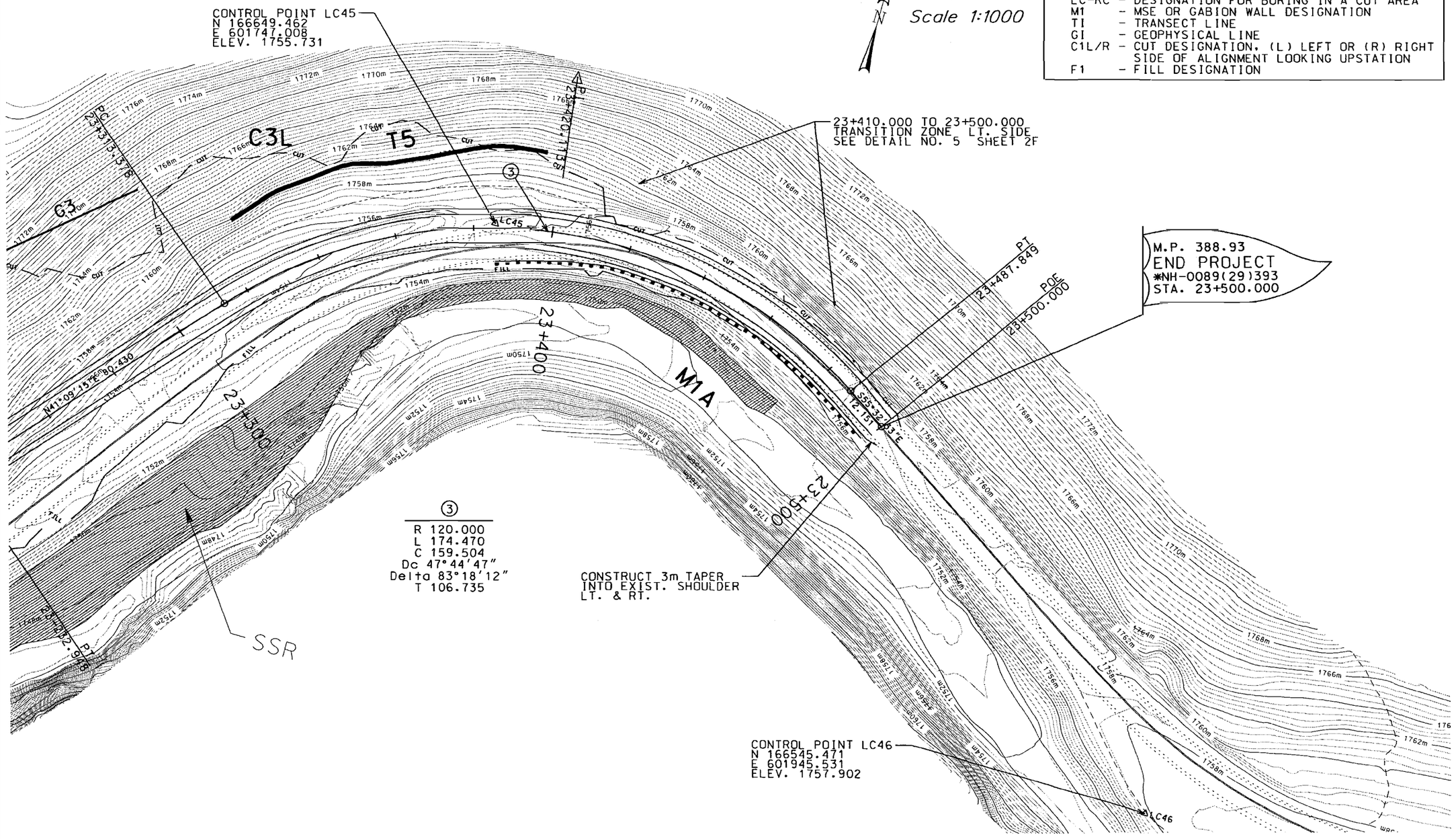
- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

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REVISIONS

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
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DATE

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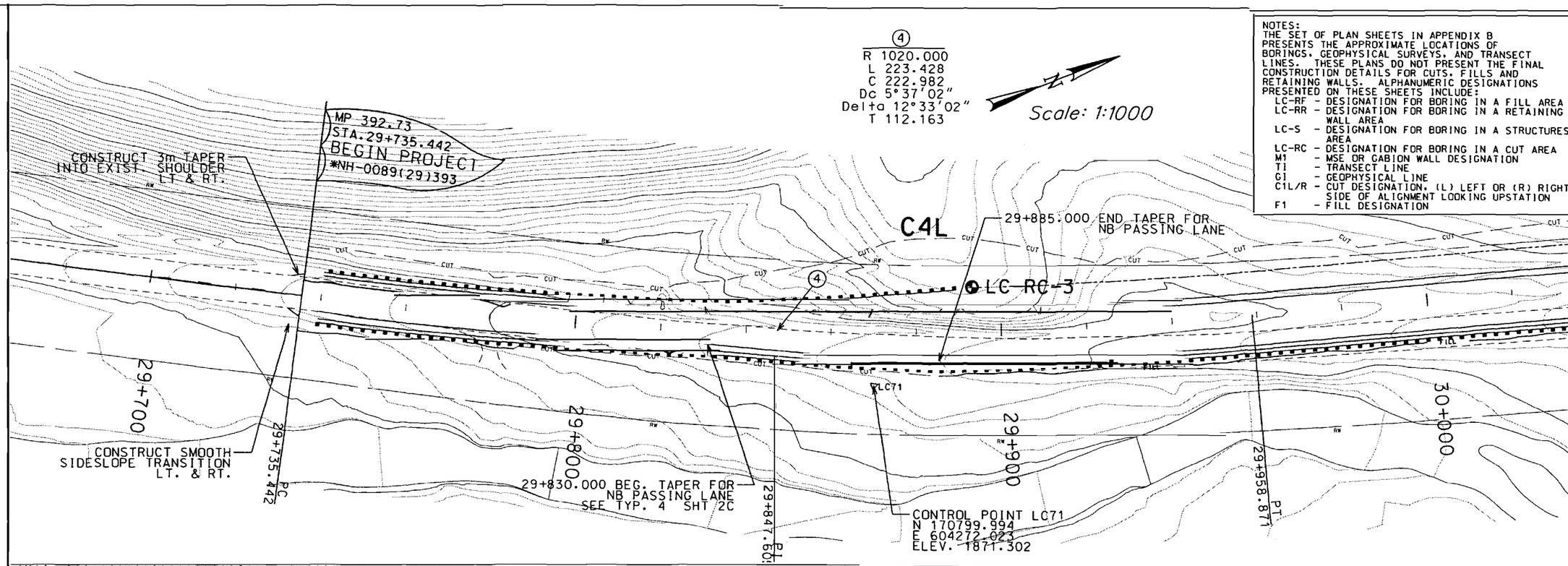

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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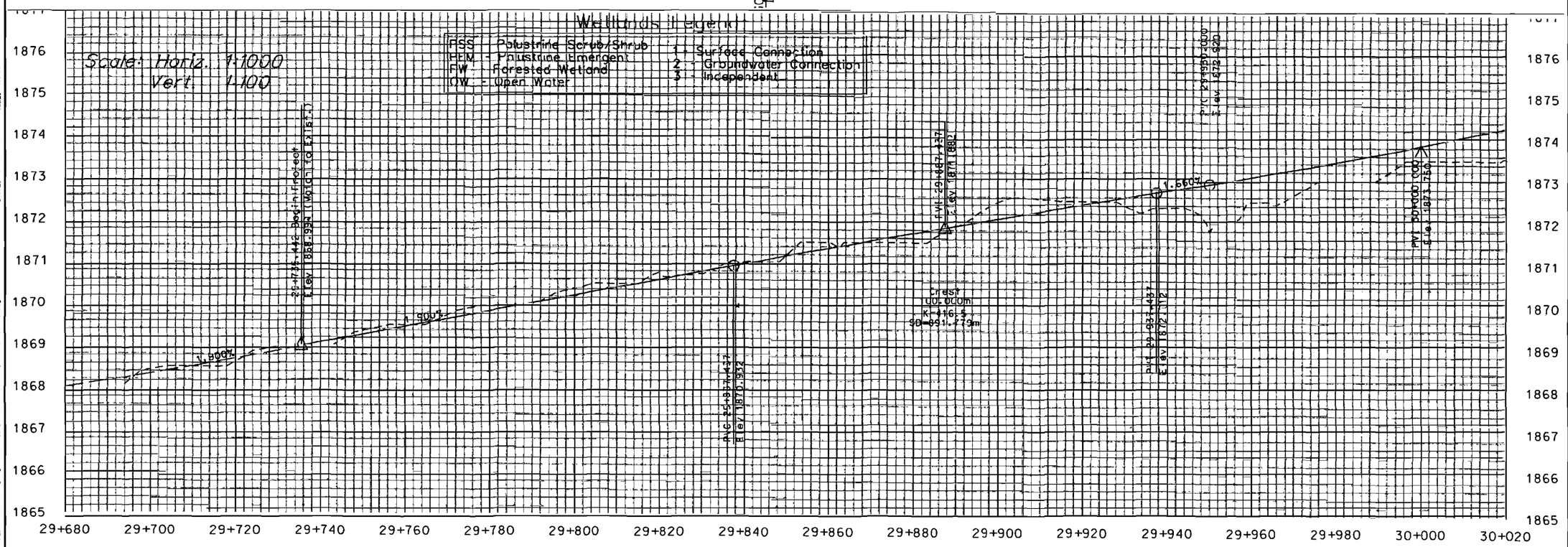
- F1 - FILL DESIGNATION



UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

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REVISIONS

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
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QUANT. CHECK

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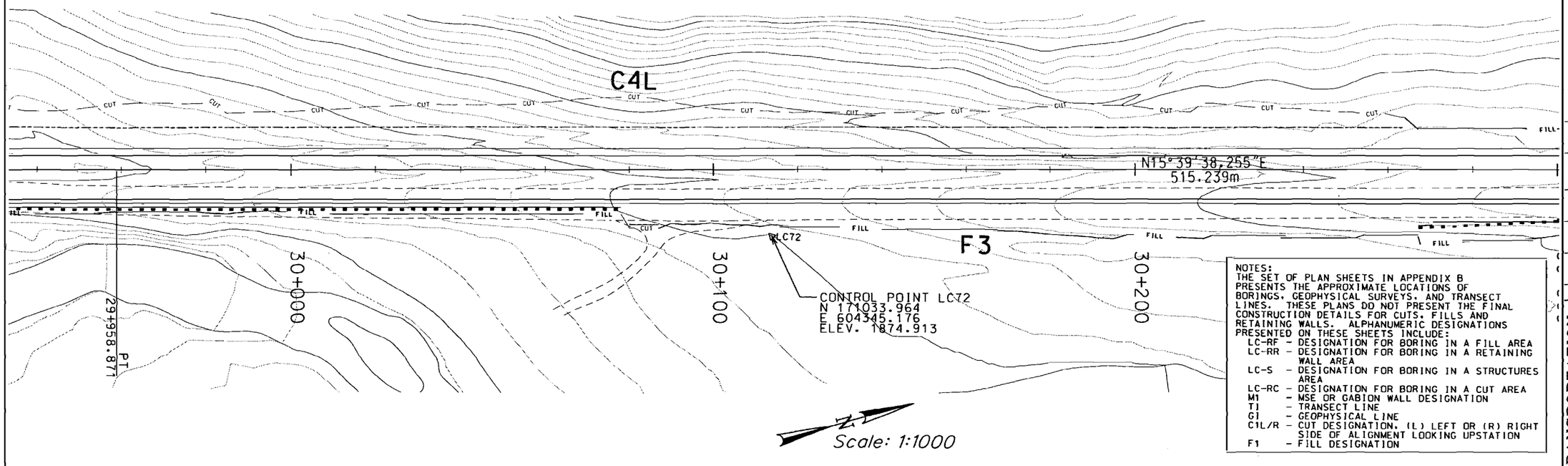

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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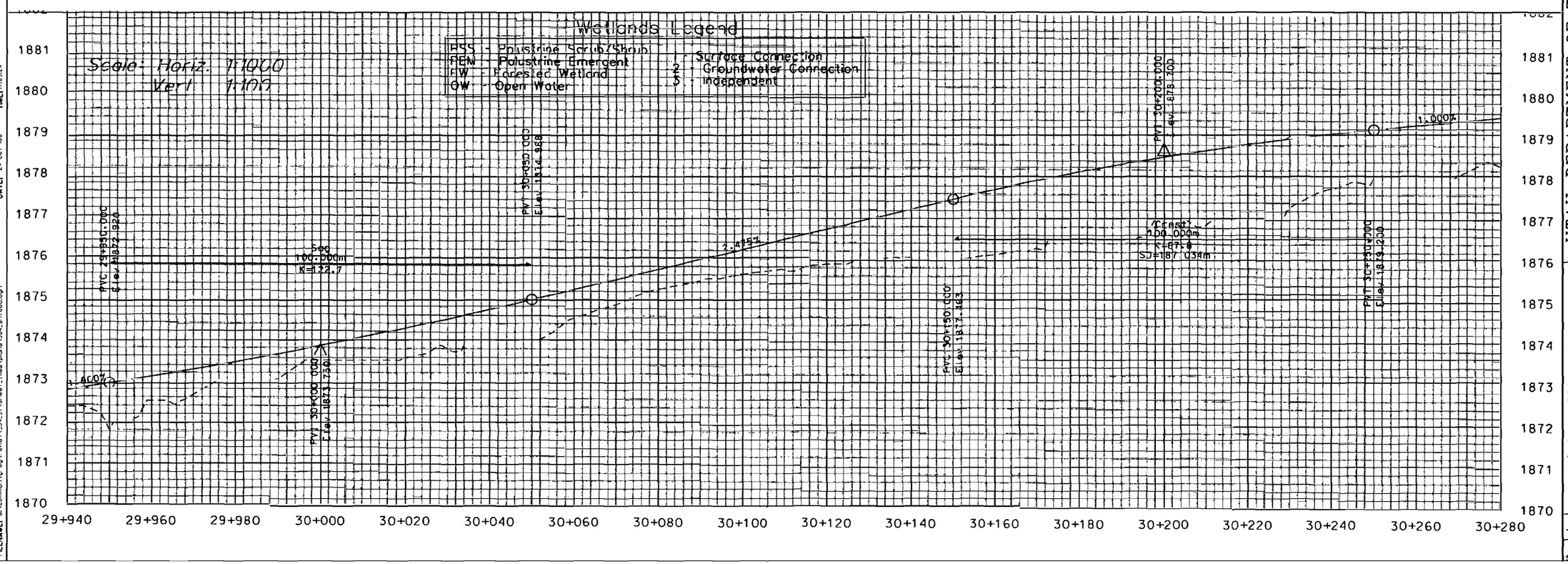

NO.	DATE	DESIGN MAPS & PARCELS COMPLETED BY	REQUEST FOR AUTHORIZATION BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION		

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION

REGION ONE - OGDEN, UTAH
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APPROVAL RECOMM. ____ DATE ____ PROJECT DESIGN ENGINEER
APPROVED ____ DATE ____ PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.

TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6A

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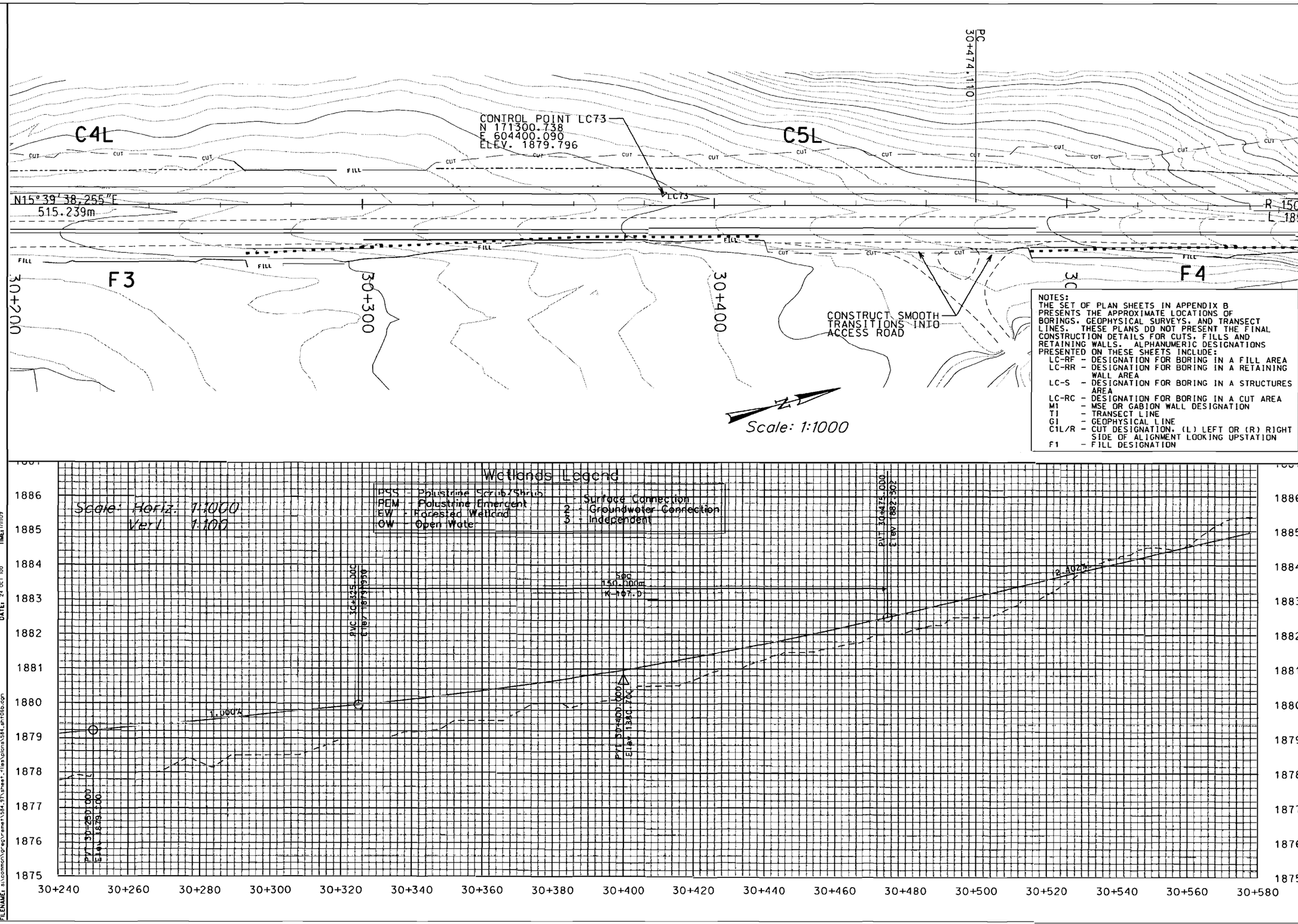

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
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- M1 - MSE OR GABION WALL DESIGNATION
- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

REVIEW

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DRAWN | CHECK | BY
QUANT. | CHECK

APPROVAL RECOMM. | DATE | PROJECT DESIGN ENGINEER
APPROVED | DATE | PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6B

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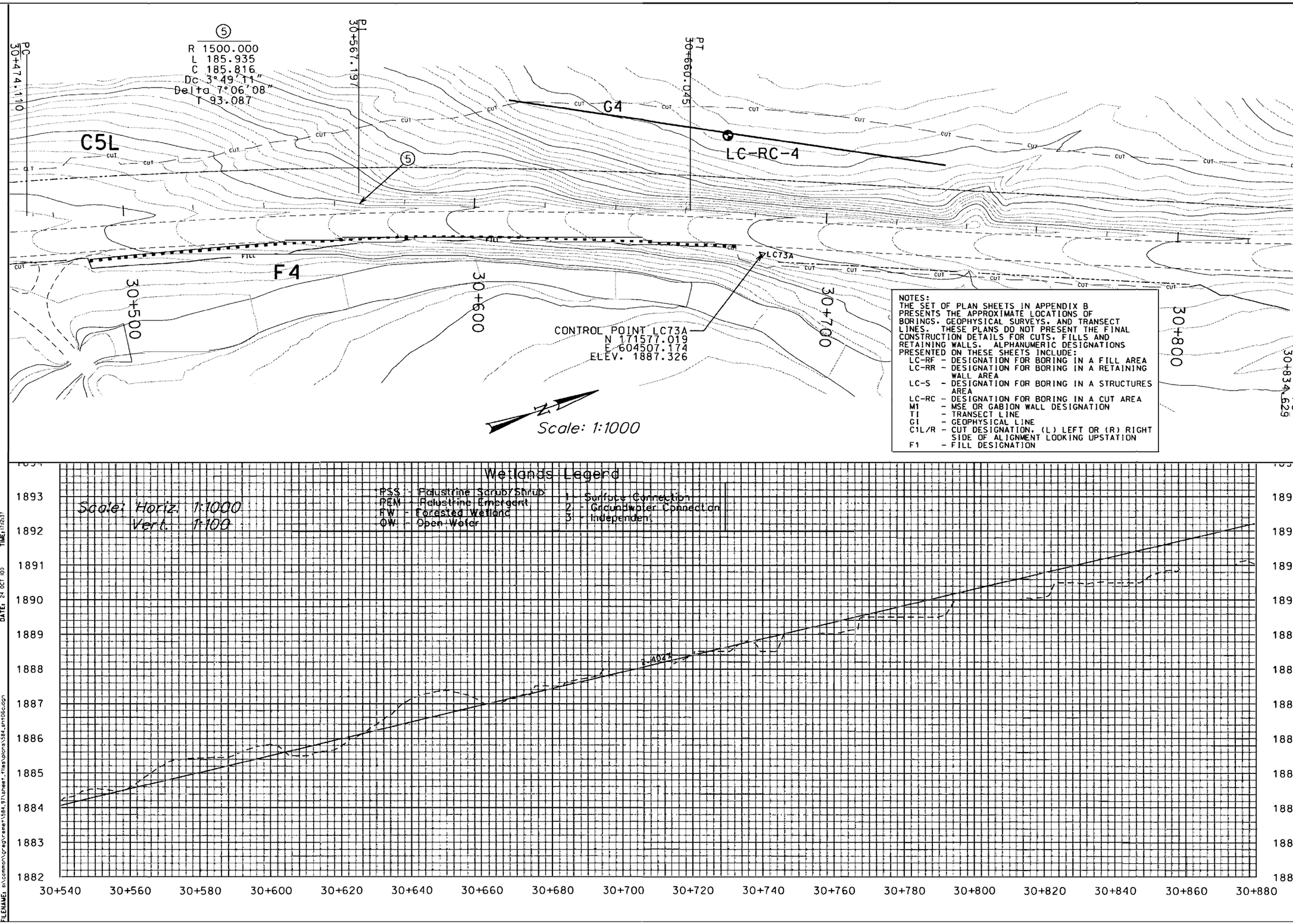

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
						ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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APPROVED DATE PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

SHEET NO. 6C

DATE: 24 OCT 00 TIME: 17:26:37

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NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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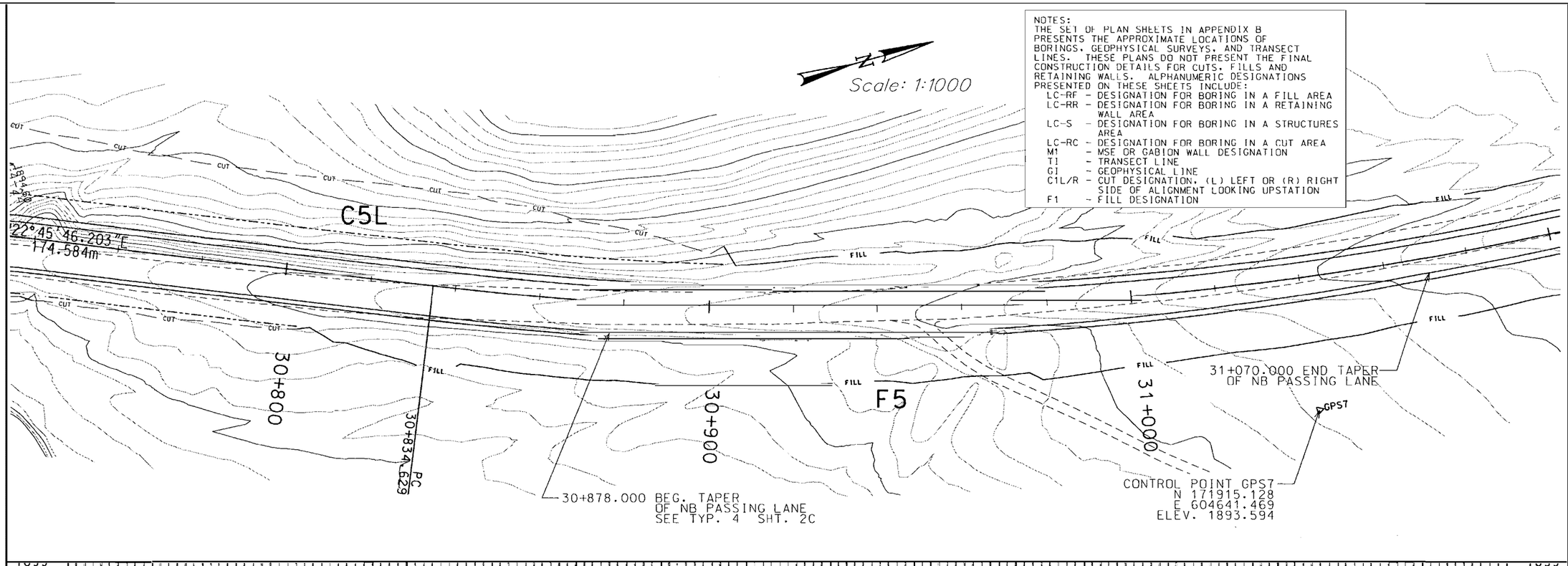
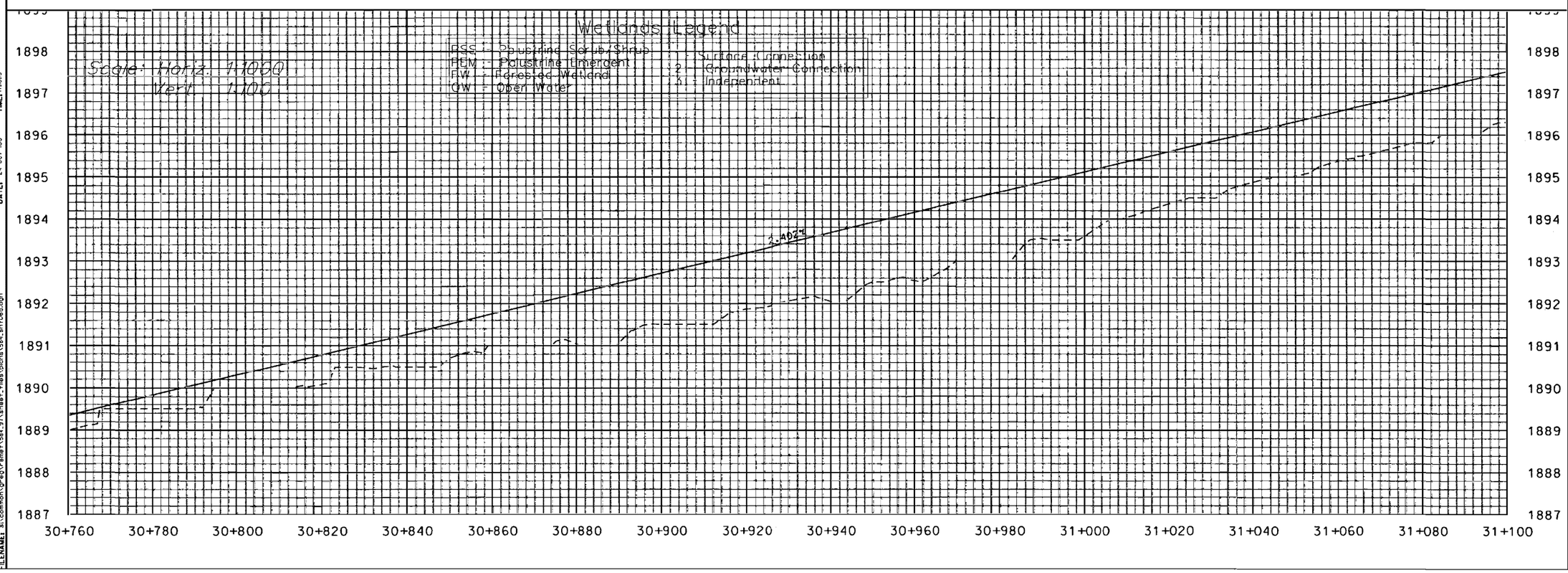
- LC-RR - DESIGNATION FOR BORING IN A RETAINING WALL AREA
- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- M1 - MSE OR GABION WALL DESIGNATION
- T1 - TRANSECT LINE
- G1 - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION





NO.	DATE	DESIGN MAPS, COORDINATES, ETC.	PARCELS, REQUEST, ETC.	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION		

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

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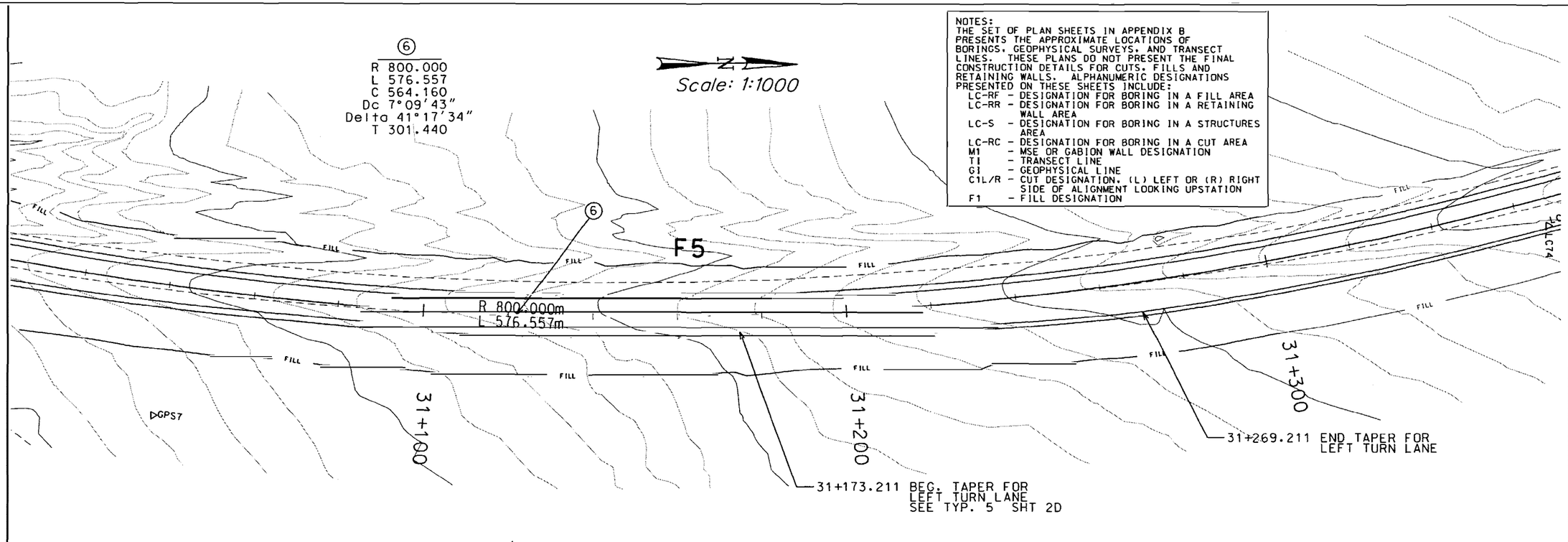

NOTES:
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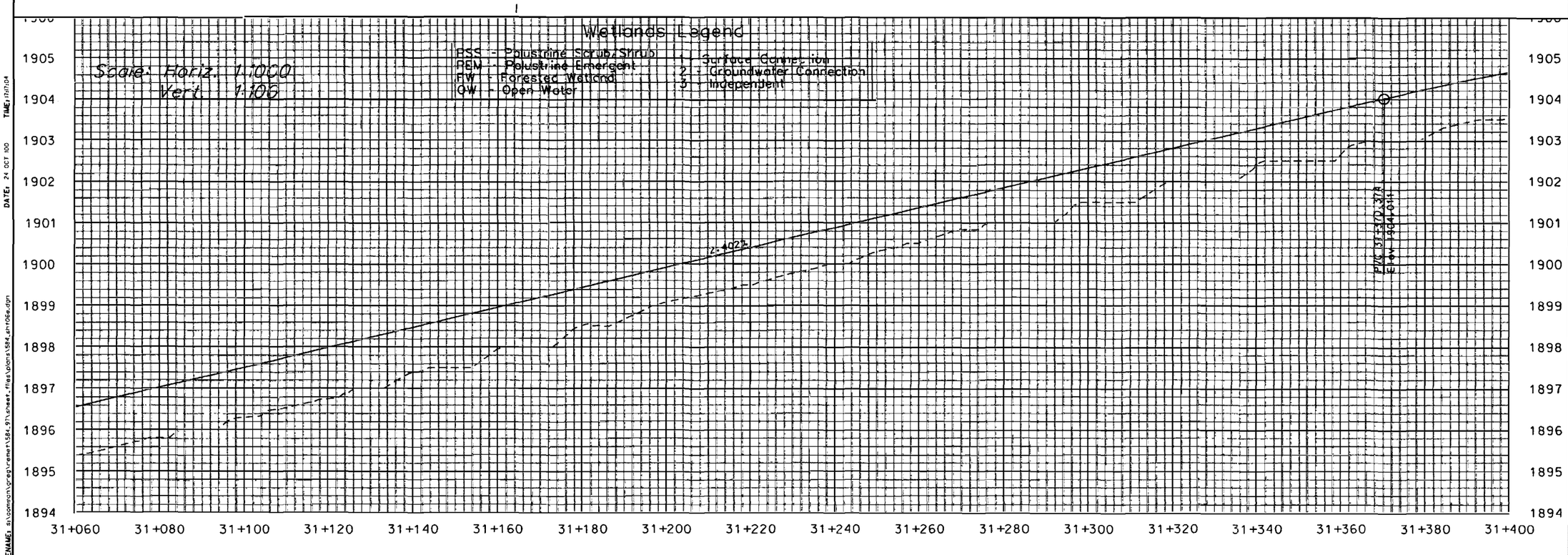
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- M1 - MSE OR GABION WALL DESIGNATION
- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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APPROVED DATE PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

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COUNTY

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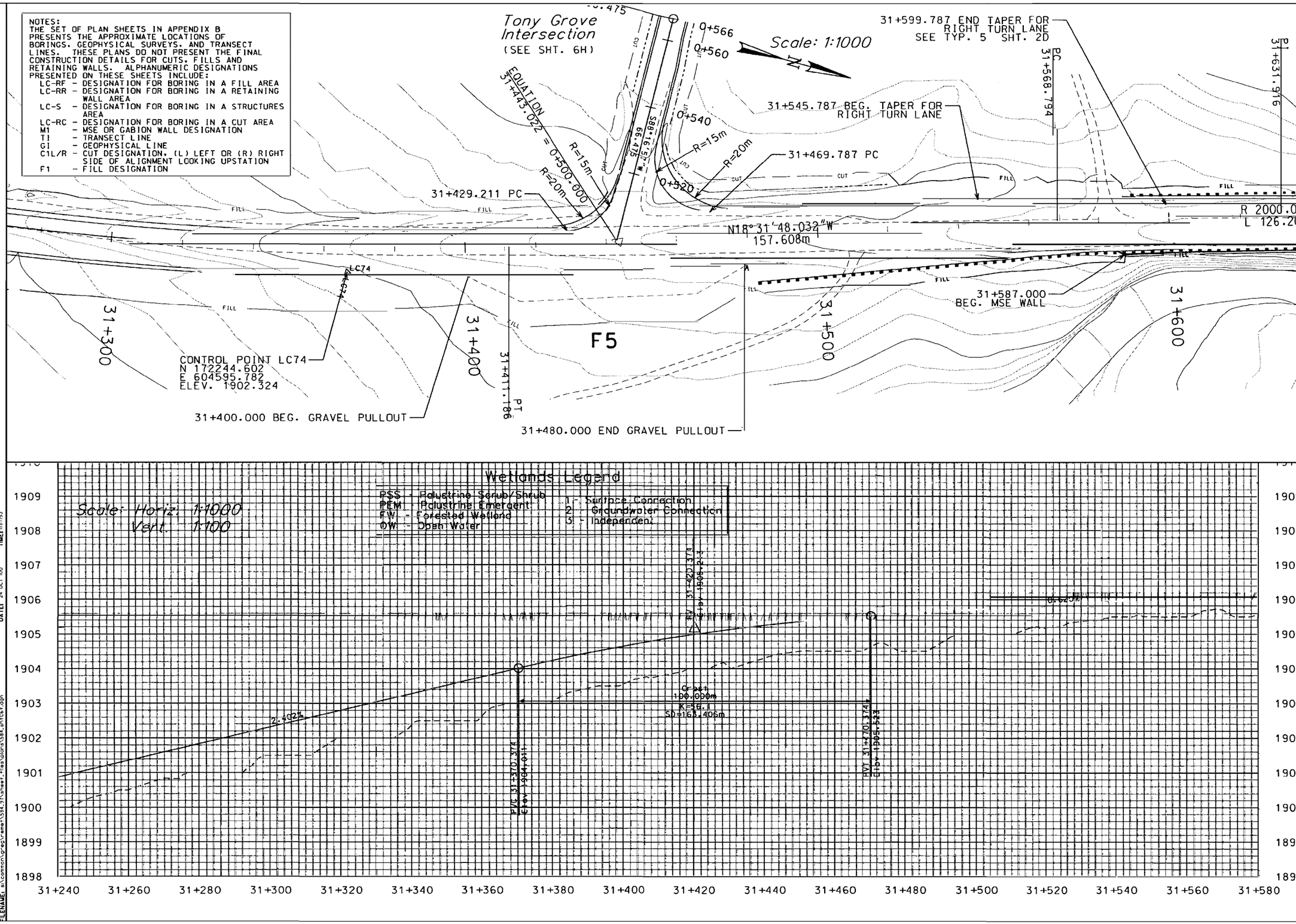

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6F

REVISIONS

ORIGINAL SUBMISSION FOR AUTHORIZATION

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APPROVAL RECOMM. DATE PROJECT DESIGN ENGINEER
APPROVED DATE PLANS & ESTIMATES ENGINEER

DATE: 24 OCT 100 TIME: 17:57:53
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NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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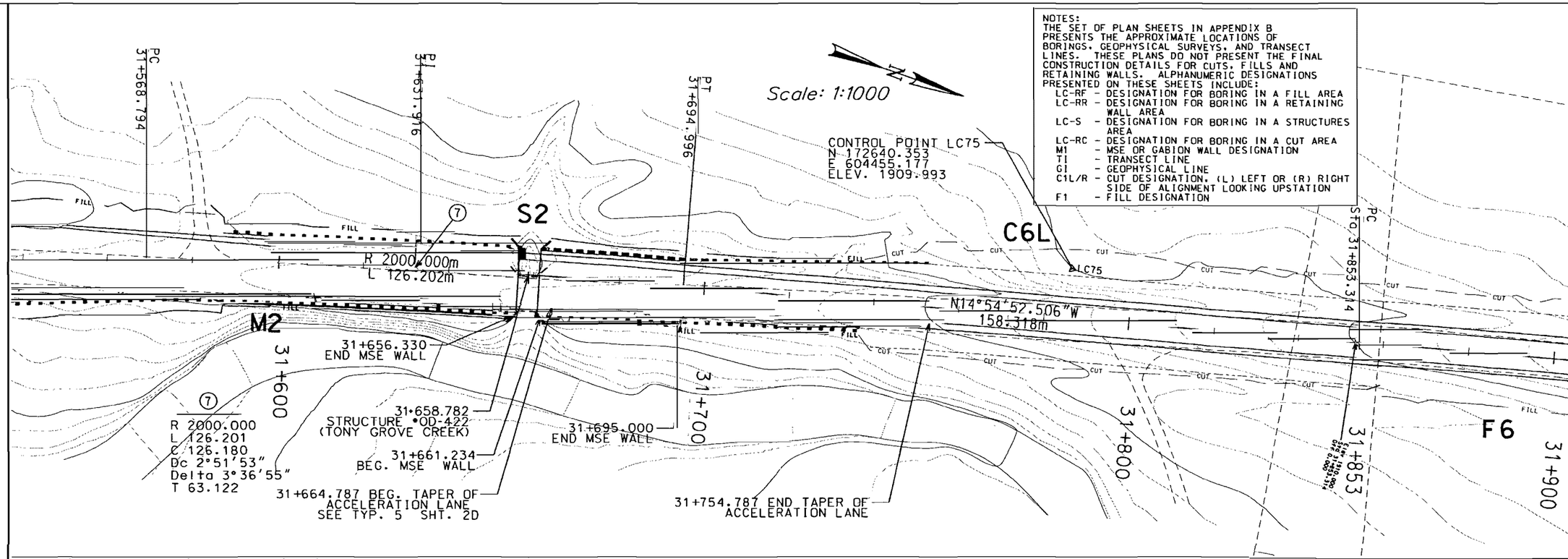
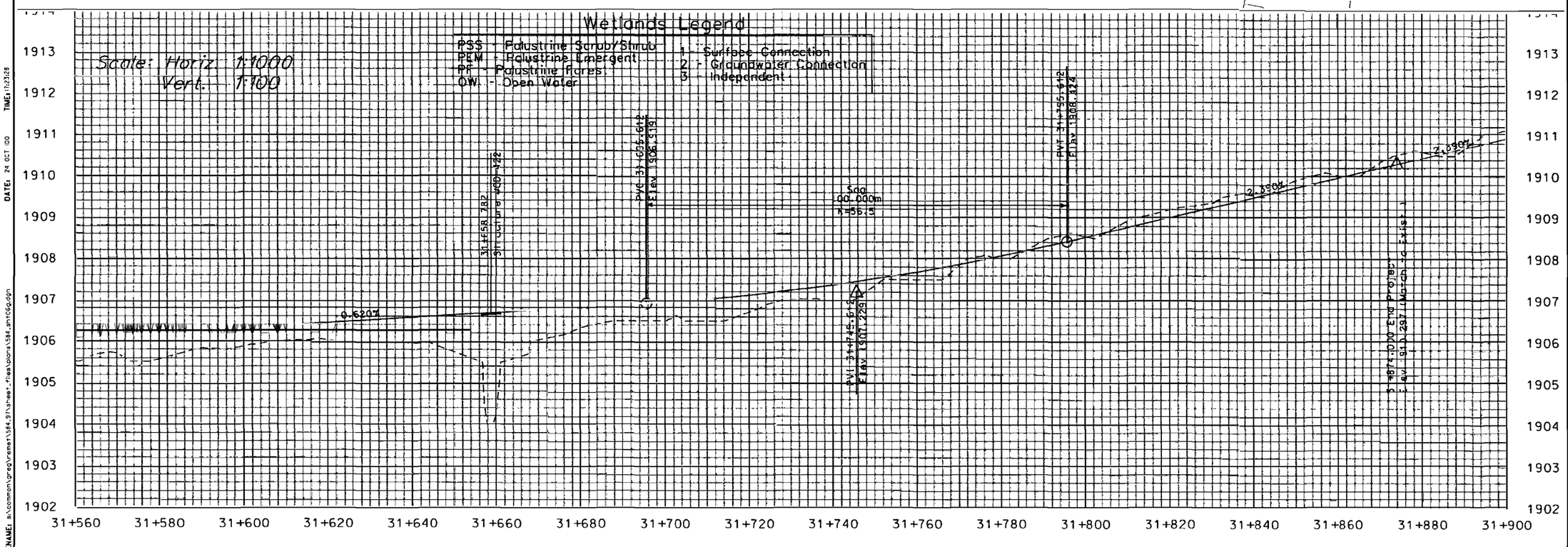
- LC-RR - DESIGNATION FOR BORING IN A RETAINING WALL AREA
- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- M1 - MSE OR GABION WALL DESIGNATION
- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION





UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6G

REVISIONS

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

ORIGINAL SUBMISSION FOR AUTHORIZATION

DATE

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QUANT. — CHECK — BY

APPROVAL RECOMM. — DATE — PROJECT DESIGN ENGINEER
APPROVED — DATE — PLANS & ESTIMATES ENGINEER

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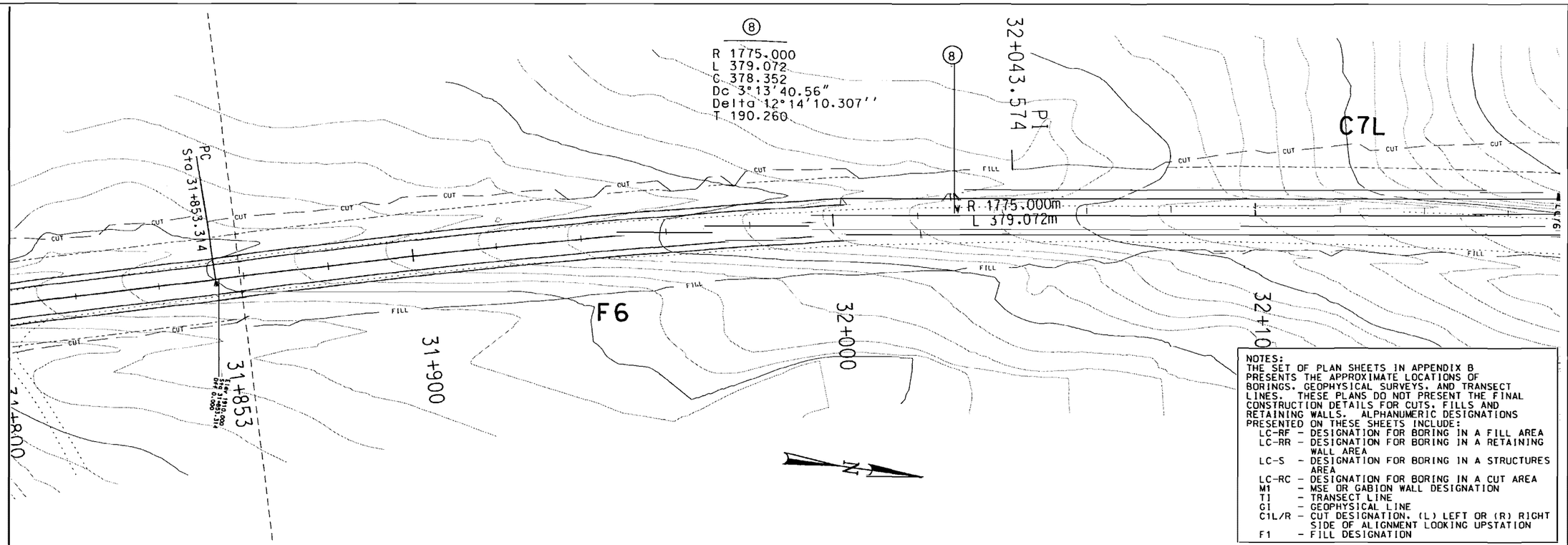

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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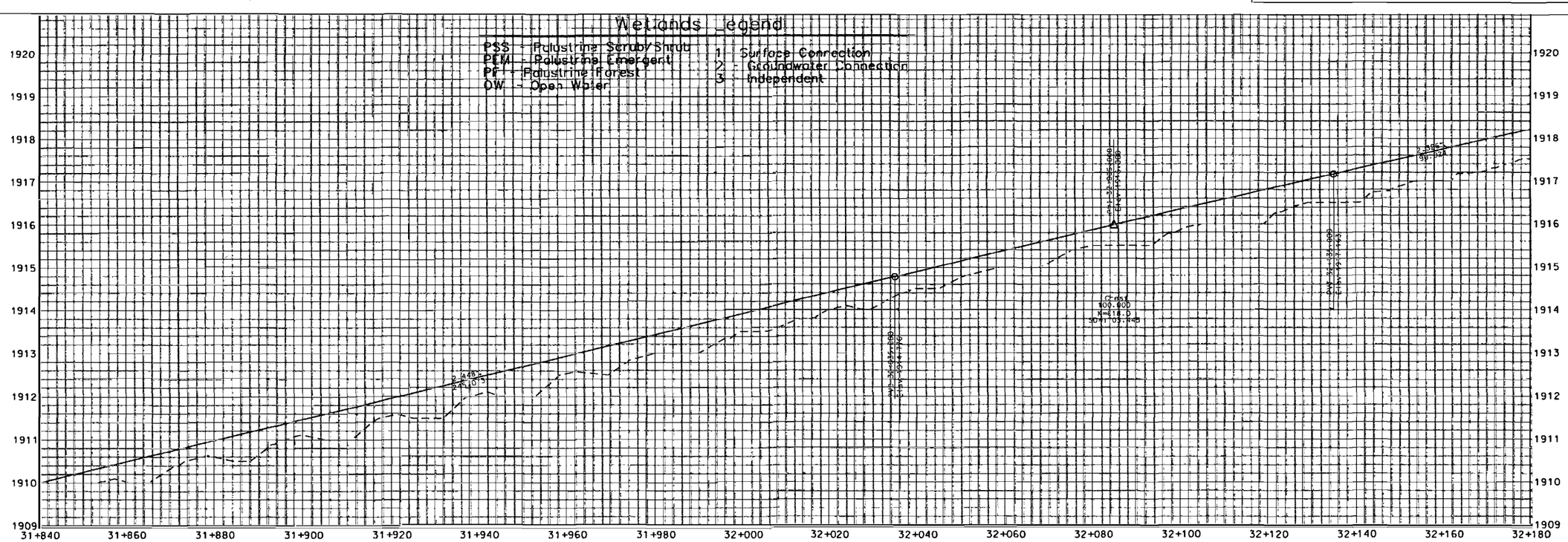
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

REVIEW
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PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6H

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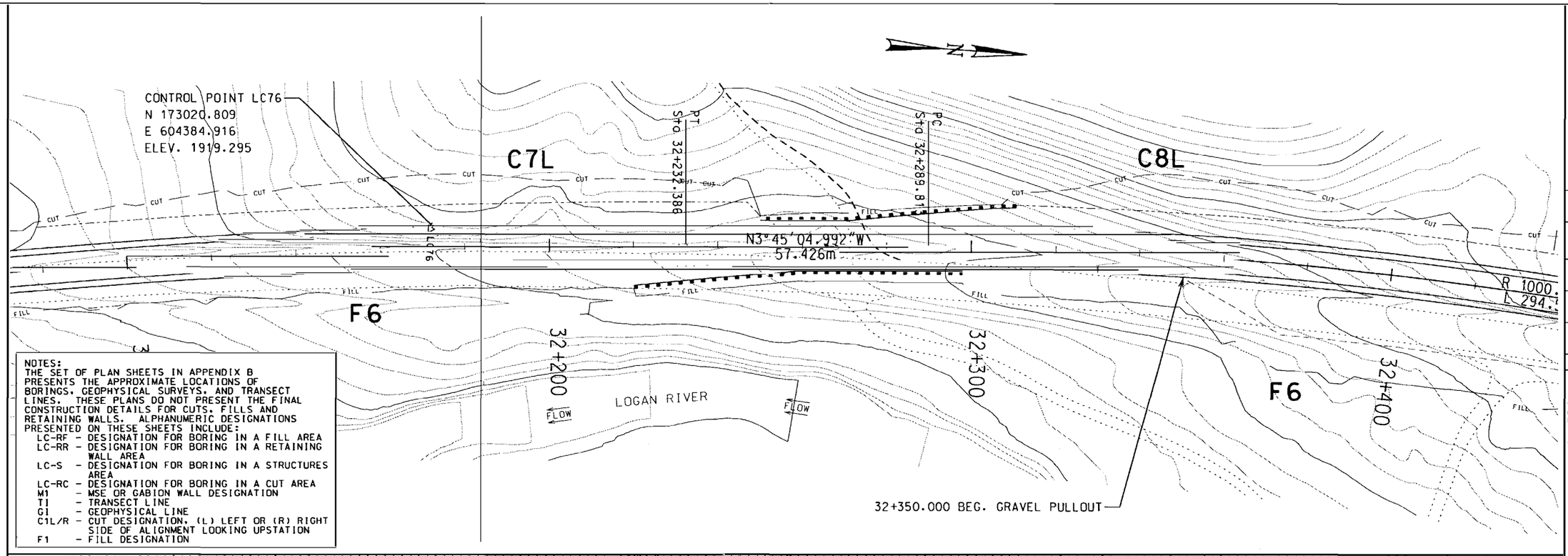

NOTES:
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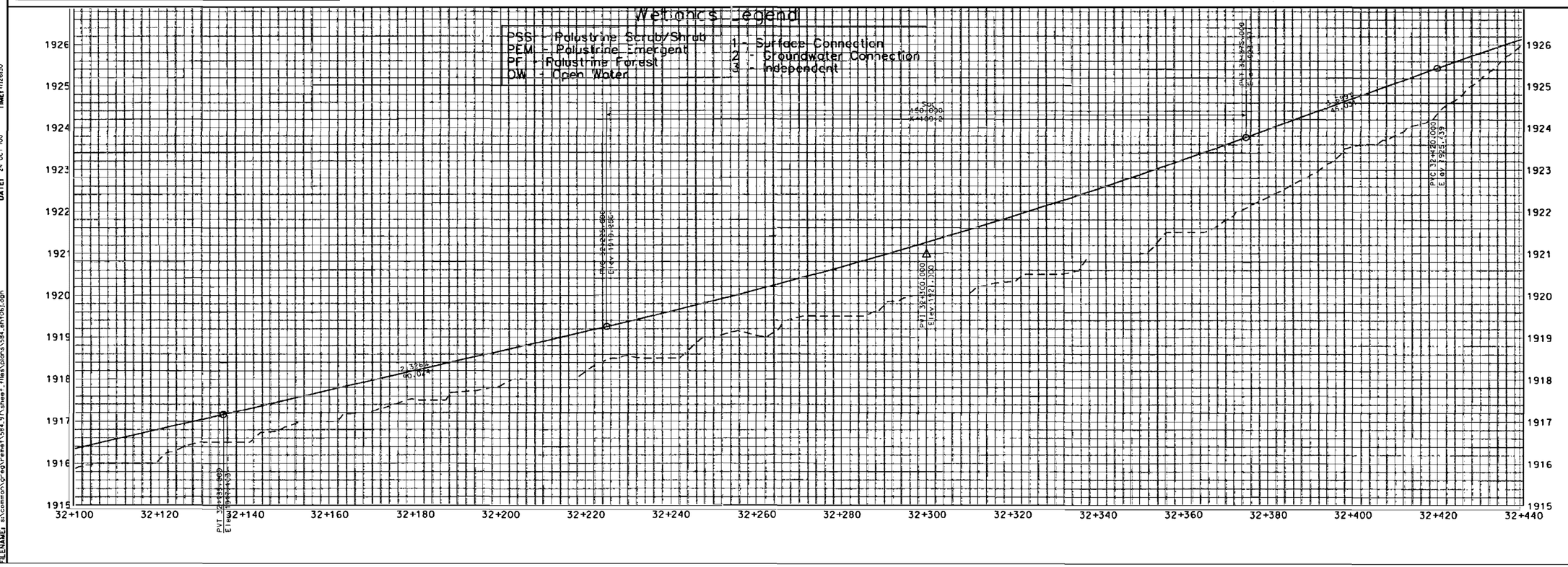
- F1 - FILL DESIGNATION



UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6J

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

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APPROVAL RECOMM. DATE PROJECT DESIGN ENGINEER
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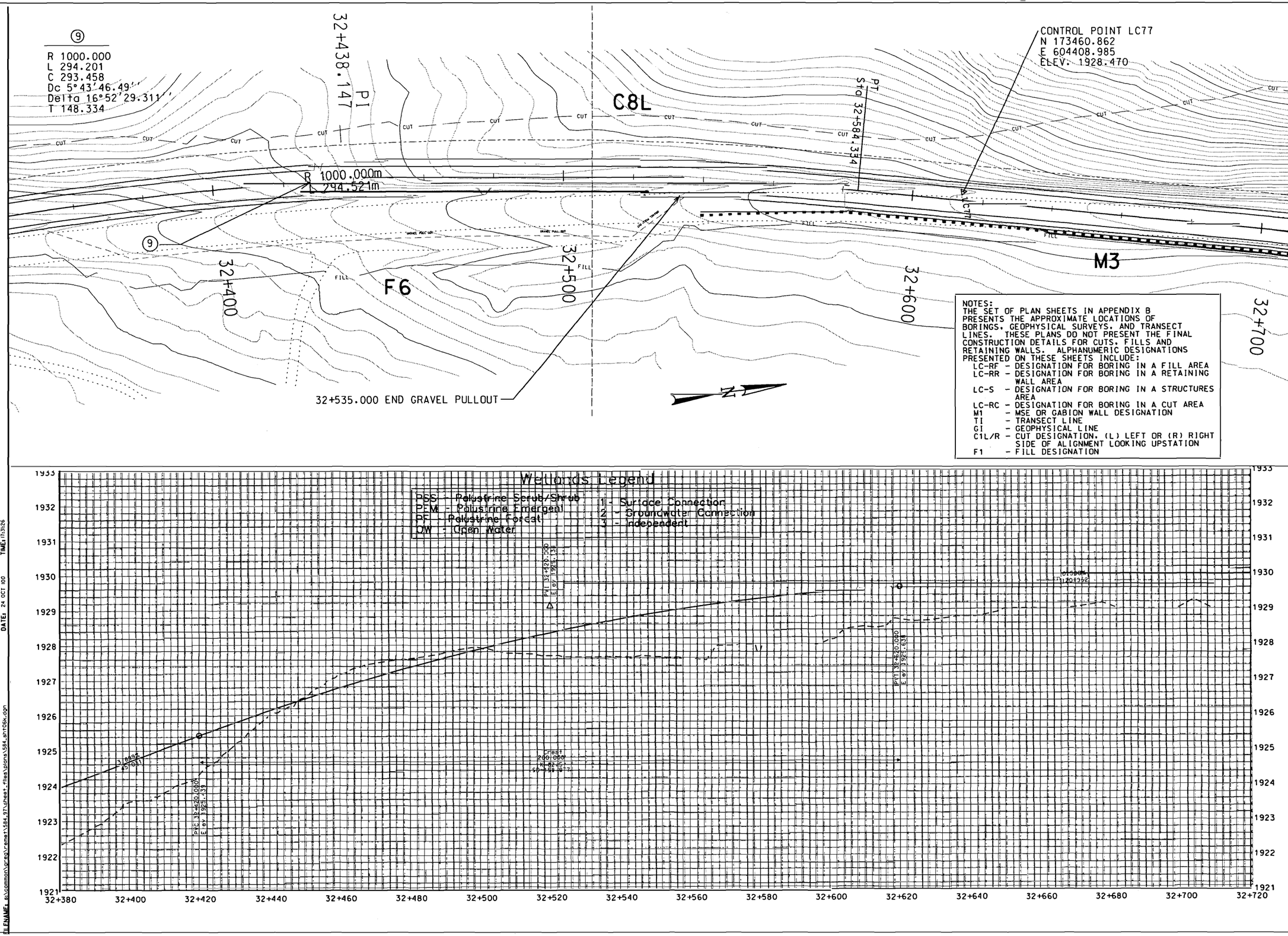

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

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COUNTY

SHEET NO. 6K

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NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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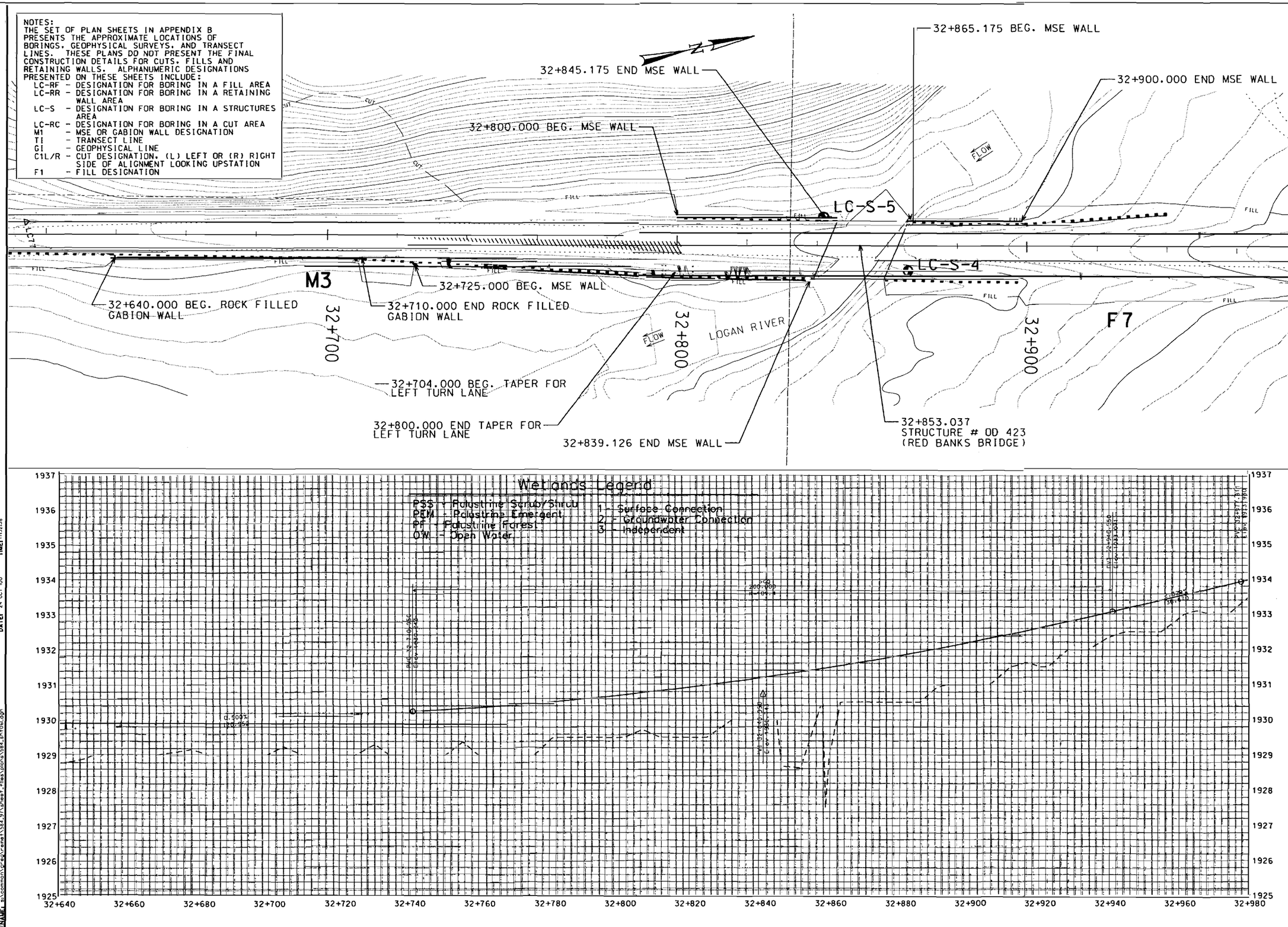

NO.	DATE	DESIGN MAPS & ACCORDING	PARCELS REQUEST	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION		

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION

REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

CACHE COUNTY

PROJECT NUMBER *NH-0089(29)393

SHEET NO. 6L

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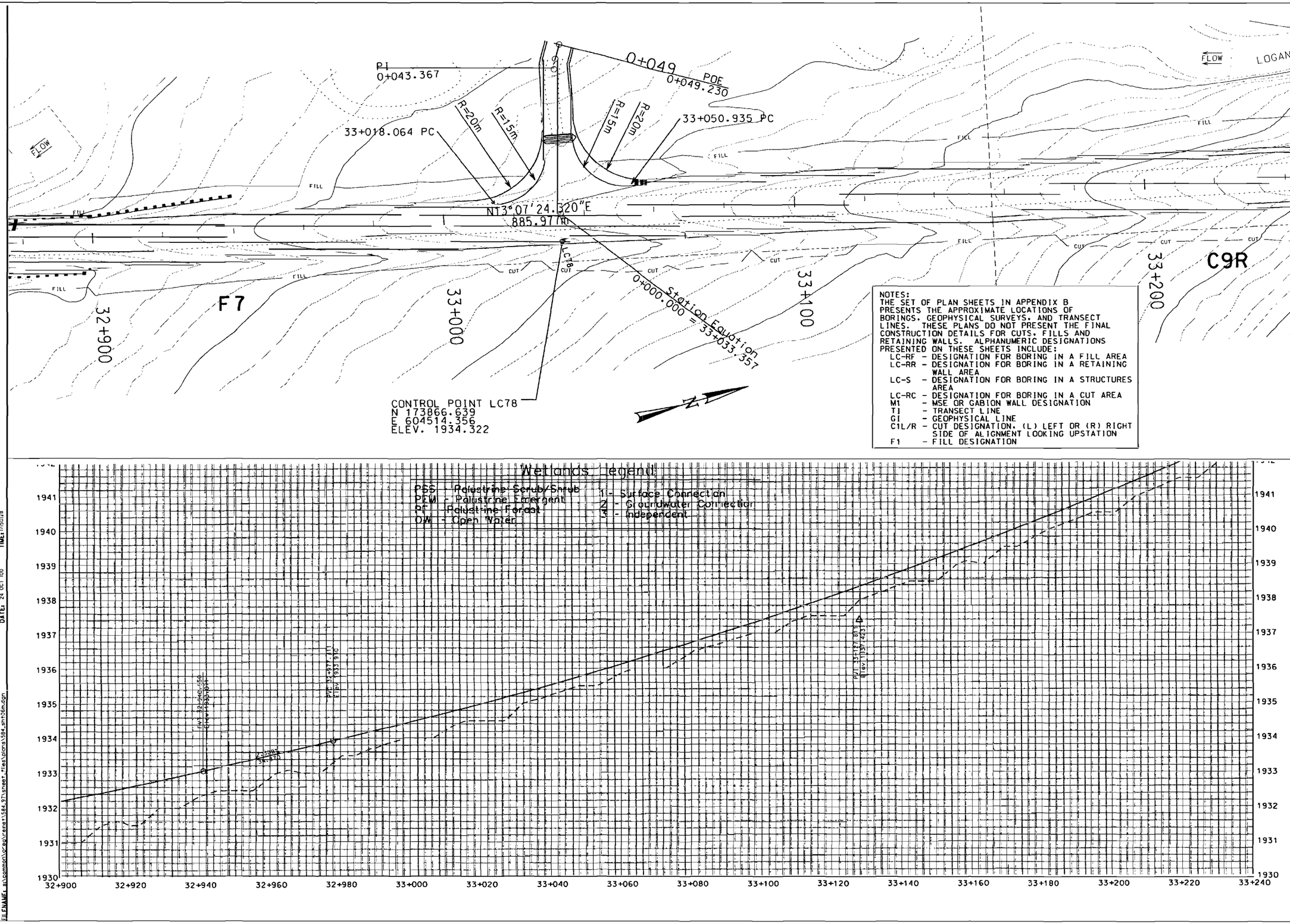

NO.	DATE	DESIGN MAPS REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

REVIEW: CHECK ____ DATE ____ BY ____

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APPROVED ____ DATE ____ PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.

TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

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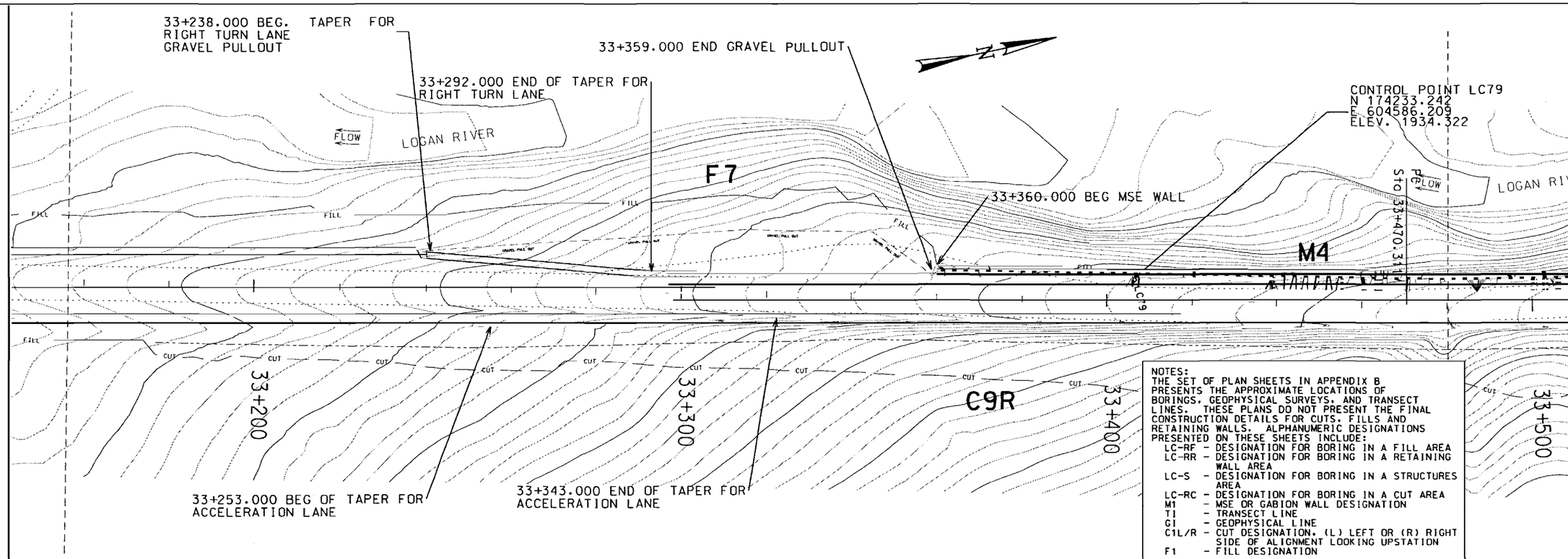

NOTES:
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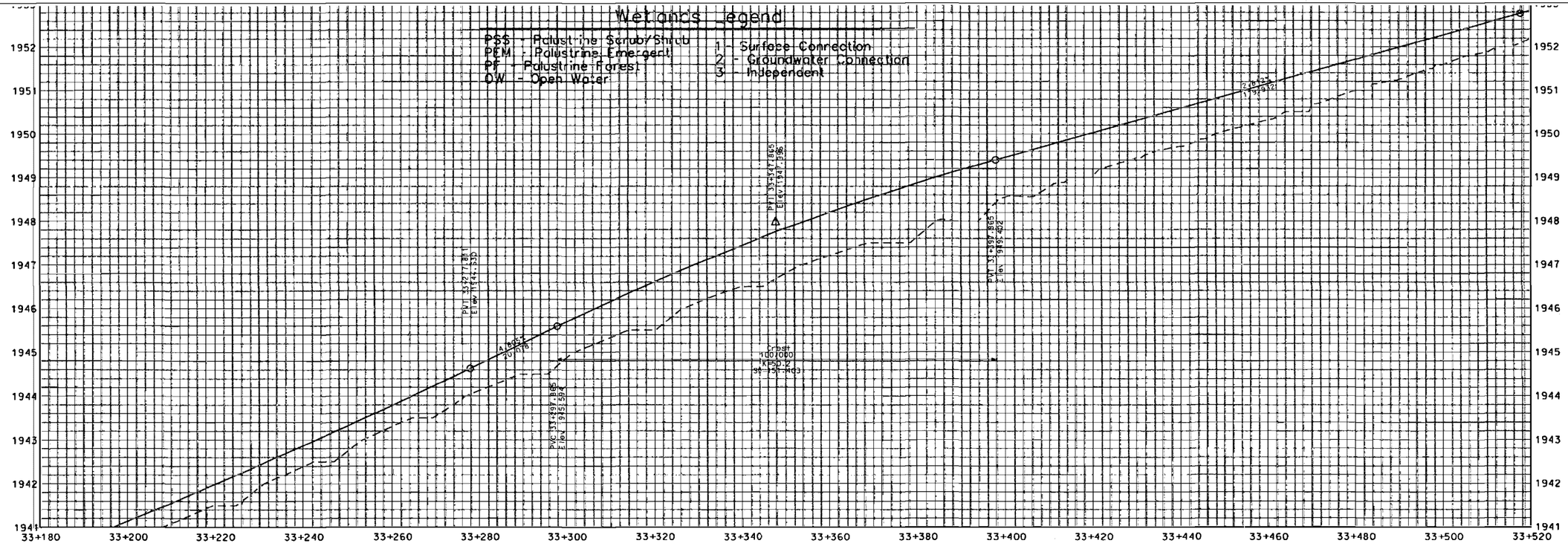

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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APPROVAL RECOMM. DATE PROJECT DESIGN ENGINEER
APPROVED DATE PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6N

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NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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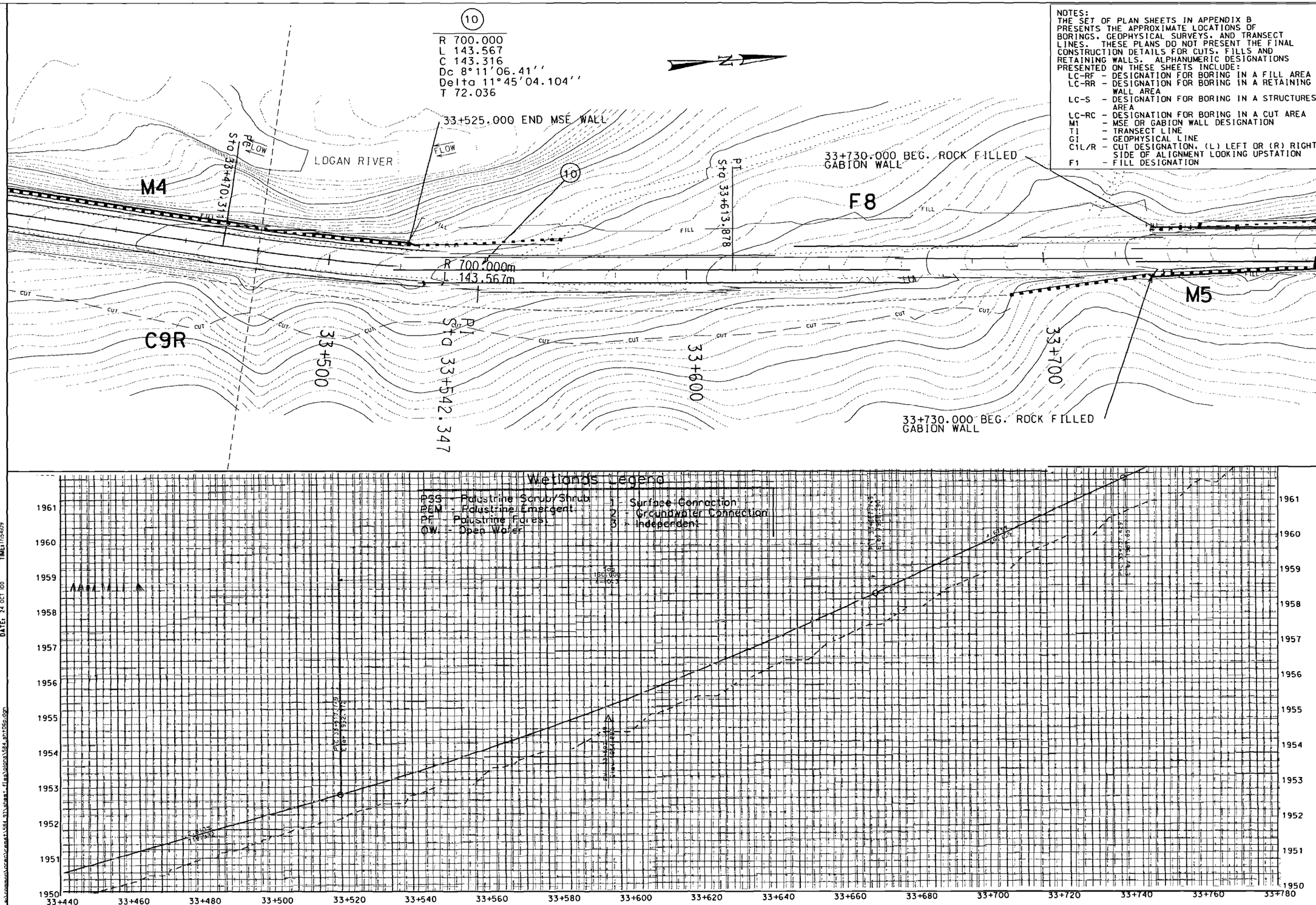
- G1 - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



NO.	DATE	DESIGN MAPS REV. BY/CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION			

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION

REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

SHEET NO. 6P

REVIEW — CHECK — DATE — BY

DESIGN — CHECK
DRAWN — CHECK
QUANT. — CHECK

APPROVAL RECOMM. — DATE — PROJECT DESIGN ENGINEER
APPROVED — DATE — PLANS & ESTIMATES ENGINEER

DATE: 24 OCT 100 TIME: 17:54:09

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NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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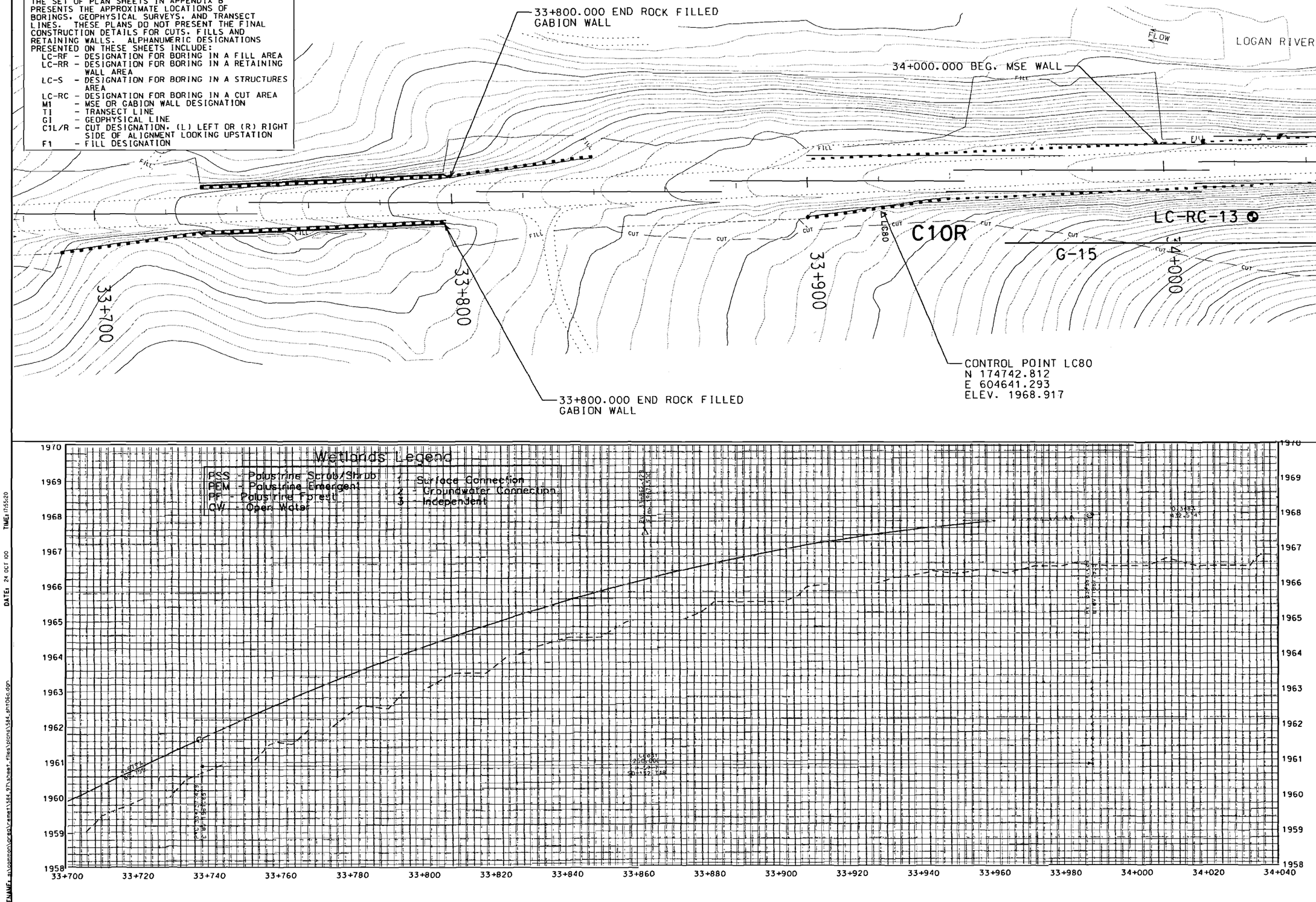
- LC-RR - DESIGNATION FOR BORING IN A RETAINING WALL AREA
- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- M1 - MSE OR GABION WALL DESIGNATION
- T1 - TRANSECT LINE
- G1 - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



NO.	DATE	DESIGN WORK PARCELS REQUEST BY DEL'W CORR. BY AFFECTED BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION	

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

REVIEW
DESIGN CHECK
DRAWN CHECK
QUANT. CHECK
APPROVAL RECOMM. DATE PROJECT DESIGN ENGINEER
APPROVED DATE PLANS & EST/MATES ENGINEER
DATE BY

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

SHEET NO. 60

DATE: 24 OCT 100 TIME: 1155:20

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NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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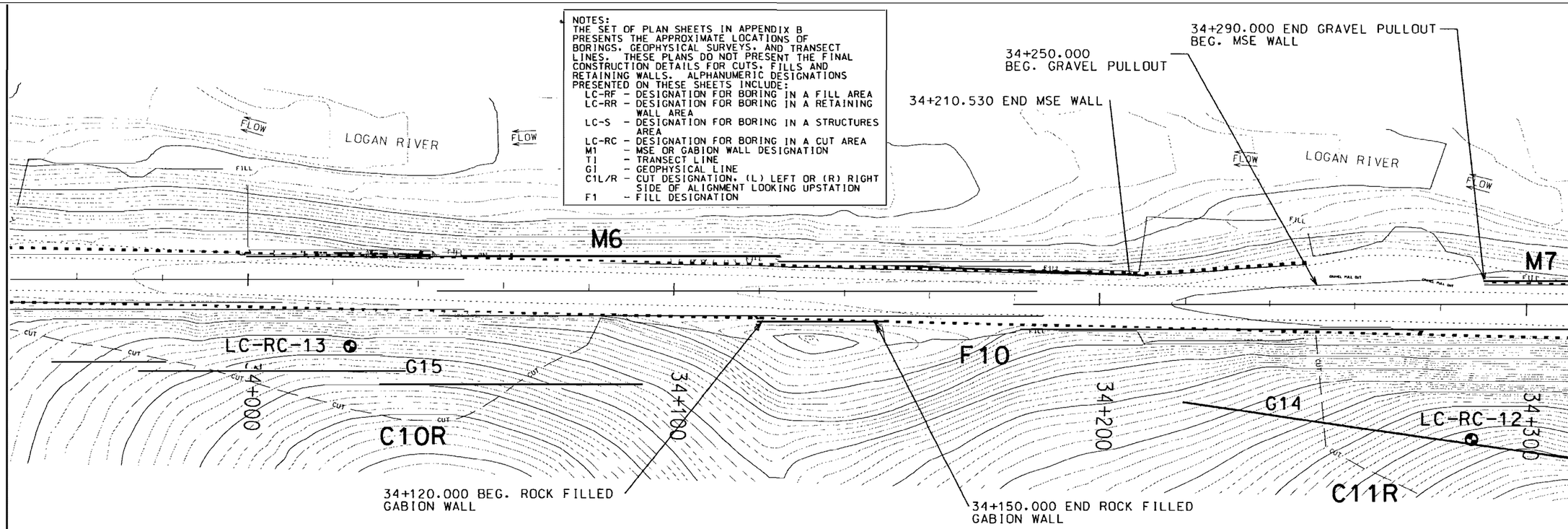
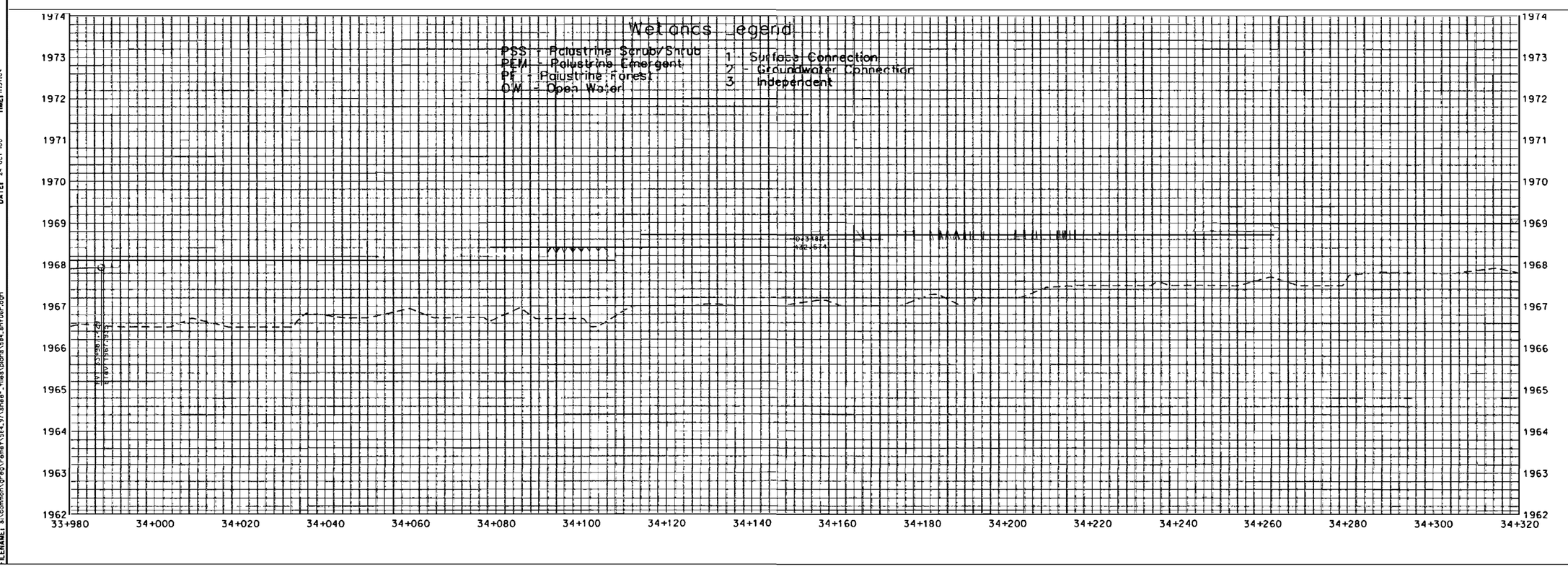
- G1 - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION





NO.	DATE	DESIGN, MAPS, REV. BY, CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
					ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

REVIEW

DESIGN ____ CHECK ____
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US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6R

DATE: 24 OCT 100 TIME: 11:51:04

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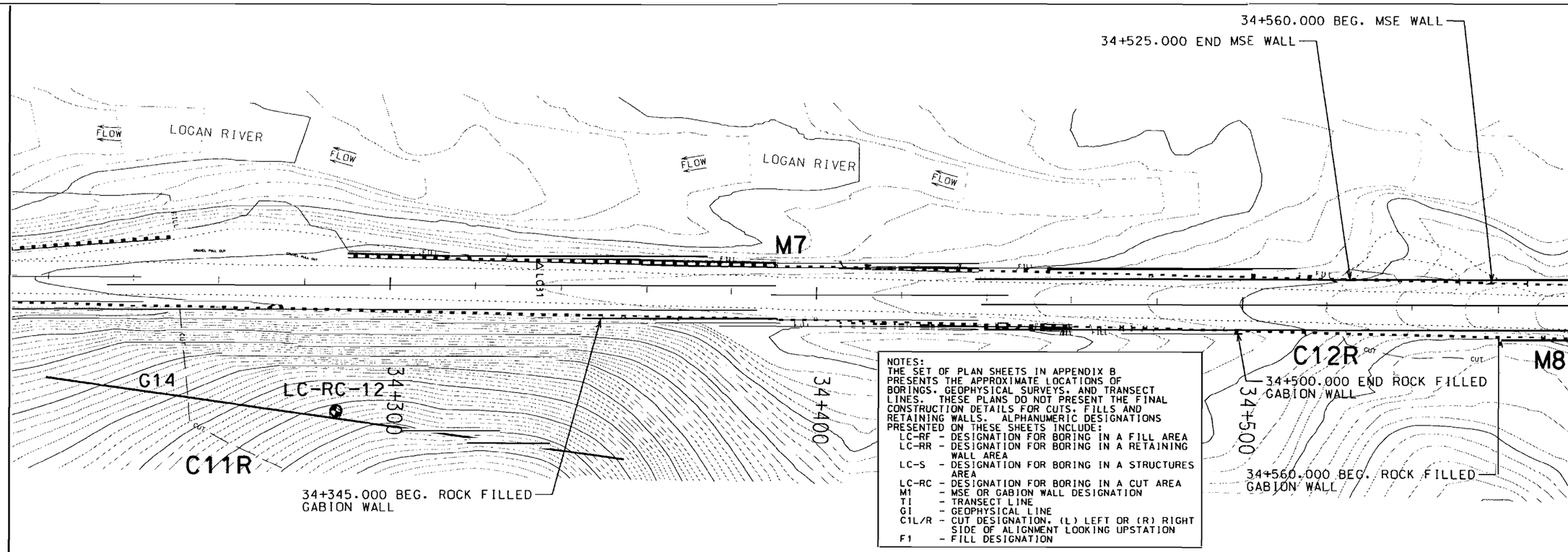

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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APPROVAL RECOMM. DATE PROJECT DESIGN ENGINEER
APPROVED DATE PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 6S

DATE: 24 OCT 100 TIME: 17:58:17
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NOTES:
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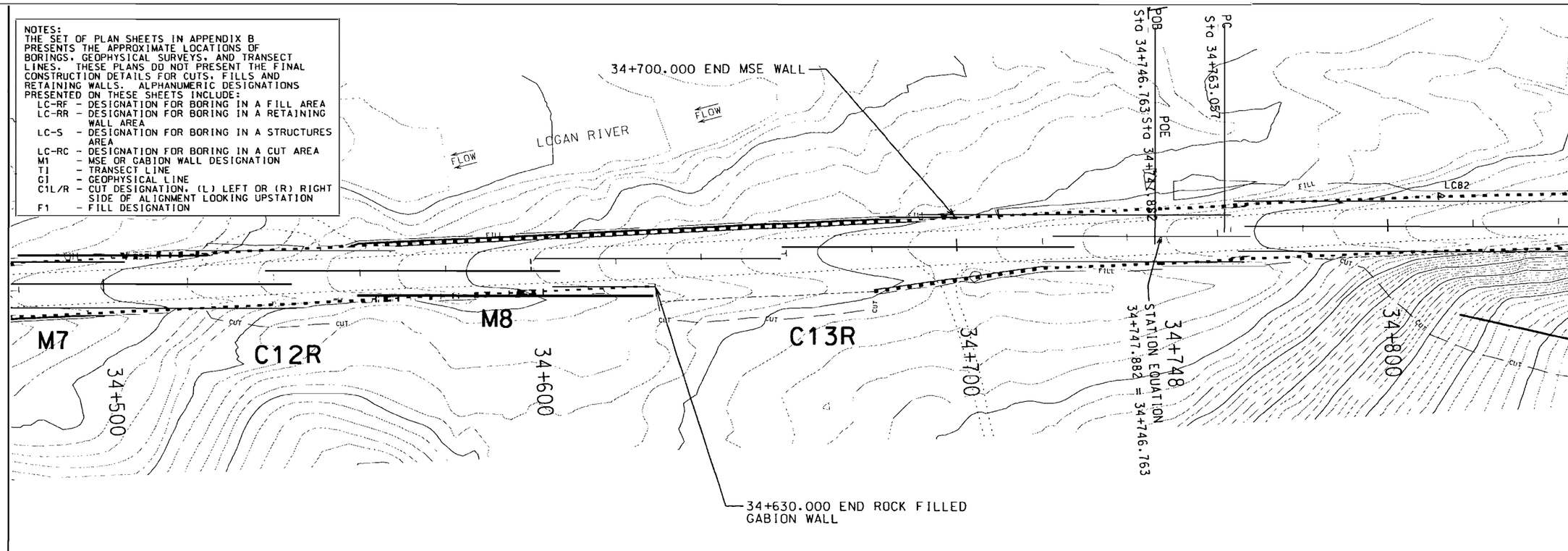
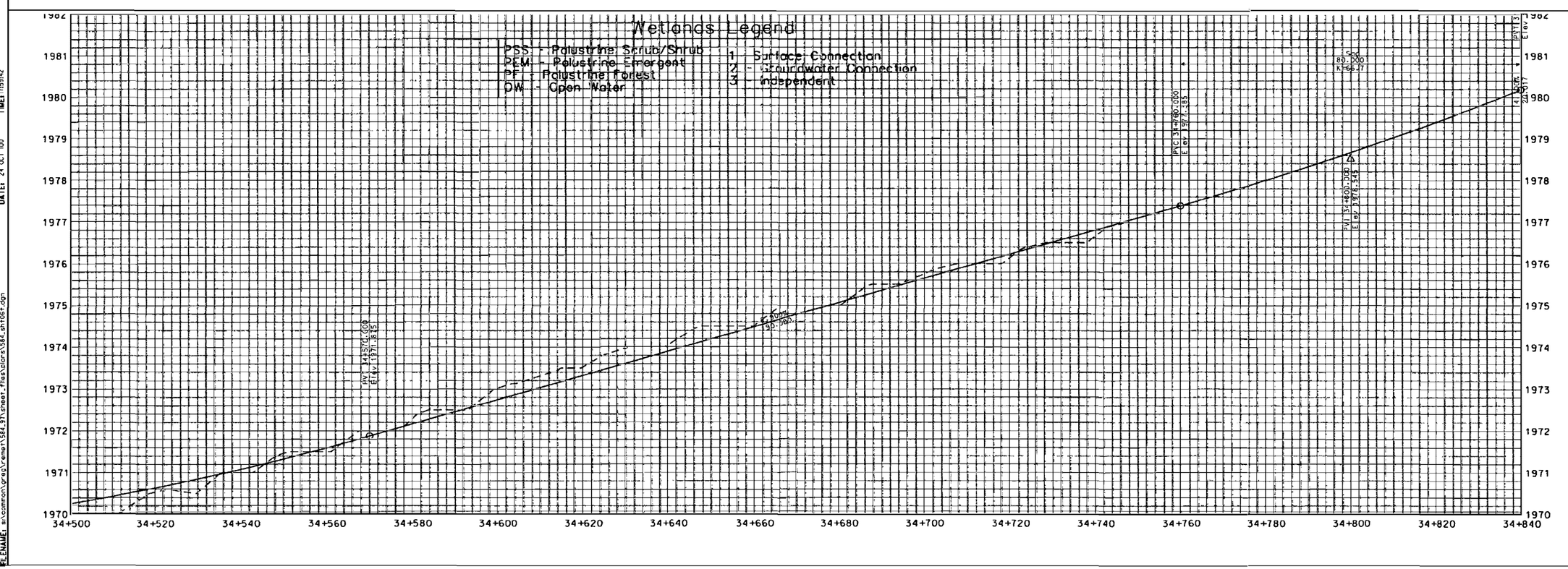
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- M1 - MSE OR GABION WALL DESIGNATION
- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION





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NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

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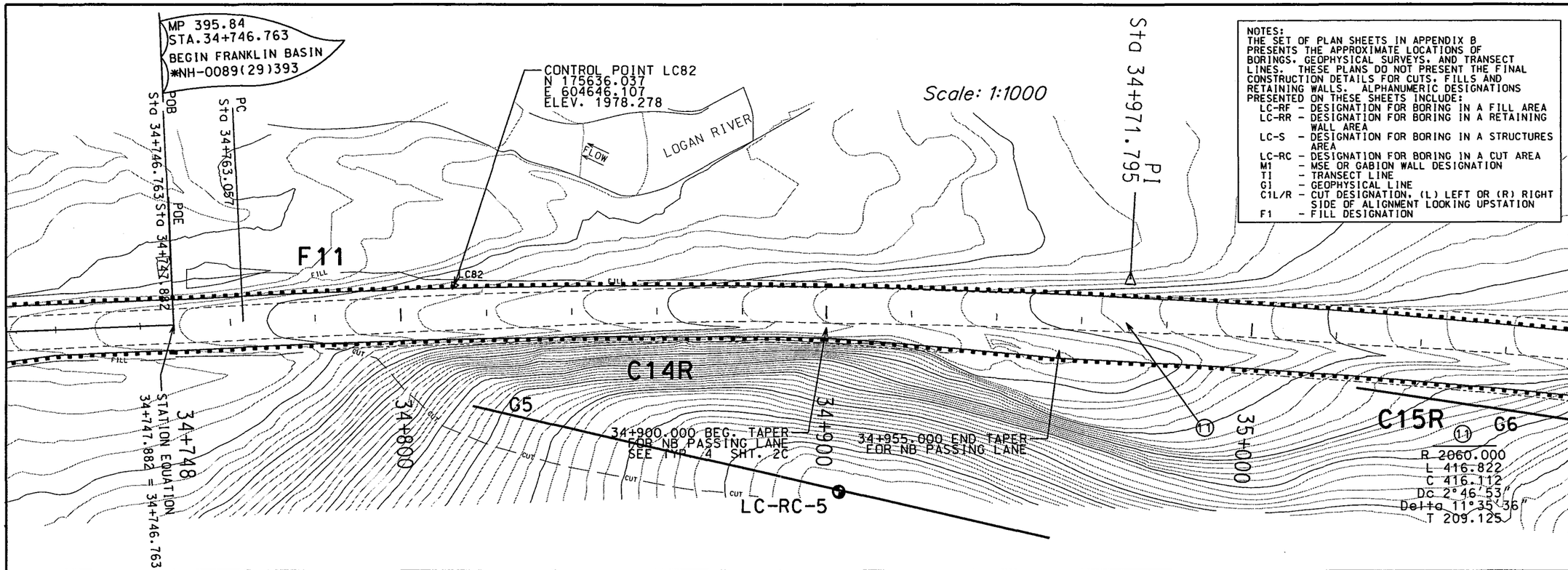
COUNTY

SHEET NO. 6T



NOTES:
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- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
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- TI - TRANSECT LINE
- GI - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 7

FILENAME: st\common\greg\remet\584_97\sheet_files\plans\584_sht07.dgn
DATE: 24 OCT 100
TIME: 18:04:44

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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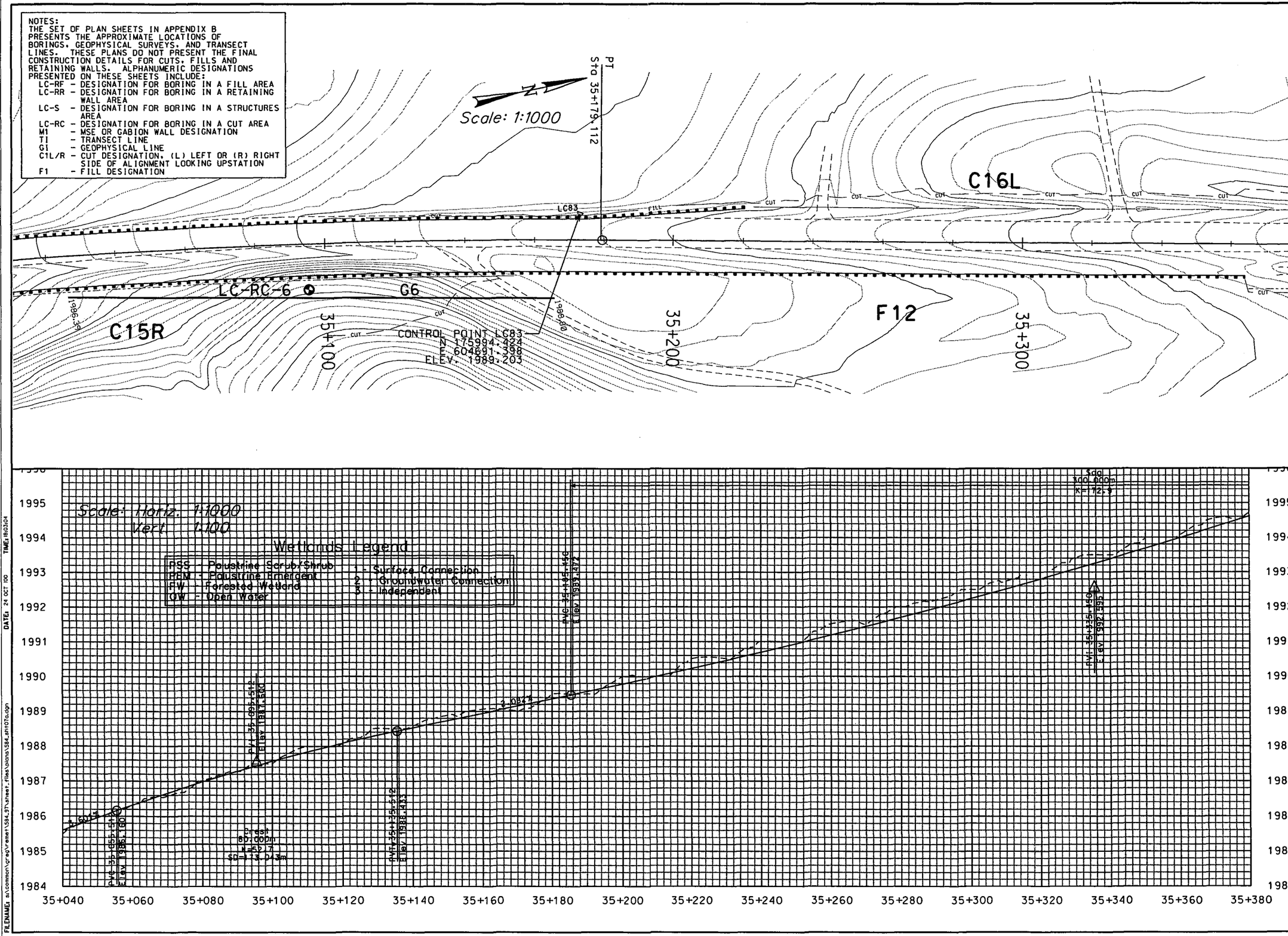
- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
- W1 - MSE OR GABION WALL DESIGNATION
- T1 - TRANSECT LINE
- G1 - GEOPHYSICAL LINE
- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION



NO.	DATE	REMARKS
		DESIGN MAPS PARCELS REQUEST REV. ALIGNMENT SELECTION

ORIGINAL SUBMISSION FOR AUTHORIZATION

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

DESIGN — CHECK — REVIEW
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QUANT. — CHECK — BY

APPROVAL RECOMM. — DATE — PROJECT DESIGN ENGINEER
APPROVED — DATE — PLANS & ESTIMATES ENGINEER

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 7A

FILENAME: a:\common\proj\rmet\S84_97\sheet_files\dgns\S84_sh107c.dgn DATE: 24 OCT 100 TIME: 18:03:04

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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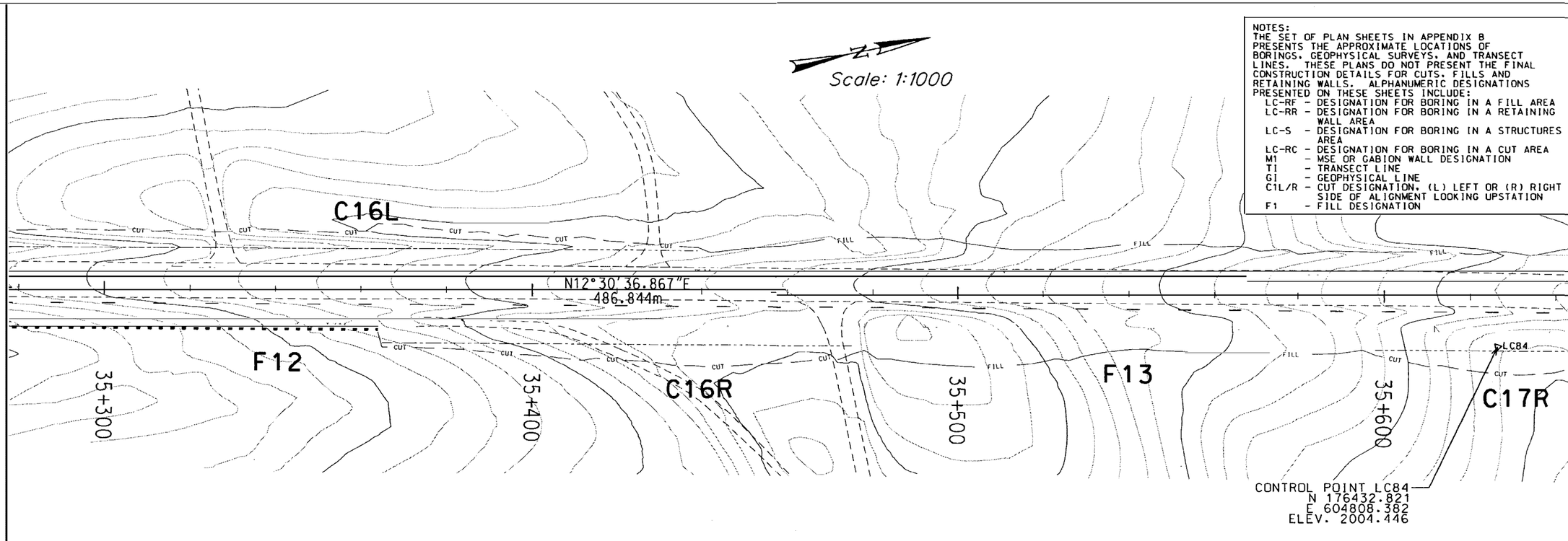

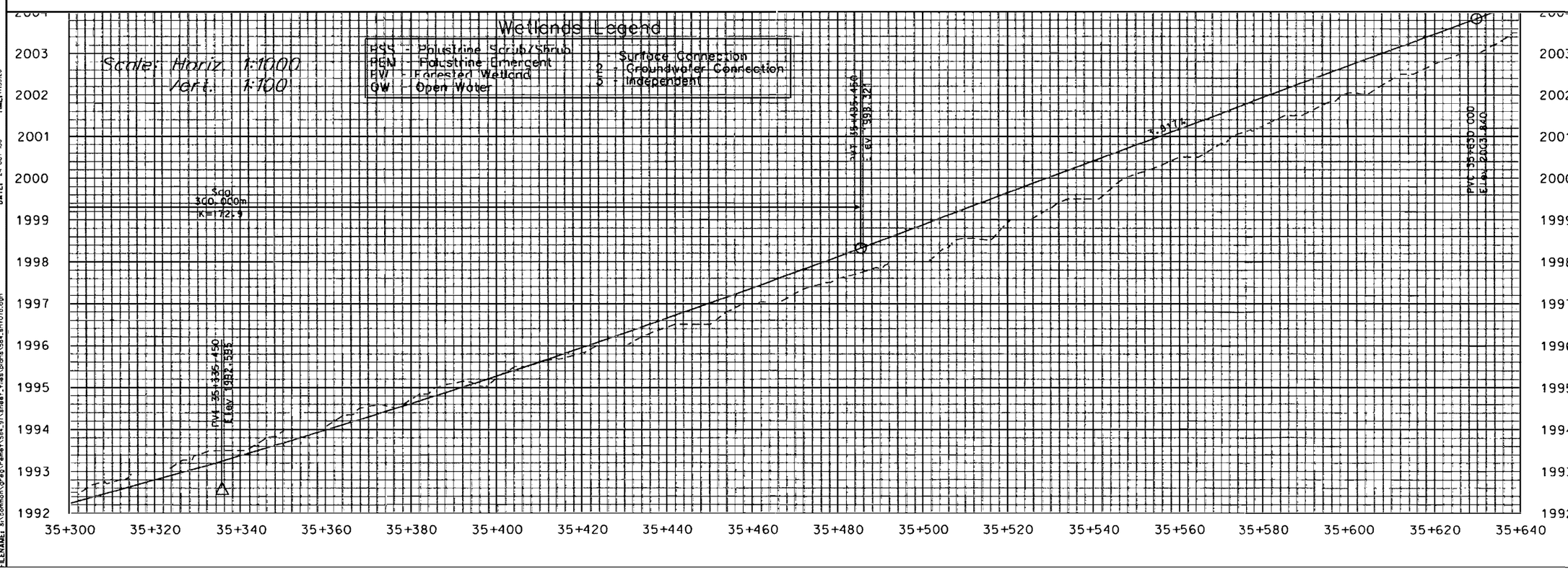

NO.	DATE	REVISIONS	REMARKS	REQUEST BY
		DESIGN REV. BY	MAPS COMPL. BY	PARCELS ACCTGD
		ORIGINAL SUBMISSION FOR AUTHORIZATION		

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

REVIEW: CHECK ____ DATE ____ BY ____

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APPROVAL RECOMM. ____ DATE ____ PROJECT DESIGN ENGINEER
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CACHE
COUNTY

SHEET NO. 7B

FILENAME: sh\common\geo\remem\584_91\sheet_files\plans\584_sn107b.dgn DATE: 24 OCT 00 TIME: 17:53:20

NOTES:
THE SET OF PLAN SHEETS IN APPENDIX B PRESENTS THE APPROXIMATE LOCATIONS OF BORINGS, GEOPHYSICAL SURVEYS, AND TRANSECT LINES. THESE PLANS DO NOT PRESENT THE FINAL CONSTRUCTION DETAILS FOR CUTS, FILLS AND RETAINING WALLS. ALPHANUMERIC DESIGNATIONS PRESENTED ON THESE SHEETS INCLUDE:

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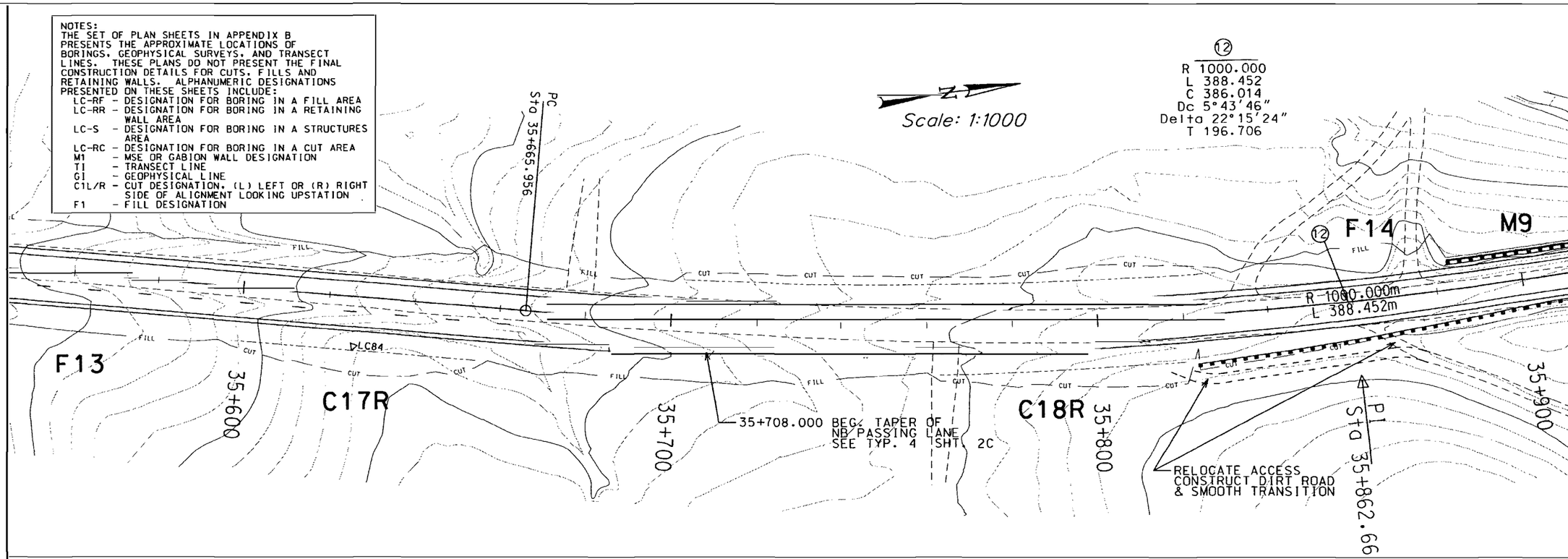

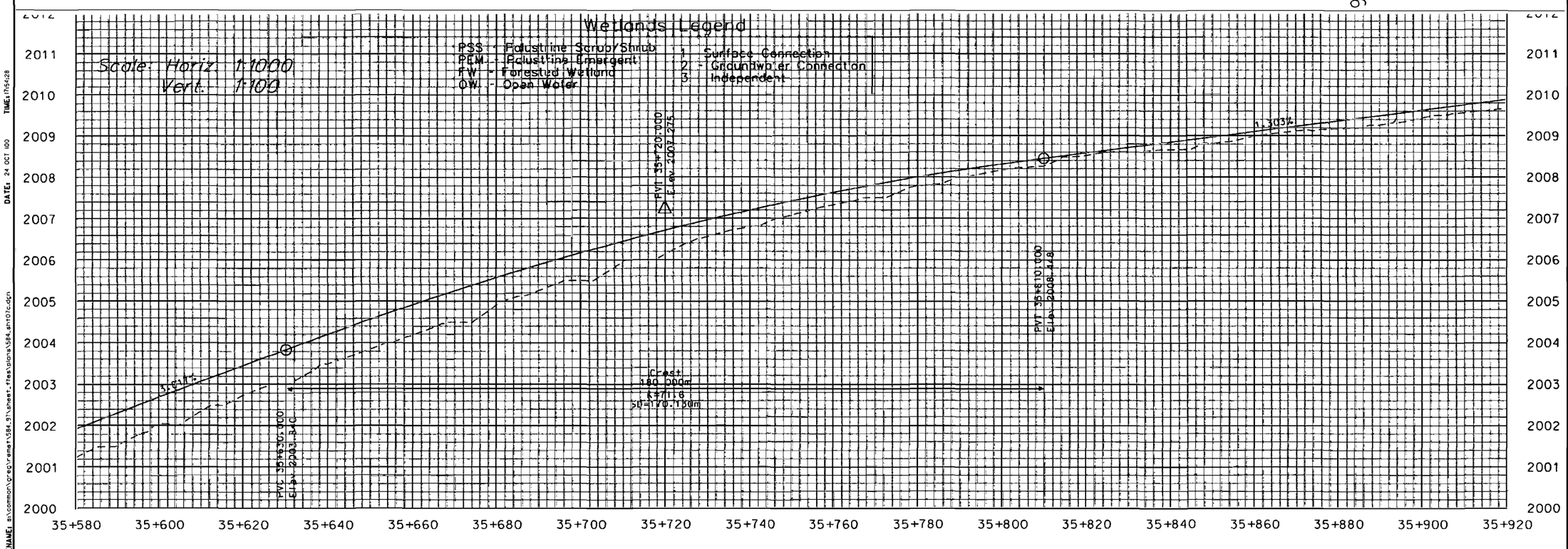

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 7C

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

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REVISIONS

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DATE: 24 OCT 100 TIME: 17:54:28
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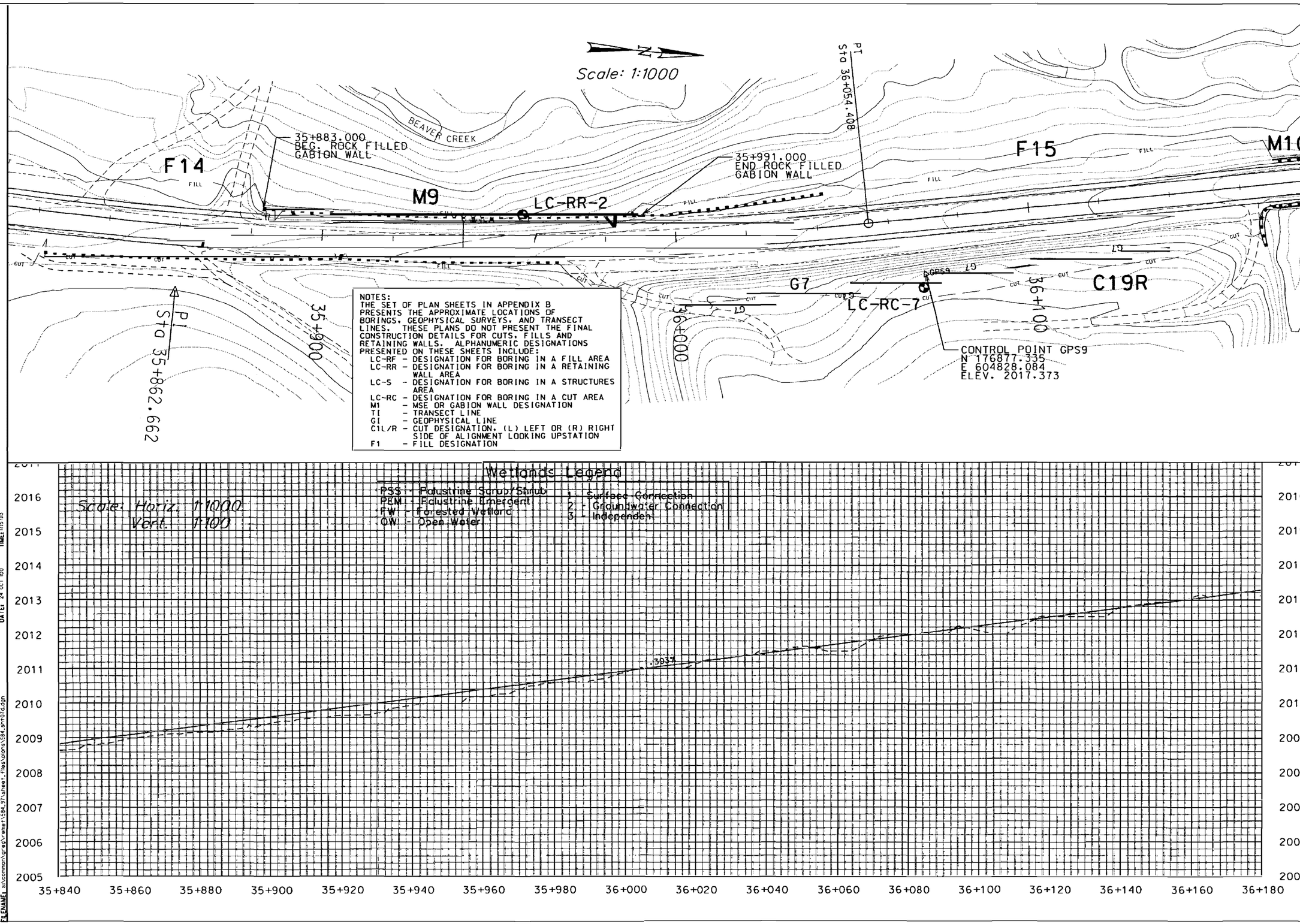

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- LC-RC - DESIGNATION FOR BORING IN A CUT AREA
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- C1L/R - CUT DESIGNATION, (L) LEFT OR (R) RIGHT SIDE OF ALIGNMENT LOOKING UPSTATION
- F1 - FILL DESIGNATION

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

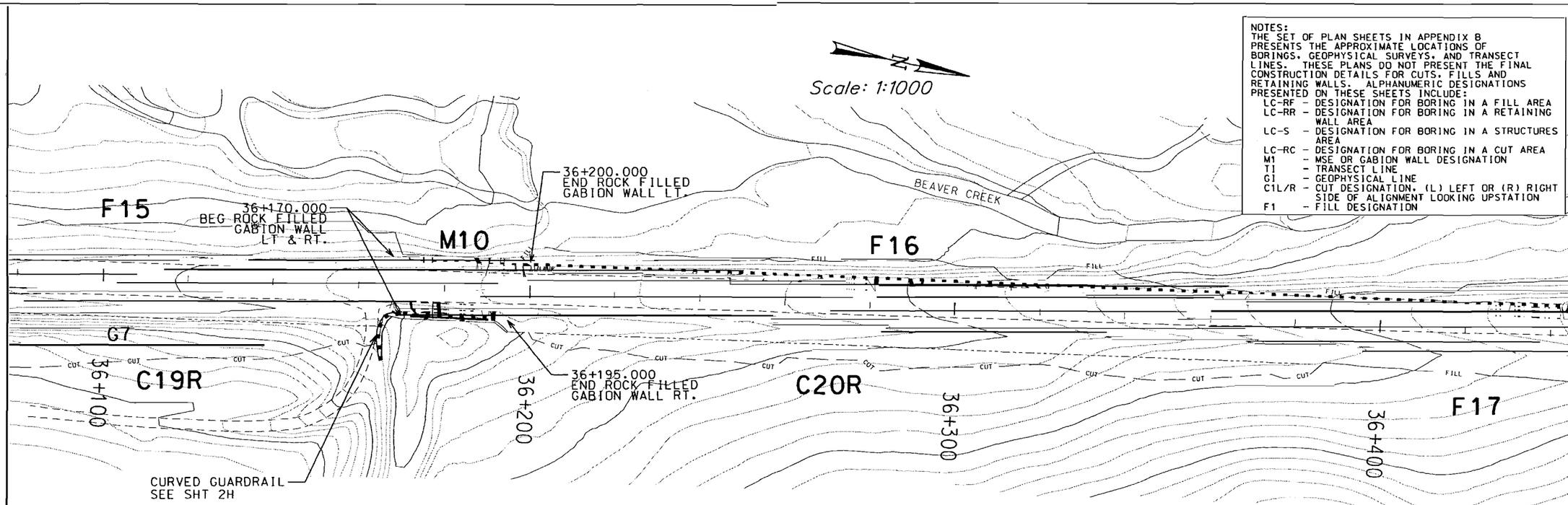
US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE
PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 7D

REVISIONS
ORIGINAL SUBMISSION FOR AUTHORIZATION

DATE: 24 OCT 100



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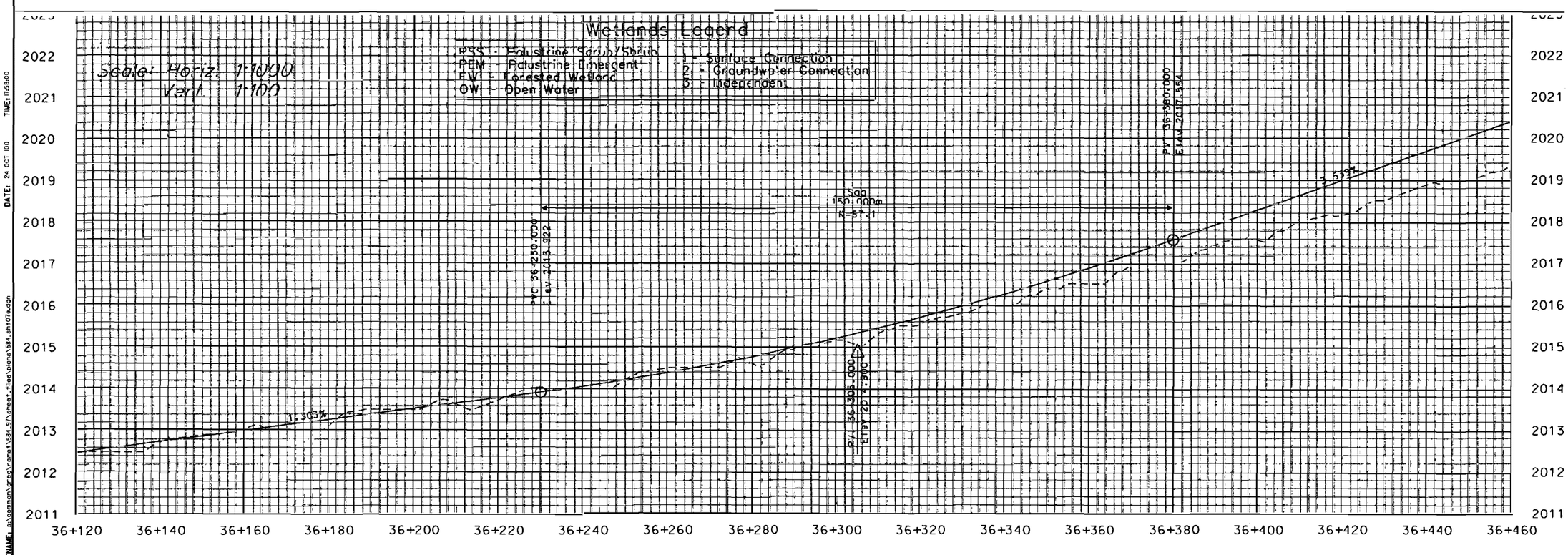

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 7E

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS

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NOTES:
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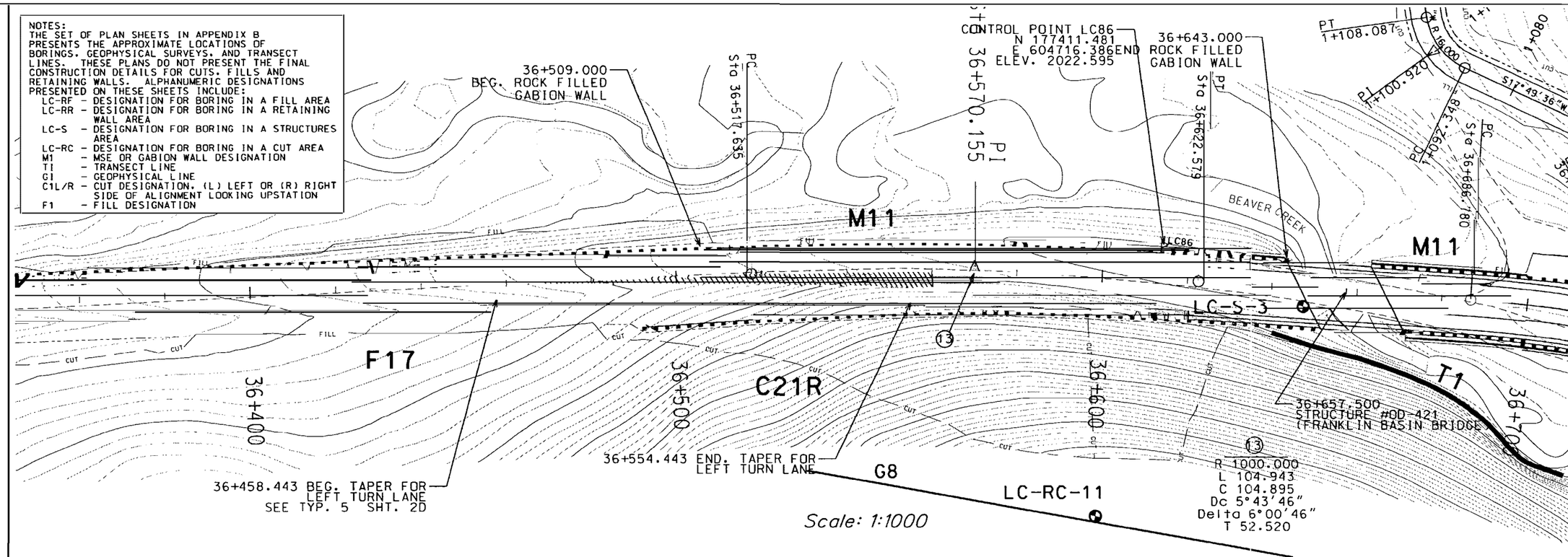
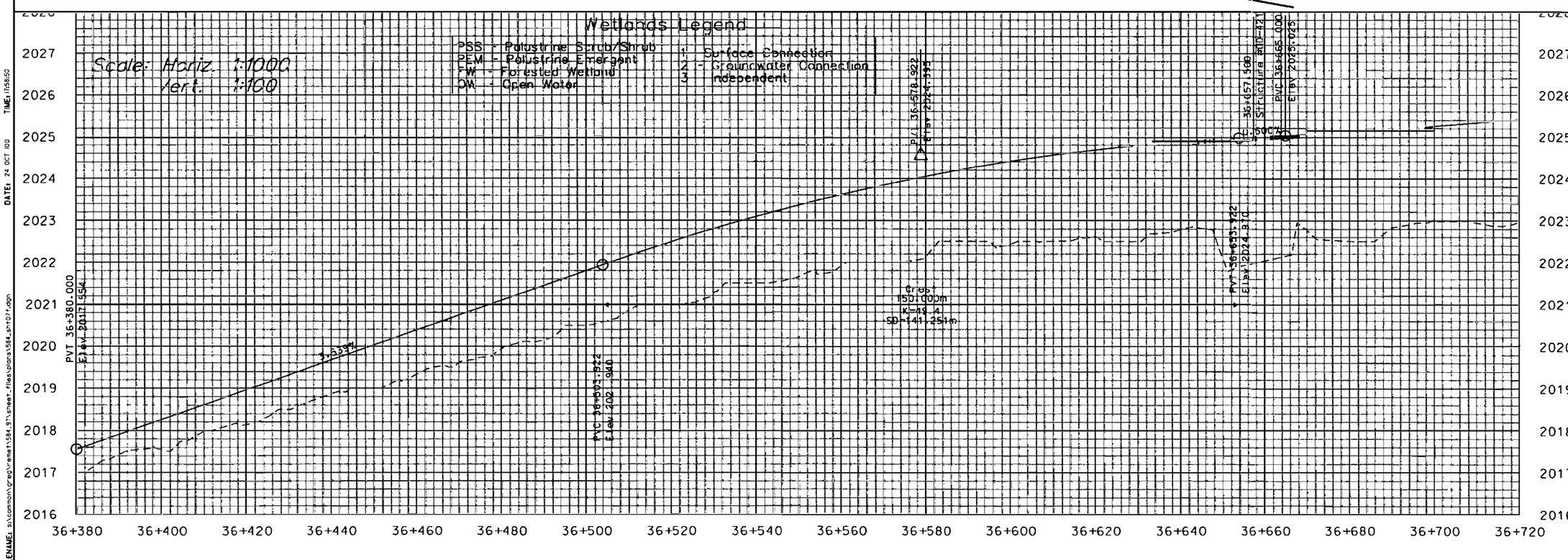
- F1 - FILL DESIGNATION





UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE
COUNTY

SHEET NO. 7F

NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION				

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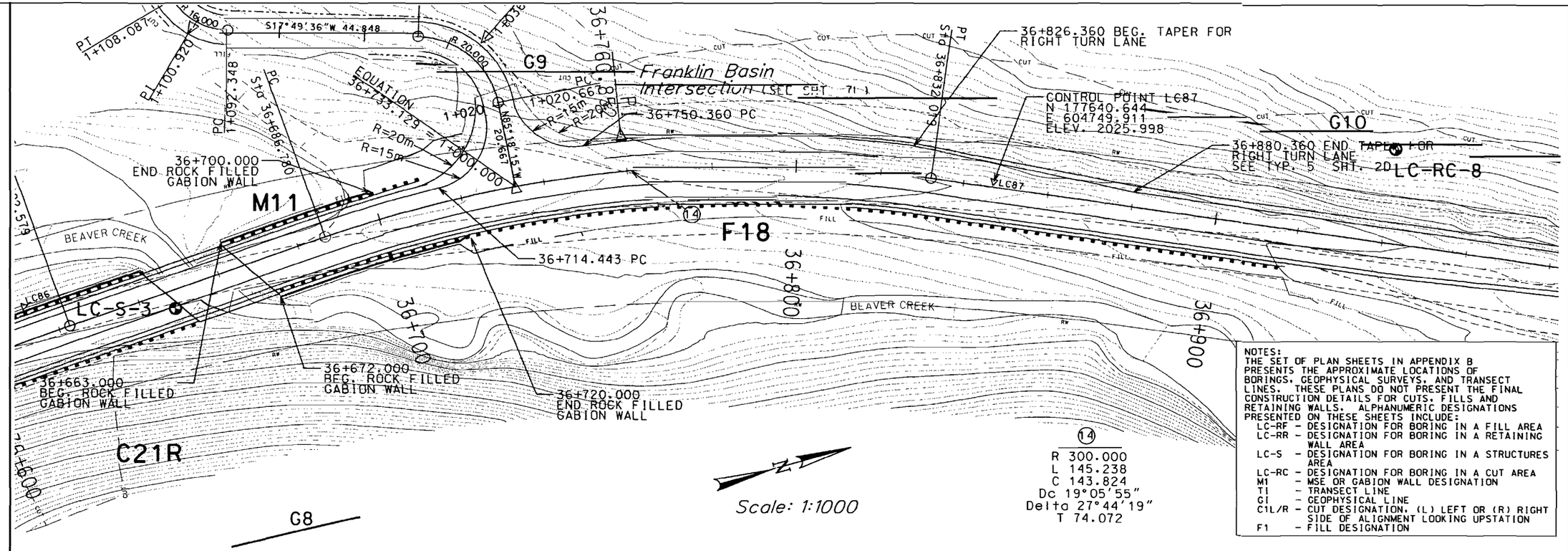

NOTES:
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- LC-RF - DESIGNATION FOR BORING IN A FILL AREA
- LC-RR - DESIGNATION FOR BORING IN A RETAINING WALL AREA
- LC-S - DESIGNATION FOR BORING IN A STRUCTURES AREA
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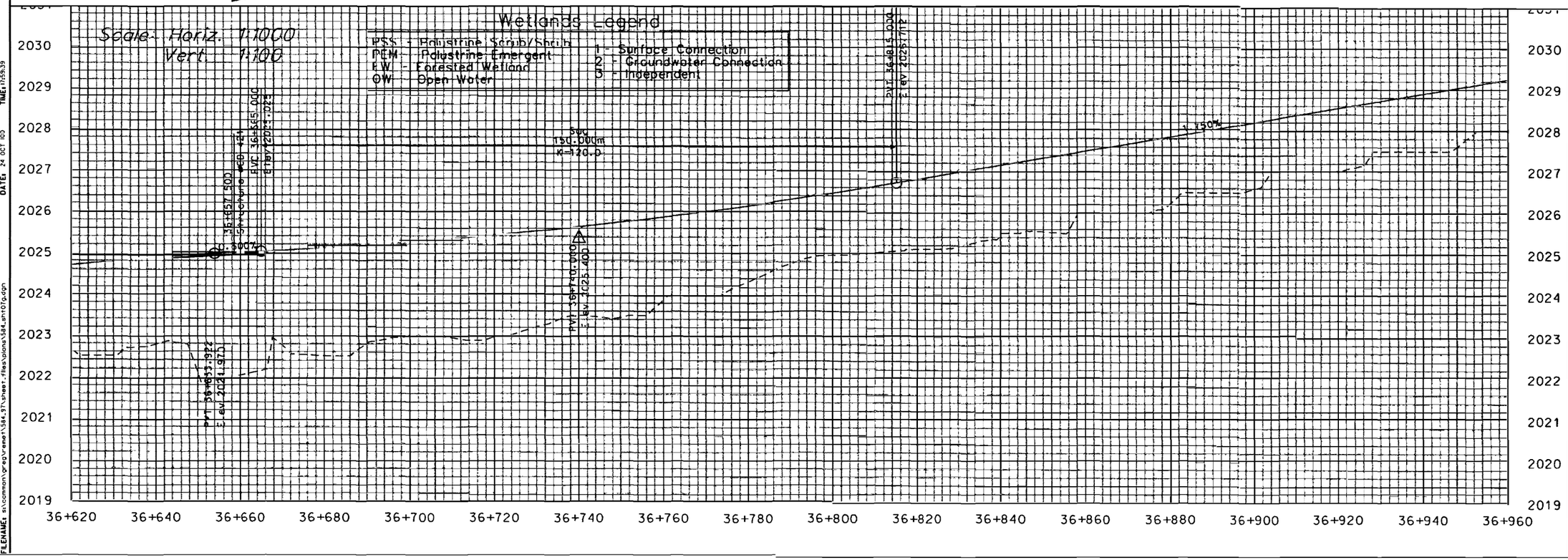
- F1 - FILL DESIGNATION



NO.	DATE	REVISIONS	REMARKS
		DESIGN, MAPS, PARCELS REQUEST RE: ROW, CORR. ST. ACCESS	
		ORIGINAL SUBMISSION FOR AUTHORIZATION	

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

SHEET NO. 7G

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DESIGN — DRAWN — QUANT.

APPROVAL RECOMM. — DATE — PROJECT DESIGN ENGINEER

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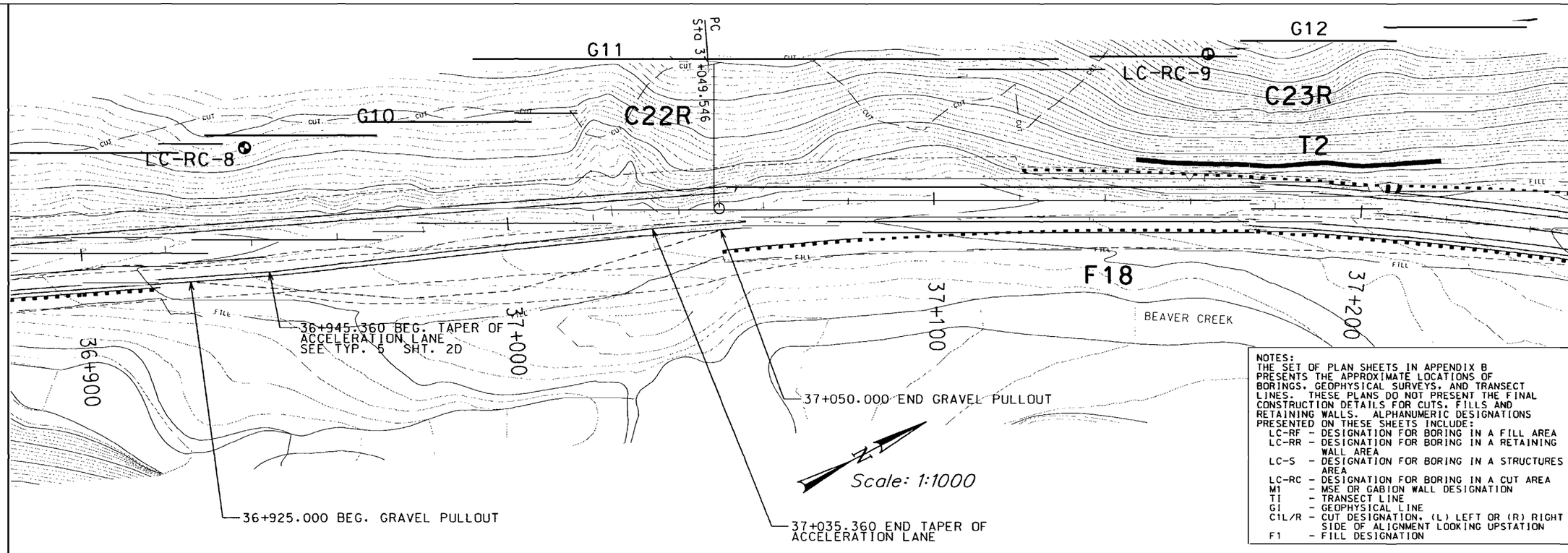

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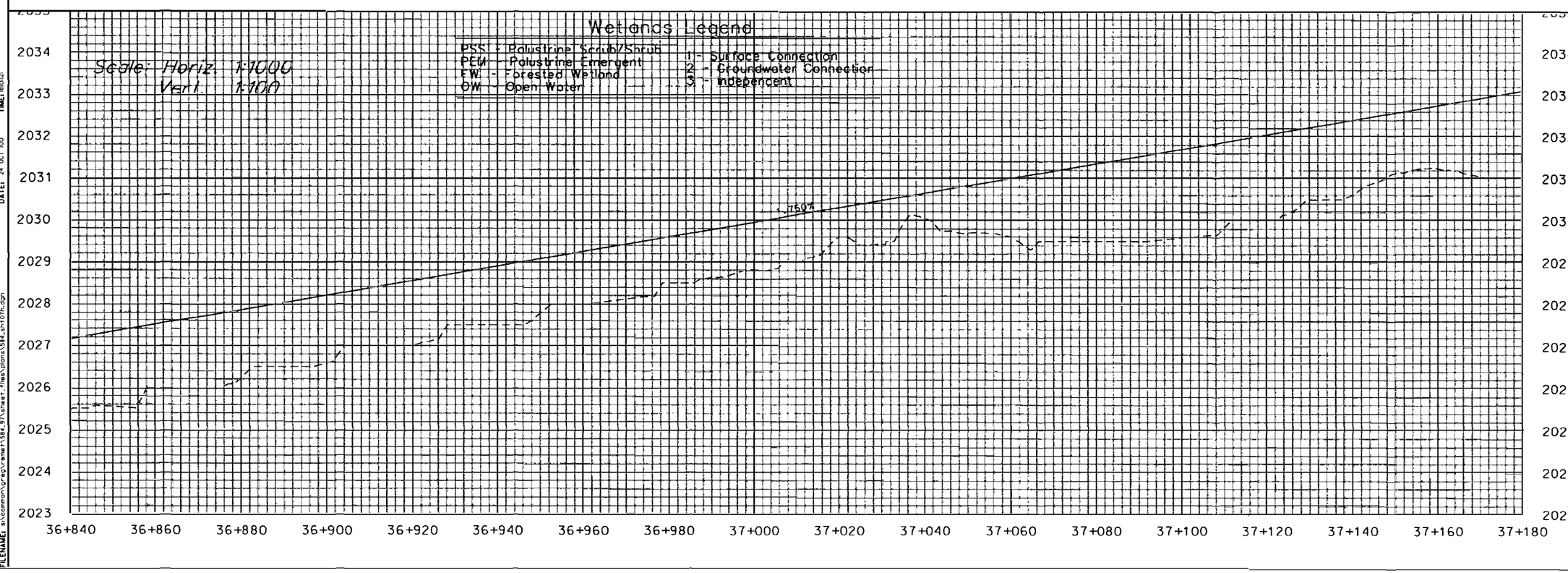

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REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON,
TONY GROVE TO FRANKLIN BASIN
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PROJECT NUMBER *NH-0089(29)393

CACHE COUNTY

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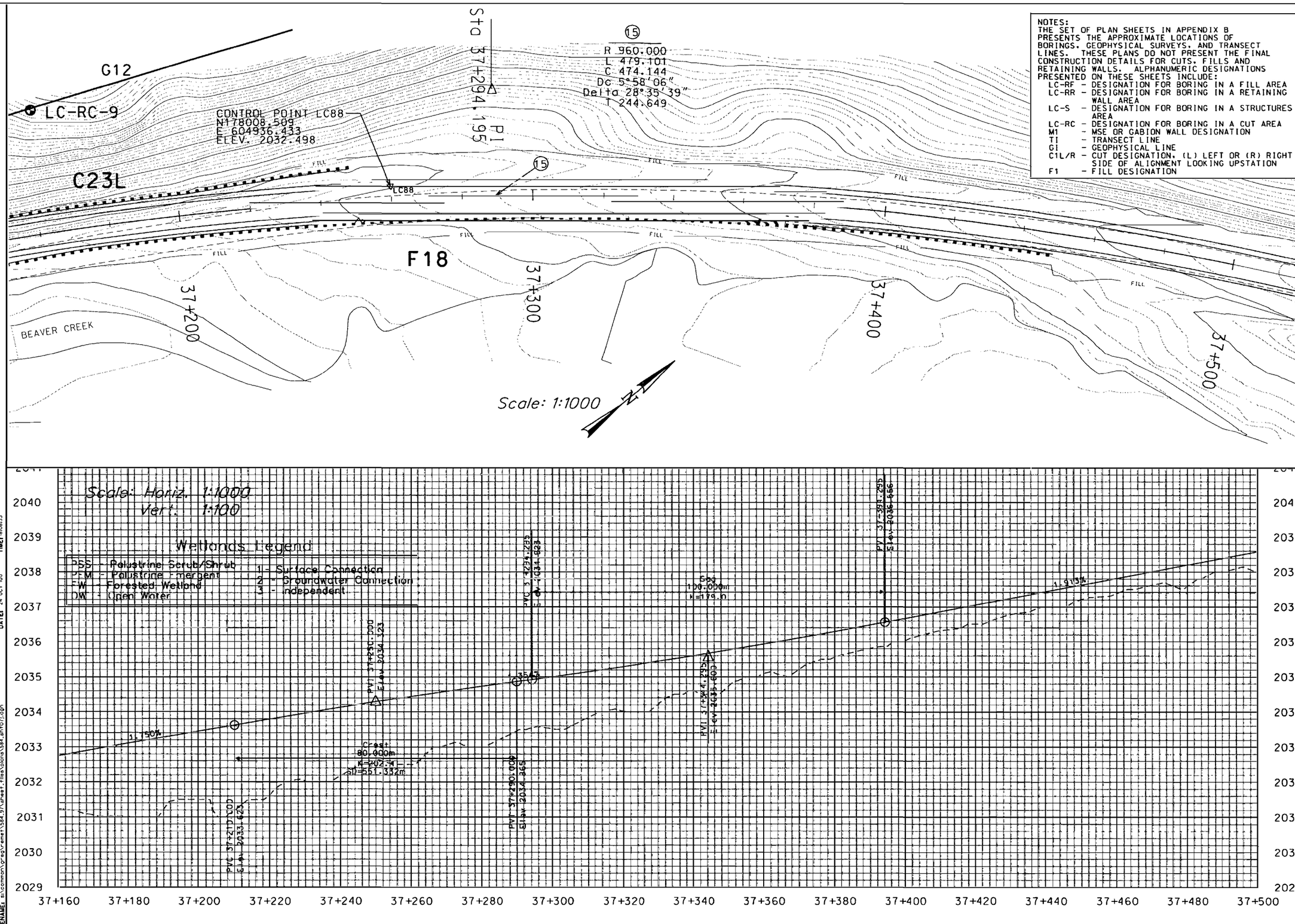

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UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

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US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN

PLAN / PROFILE

PROJECT NUMBER *NH-0089(29)393

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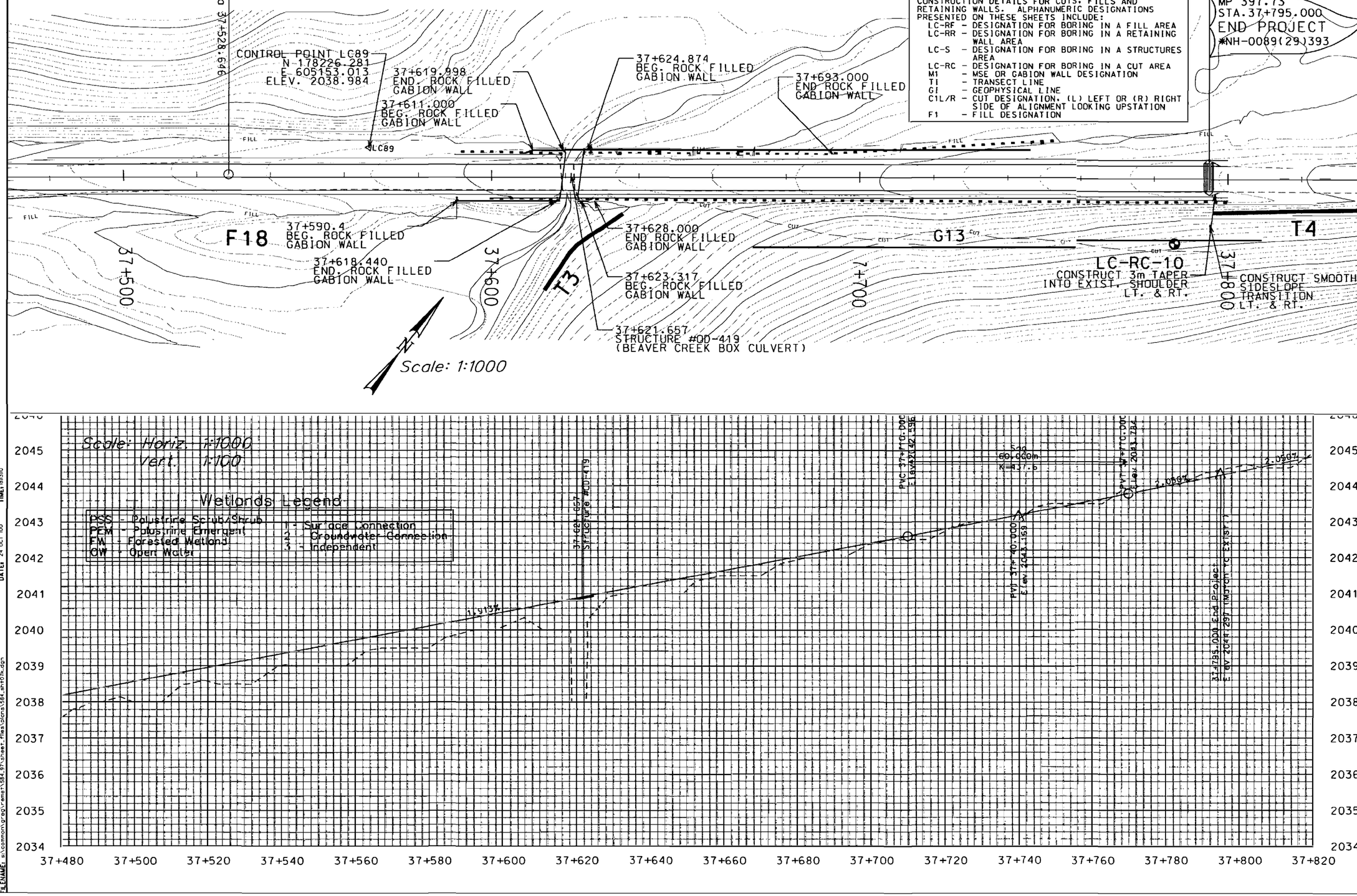

UTAH DEPARTMENT OF TRANSPORTATION
REGION ONE - OGDEN, UTAH
ROADWAY DESIGN

US-89 LOGAN CANYON.
TONY GROVE TO FRANKLIN BASIN
PLAN / PROFILE
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APPENDIX B

Appendix B

Explanation and Boring Logs

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

EXPLANATION TO BORING LOGS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOLS GRAPHIC	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVELS MORE THAN 50% OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SANDS MORE THAN 50% OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE-GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50			ML	INORGANIC SILTS & VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

OTHER CLASSIFICATIONS USED FOR BORING LOGS

CLASSIFICATION	DESCRIPTION	GRAPHIC SYMBOL
BOULDERS BOULDERS AND COBBLES IS IN A CLAY MATRIX. GRAVELS, COBBLES, AND BOULDERS	SEE "GRADATION" SECTION ON EXPLANATION SHEET FOR PARTICLE SIZE RANGES	
CONGLOMERATE	CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT	
QUARTZITE		
LIMESTONE		
DOLOMITE		
SHALE		

SOIL LABORATORY TEST DESCRIPTIONS

UNIT WEIGHT – DETERMINES WET WEIGHT (WW) AND DRY WEIGHT (DW) OF RELATIVELY UNDISTURBED SOIL SPECIMEN; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

WATER CONTENT (ASTM D 4318) – DETERMINES WATER CONTENT (WC) OF SOILS BY DRYING WITH DIRECT HEAT; RESULTS REPORTED ON BORING LOGS

ATTERBERG LIMITS (ASTM D 4318) – DETERMINES PLASTICITY INDEX (PI), PLASTIC LIMIT (PL), AND LIQUID LIMIT (LL) OF SOILS; RESULTS [INCLUDING NON-PLASTIC (NP), IF APPLICABLE] REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

PARTICLE-SIZE ANALYSIS (ASTM D 422) – DETERMINES DISTRIBUTION OF GRAIN SIZES IN A SOIL SPECIMEN:

#4 = %PASSING NO.4 SIEVE (% SAND+FINE-GRAINED SOIL)
#200 = % PASSING NO. 200 SIEVE (% FINE-GRAINED SOIL)
0.005mm = % SMALLER THAN 0.005mm; DETERMINED BY HYDROMETER (PERCENT CLAY);
RESULTS REPORTED ON FIELD TEST BORING LOGS AND IN GEOTECHNICAL REPORT

CONSOLIDATION TEST (ASTM D 2435) – DETERMINES RATE AND MAGNITUDE OF CONSOLIDATION OF A SOIL SPECIMEN WHEN IT IS RESTRAINED LATERALLY AND LOADED AND DRAINED AXIALLY; RESULTS, INCLUDING PRECONSOLIDATION PRESSURE (Pp), VIRGIN CONSOLIDATION INDEX (Cc), RECOMPRESSION INDEX (Cr), AND COEFFICIENT OF CONSOLIDATION (Cv), REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166) – DETERMINES UNCONFINED COMPRESSIVE STRENGTH (qu) OF A RELATIVELY UNDISTURBED COHESIVE SOIL SPECIMEN USING A STRAIN-CONTROLLED APPLICATION OF THE AXIAL LOAD; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

CHEMICAL TESTS – DETERMINE SULFATES (SO4) AND SOLUBLE SALTS CONTENT, pH, AND MINIMUM ELECTRICAL RESISTIVITY (MR) OF SOIL SPECIMEN; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

ROCK LABORATORY TEST DESCRIPTIONS

UNIAXIAL COMPRESSIVE STRENGTH WITH POISSON'S RATIO (ASTM D 2938/3148) – DETERMINES UNCONFINED COMPRESSIVE STRENGTH (qu) AND POISSON'S RATIO (μ) OF AN INTACT ROCK CORE SPECIMEN; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

BULK DENSITY, POROSITY, AND PERCENT MOISTURE – DETERMINES BULK DENSITY (BD), POROSITY (n), AND WATER CONTENT (WC) OF AN INTACT ROCK CORE SPECIMEN; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

SLAKE DURABILITY (ASTM D 4644) – DETERMINES SLAKE DURABILITY INDEX (SD) OF A SHALE OR SIMILAR WEAK ROCK AFTER 2 DRYING AND WETTING CYCLES WITH ABRASION; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

SWELLING/SETTLEMENT POTENTIAL (SIMILAR TO ASTM D4546)– DETERMINES MAGNITUDE OF SWELL OR SETTLEMENT (%H) OF A RELATIVELY UNDISTURBED COHESIVE SOIL/ROCK SPECIMEN; RESULTS REPORTED ON BORING LOGS AND IN GEOTECHNICAL REPORT

SOIL FIELD CLASSIFICATION/ SAMPLE DATA

PENETRATION RESISTANCE

STANDARD PENETRATION TEST (ASTM D 1586) – NUMBER OF BLOWS REQUIRED TO DRIVE A STANDARD 50.8mm OUTSIDE DIAMETER SPLIT BARREL SAMPLER 304.8mm USING A 63.5kg WEIGHT FALLING FREELY FOR 760mm. BLOWS RECORDED IN THREE 152.4mm INCREMENTS FOR A TOTAL DRIVE OF 450mm.

EQUIVALENT SPT "N-VALUES" FOR DAMES & MOORE TYPE-U SAMPLER, WITH AN OUTSIDE DIAMETER OF APPROXIMATELY 84.0mm, WERE APPROXIMATED BY DIVIDING THE TYPE-U "N-VALUE" BY 2.

RELATIVE DENSITY – COHESIONLESS SOILS

DESCRIPTION OF RELATIVE DENSITY	SPT N-VALUE BLOWS PER 0.3m	RELATIVE DENSITY (%)
VERY LOOSE	< 4	0–15
LOOSE	4 – 10	15–35
MEDIUM DENSE	10 – 30	35–65
DENSE	30 – 50	65–85
VERY DENSE	> 50	85–100

CONSISTENCY – COHESIVE SOILS

CONSISTENCY	SPT N-VALUE BLOWS/0.3m	THUMB PENETRATION
VERY SOFT	< 2	EASILY PENETRATED MORE THAN 25mm
SOFT	2 – 4	EASILY PENETRATED 25mm
MEDIUM STIFF	4 – 8	CAN BE PENETRATED OVER 6mm WITH MODERATE EFFORT
STIFF	8 – 15	INDENTED ABOUT 6mm, PENETRATED WITH GREAT EFFORT
VERY STIFF	15 – 30	READILY INDENTED BY THUMBNAIL
HARD	30 – 60	INDENTED WITH DIFFICULTY BY THUMBNAIL
VERY HARD	>60	THUMBNAIL WILL NOT INDENT SOIL

GRADATION

MATERIAL	FRACTION	SIEVE SIZE	GRAIN SIZE
BOULDERS		> 304.8mm	> 304.8mm
COBBLES		75 to 304.8mm	75 to 304.8mm
GRAVEL	COARSE	19 to 75 mm	19 to 75mm
	FINE	No. 4 to 19mm	4.75 to 19mm
SAND	COARSE	No. 10 to No. 4	2 to 4.75mm
	MEDIUM	No. 40 to No. 10	430µm to 2mm
	FINE	No. 200 to No. 40	75 to 430um
FINES(SILT AND CLAY)		PASSING No. 200	< 75um

NOTE: GRADATIONS ARE FOR RETRIEVED SAMPLES ONLY. IN-PLACE MATERIAL MAY HAVE LARGER PARTICLE SIZES.

CRITERIA FOR DESCRIBING MOISTURE CONTENT

SLIGHTLY MOIST	ABSENCE OF MOISTURE, DUSTY, DRY TO TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL IS BELOW WATER TABLE

VARIATIONS IN SOIL STRATIGRAPHY

TRACE	< 5%
FEW	5 to 10%
LITTLE	15 to 25%
SOME	30 to 45%
MOSTLY	50 to 100%

CRITERIA FOR CLAY PLASTICITY AND DRY STRENGTH

PLASTICITY	PLASTICITY INDEX	DRY STRENGTH
NON-PLASTIC	0 – 3	VERY LOW
LOW	3 – 15	LOW
MEDIUM	15 – 30	MEDIUM
HIGH	>30	HIGH

ROCK FIELD CLASSIFICATION/ SAMPLE DATA

RQD LENGTH – SUM OF LENGTHS OF WHOLE CORE PIECES WITH LENGTH EQUAL TO OR GREATER THAN 10 cm (PER ASTM D6032-96 AND FHWA-TS-89-045, APPENDIX A, p14).

RQD – ROCK QUALITY DESIGNATION. COMPUTED FROM RQD LENGTH DIVIDED BY LENGTH OF CORE ADVANCE ("DRILL RUN TO" MINUS "DRILL RUN FROM").

RQD (%)	ROCK DESCRIPTION
<25	VERY POOR
25–50	POOR
50–75	FAIR
75–90	GOOD
>90	EXCELLENT

WHOLE CORE LENGTH – SUM OF ALL WHOLE CORE PIECES IN THE DRILL INTERVAL. A CORE SPECIMEN IS CONSIDERED A WHOLE PIECE IF 1) SOME COMPONENT OF A CORE PIECE HAS A FULL CORE DIAMETER, OR 2) A FRACTURED CORE PIECE (WITH FRACTURE PARALLEL TO CORE AXIS) HAS A LENGTH EQUAL TO OR GREATER THAN THE CORE DIAMETER.

NO. OF WHOLE PIECES – NO. OF WHOLE CORE PIECES WHICH MEET CRITERIA LISTED ABOVE.

LENGTH LONGEST PIECE – LENGTH OF LONGEST WHOLE PIECE IN A DRILL RUN.

LENGTH >=30.5cm – SUM OF LENGTHS OF CORE PIECES EQUAL TO GREATER THAN 30.5cm.

BROKEN ZONE LENGTH – TOTAL LENGTH OF CORE INTERVALS COMPOSED OF PIECES WITH LENGTHS LESS THAN ONE CORE DIAMETER, IN WHICH MORE THAN 50% CONSISTS OF FRAGMENTS WITH A DIAMETER GREATER THAN 1.3cm.

RUBBLE ZONE LENGTH – TOTAL LENGTH OF CORE INTERVALS COMPOSED OF PIECES WITH LENGTHS LESS THAN ONE CORE DIAMETER, IN WHICH MORE THAN 50% CONSISTS OF FRAGMENTS WITH A DIAMETER LESS THAN 1.3cm.

BEDDING ANGLE – ANGLE (MEASURED FROM THE HORIZONTAL PLANE) AT WHICH ROCK BEDS WITHIN A DRILL RUN ARE ESTIMATED TO BE LAYERED.

HARDNESS – A DESCRIPTION OF UNCONFINED CONPRESSIVE STRENGTH OF ROCK BASED ON THE DEERE, ET. AL., HARDNESS CLASSIFICATION SCALE:

HARDNESS	DESCRIPTION	APPROX. RANGE OF UNCONFINED COMPRESSIVE STRENGTH (kPa)
R0	EXTREMELY SOFT	193 – 690
R1	VERY SOFT	690 – 6,895
R2	SOFT	6,895 – 27,580
R3	AVERAGE	27,580 – 55,160
R4	HARD	55,160 – 110,320
R5	VERY HARD	110,320 – 220,640
R6	EXTREMELY HARD	> 220,640

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Boring: LC-RC-01
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

TOPSOIL: Silty clay (CL), moist to wet, low to medium plasticity, dark brown, with organics

BOULDERS IN A CLAY MATRIX WITH GRAVEL AND COBBLES: very dense, contains quartzite and limestone fragments

LIMESTONE BEDROCK: moderately strong, weathered, highly fractured, thinly bedded, brecciated, with calcite- and clay-filled fractures, bedding angle ranges from 8 to 15 degrees, moderately to highly weathered
note: recovered sample (4.9-5.3m) contains numerous fractures at angles of 60 degrees or more
note: recovered sample (5.3-5.6m) contains 2 fractures at angles of 60 degrees or more
note: recovered sample (5.6-6.4m) contains 3 fractures at angles of 60 degrees or more
note: recovered sample (6.4-7.6m) contains 5 fractures at angles of 60 degrees or more
note: grades with occasional voids approxomately 3 to 6cm thick; recovered sample (7.6-9.3m) contains 4 fractures at angles of 60 degrees or more
note: grades very strong with weak zones; highly fractured from approximately 9.5 to 11.0m below existing grade; relatively small voids are present; recovered sample (9.3-11.0m) contains numerous fractures at angles of 60 degrees or more
note: recovered sample (11.0-11.3m) contains 1 fracture at an angle of 60 degrees or more
note: grades with some reddish coloration, recovered sample (11.3-12.5m) contains 4 fractures at angles of 60 degrees or more
note: recovered sample (12.5-14.0m) contains 4 fractures at angles of 60 degrees or more

Boring completed at 14.0m below existing grade.

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
	0	C			0.0	0.9	0	0											
		C			0.9	1.8	0	0											
5		C			1.8	3.4	0	0											
10		C			3.4	3.7	15	50											
		C			3.7	4.9	95	78											
15	5	C			4.9	5.3	40	87	0	0	3	2	3	0	37	0	10	R3	
		C			5.3	5.6	34	110	0	0	6	1	6	0	27	0	15	R3	
20		C			5.6	6.4	70	92	43	56	52	4	21	0	18	0	10	R3	WW = 26.06 kN/m³, q_u = 43625 kN/m², μ = 0.118
		C			6.4	7.6	128	105	21	18	79	12	21	0	49	0	10	R3	WC = 0.9%, SG_s = 2.81
25		C			7.6	9.3	153	91	55	33	107	17	12	0	46	0	10	R3	
30	10	C			9.3	11.0	153	91	46	27	85	5	27	0	52	15	30	R5	WW = 25.81 kN/m³, q_u = 158413 kN/m², μ = 0.141, SD = 94.3
35		C			11.0	11.3	31	100	9	30	9	1	9	0	21	0	10	R4	
		C			11.3	12.5	122	100	101	83	95	8	18	0	21	6	8	R4	
40		C			12.5	14.0	153	100	43	28	67	7	21	0	79	6	8	R4	
45																			
50	15																		
55																			
60	19																		

Lab Test Abbreviations
WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-01** Sheet **1** of **1**

Logged by:	**M. Flint**
Date Start/Finish:	**05-13-99 / 05-14-99**
Weather:	**Rainy/sunny, 50±5 °F**
Station: **22+788.965**	Offset: **19.548**
Coordinates: N: **166400.9**	E: **601245.5** Elev.:**1771.439**
Groundwater Depth (m):	**Unknown - hole caved at 4.9m**
Depth to Bedrock (m):	**4.6**
Total Depth Drilled (m):	**14.0**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

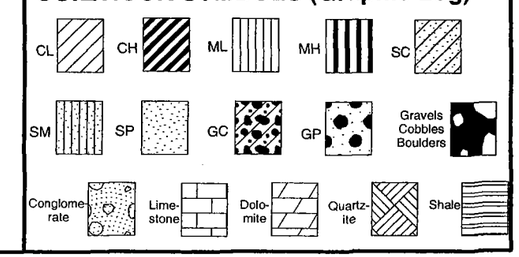
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-02
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
	0		S	2-2-3	5	0.0	0.5	8	17											
			C			0.5	1.1	15	25											
			C			1.1	1.2	22	142											
			C			1.2	1.4	13	83											
5			C			1.4	1.8	33	72											#4 = 86.6%, #200 = 64.7%
			C			1.8	3.4	52	34											
10			C			3.4	4.9	88	58											PI = 22, PL = 21, LL = 43
15	5		C			4.9	6.4	101	66											
20			C			6.4	7.9	153	100	116	76	153	6	40	40	18	0	8	R3	
25			C			7.9	9.5	153	100	76	50	153	9	21	0	18	0	8	R3	WW = 25.80 kN/m³, q_u = 34254 kN/m², μ = 0.340
30	10		C			9.5	11.0	153	100	64	42	153	5	21	0	76	0	10	R3	
35			C			11.0	12.5	153	100	101	66	153	8	24	0	43	0	10	R3	
40			C			12.5	14.0	156	102	156	102	156	8	31	31	0	0	10	R3	
45	15		C			14.0	15.6	153	100	146	96	153	7	46	79	0	0	5	R3	
50			C			15.6	17.1	153	100	116	76	153	6	40	40	34	0	5	R3	
55																				
60	19																			

TOPSOIL: Silty clay (CL), with trace sand and gravel, soft, moist, low plasticity, dark brown, with organics

SILTY CLAY (CL): with some gravel, wet, medium to high plasticity, brown

BOULDERS IN A CLAY MATRIX, very dense, consists primarily of quartzite and limestone; wet, moderately plastic, yellowish red, with calcareous deposits, sand, and gravel

note: grades with occasional clayey gravel layers and less calcareous deposits

note: grades very soft/very loose, with red coloration; loss of water indicates a void at about 6.1m below existing grade

LIMESTONE BEDROCK: moderately strong, fractured, thinly bedded, with calcite- and clay-filled fractures, bedding angle ranges from 5 to 10 degrees

note: *recovered sample (6.4-7.9m)contains 4 fractures at angles of 60 degrees or more*

note: recovered sample (7.9-9.5m) contains 4 fractures at angles of 60 degrees or more

note: grades moderately weak to weak and highly fractured from approximately 9.5 to 11.0m below existing grade, recovered sample contains (9.5-11.0m) at least 6 fractures at angles of 60 degrees or more

note: grades moderately strong, slightly fractured, recovered sample (11.0-12.5m) contains 4 fractures at angles of 60 degrees or more

note: recovered sample (12.5-14.0m) contains 2 fractures at angles of 60 degrees or more

note: recovered sample (14.0-15.6m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (15.6-17.1m) contains 3 fractures at angles of 60 degrees or more

Boring completed at 17.1m below existing grade.

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-02** Sheet **1** of **1**

Logged by:	**M. Flint**
Date Start/Finish:	**05-17-99 / 05-18-99**
Weather:	**Sunny, 50±5 °F**
Station: **23+242.378**	Offset: **-47.118**
Coordinates: N: **166588.7**	E: **601604.6** Elev.:**1771.967**
Groundwater Depth (m):	**Unknown - hole caved at 6.1m**
Depth to Bedrock (m):	**6.4**
Total Depth Drilled (m):	**17.1**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

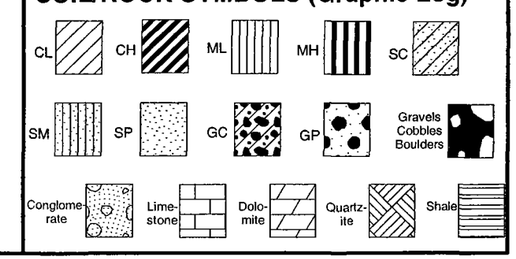
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and *51mm OD split spoon sampler*
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



Boring: LC-RC-03
Sheet 1 of 1

SOIL/ROCK SAMPLE DATA

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces > = 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
BOULDERS IN A CLAY MATRIX WITH COBBLES: glacial till, very hard/very dense, consists primarily of quartzite, moderately plastic		0					0.0	0.3													
	5			C			0.3	1.8	61	40											
				C			1.8	2.0	15	100											
	10			C			2.0	3.4	82	60											
	15			C			3.4	4.9	52	34											PI = 18, PL = 18, LL = 36, #4 = 28.6%, #200 = 23.5%
SILTY CLAY (CL): glacial till with sand and numerous interbedded gravels, cobbles, and boulders, low to medium plasticity, brownish yellow		5		S	14-6-7	13	4.9	5.3	18	40											
	20			C			4.9	6.4	15	10											
SANDY BOULDERS WITH GRAVELS AND COBBLES: glacial till, very hard/very dense, consists primarily of quartzite				C			6.4	6.9	9	20											
	25			C			6.9	7.6	46	60											
Boring completed at 7.6m below existing grade.	30	10																			
	35																				
	40																				
	45																				
	50	15																			
	55																				
	60																				
		19																			

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-03** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-21-99 / 05-21-99**
Weather:	**P. cloudy, 62±5 °F**
Station: **29+893.128**	Offset: **-10.151**
Coordinates: N: **170829.8**	E: **604258.4** Elev.:**1876.058**
Groundwater Depth (m):	**Unknown - hole caved at 2.9m**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**7.6**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-04
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	USCS Classification / Sample Description	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Remarks
	0	TOPSOIL: Silty clay (CL), with trace sand, moist to wet, low to medium plasticity, dark brown, with organics				0.0	0.3			
5		COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL AND BOULDERS: very dense, moist to wet, moderately plastic, brown to yellowish red	C			0.3	1.8	88	58	PI = 25, PL = 15, LL = 40, #4 = 52.8%, #200 = 25.7%, 0.005mm = 20.2%
10			C			1.8	3.4	76	50	
15		GRAVEL (GP): with interbeds of cemented sand, gravelly sand, silty clay, and occasional boulders, loose to dense, moist, brown/multi-colored **note:** relatively fast core advance; relatively soft zones indicate presence of silty clay interbeds	C			3.4	4.9	61	40	
20	5		C			4.9	6.4	46	30	
		SILTY SAND (SM): with gravel, predominantly coarse-grained, brown to yellowish red, with mica and thin layers (10cm thick) of cemented fine grained sand (A-1-b)	S	19-14-15	29	6.4	6.9	21	47	WC = 22.3%, #4 = 71%, #200 = 14.3%
25			C			6.4	7.9	61	40	
		SANDY GRAVEL (GP): with thin layers of cemented fine sand and boulder fragments, predominantly fine grained gravel and fine to medium grained sand, brown/multi-colored	S	7-9-17	26	7.9	8.4	15	33	
30			C			7.9	9.5	15	10	
		GRAVEL (GP): with occasional boulder fragments, cobbles, and boulders, predominantly coarse grained, medium dense to very dense, multi-colored **note:** SPT sampler refusal at 9.5m	S	>100/0.3m	>100/0.3m	9.5	9.9	0	0	
35	10	note: grades with cobbles and boulders	C			9.5	11.0	46	30	
			C			11.0	11.9	92	100	
40			C			11.9	12.5	46	75	
			C			12.5	13.4	46	50	
45		Boring completed at 13.4m below existing grade.								
50	15									
55										
60	19									

Graphic Log

Sample Type | Len. Whole Pieces >= 10.2cm (cm) | RQD (%) | Whole Core Length (cm) | No. of Whole Pieces | Length Longest Piece (cm) | Length +30.5cm Fraction (cm) | Broken Zone Length (cm) | Rubble Zone Length (cm) | Bedding Angle (deg.) | Average Hardness

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-04** Sheet **1** of **1**

Logged by:	**M. Flint**
Date Start/Finish:	**05-18-99 / 05-18-99**
Weather:	**P. cloudy, 60±5 °F**
Station: **30+671.019**	Offset: **-23.335**
Coordinates: N: **171579.5**	E: **604471.6** Elev.:**1895.648**
Groundwater Depth (m):	**Unknown - hole caved at 4.7m**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**13.4**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	*Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run*

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN.LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-05
Sheet 1 of 2

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	USCS / Sample Description	Lab Test Results
	0					0.0	0.3													SANDY CLAY (CL): with gravel, low to medium plasticity, brown with trace organics; gravel is fine-grained and angular	
5			C			0.3	1.8	101	66												
10			C			1.8	3.4	73	48											BOULDERS IN A CLAY MATRIX: limestone, with gravel fragments and calcite-filled fractures; CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, brown; gravel is fine to coarse grained, angular, vertically oriented, consists of shale and/or limestone fragments	
			C			3.4	4.6	55	45												
15	5		C			4.6	6.3	67	40											GRAVEL (GP): with clay, fine-grained, angular, consists of shale and/or limestone fragments; CLAYEY SAND (SC): with silt, gravel, and trace cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, vertically oriented, consists of shale and/or limestone fragments	#4 = 80%, #200 = 29.5%
20																					
25			C			6.3	7.9	113	67											GRAVEL (GP): fine-grained, angular, vertically oriented, with limonite, consists of shale and/or limestone fragments; CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists of shale and/or limestone fragments	PI = 9, PL = 20, LL = 29
30			C			7.9	9.5	137	90												
35	10		C			9.5	11.0	107	70												
			C			11.0	12.2	131	108											BOULDER: limestone	
40			C			12.2	13.4	98	80											CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown; gravel is fine to coarse grained, angular, randomly oriented, consists of limestone fragments	#4 = 75.7%, #200 = 35.6%, 0.005mm = 17.2%
45			C			13.4	14.0	70	115											BOULDER: limestone	
50	15		C			14.0	15.6	128	84											COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown	
55			C			15.6	16.6	76	71												
60	19		C			16.6	18.0	85	62												PI = 9, PL = 20, LL = 29, #4 = 40.2%, #200 = 21.6%

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-05** Sheet **1** of **2**

Logged by:	D. Risley
Date Start/Finish:	06-03-99 / 06-04-99
Weather:	P. cloudy/rainy, 58±5 °F
Station: 34+903.510	Offset: 42.171
Coordinates: N: 175723	E: 604700.4 Elev.:1999.474
Groundwater Depth (m):	Unknown - hole caved at 3.7m
Depth to Bedrock (m):	*Not encountered*
Total Depth Drilled (m):	24.4
Drill Contractor:	Agapito Drilling, Inc.
Driller:	Jacob & Pat
Rig Type / Drilling Method:	SD 1500 Track Rig / Rotary
Hole Diameter (mm):	74
Orientation/Bearing:	Vertical / --
Core Barrel Length (m):	1.52

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows *required to drive sampler the last 305mm or* distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-05
Sheet 2 of 2

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	USCS Classification / Sample Description
	19		C			18.0	19.8	149	82											
65	20		C			19.8	21.4	134	88											CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists predominantly of limestone fragments
70			C			21.4	22.7	98	71											COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown
75			C			22.7	23.5	76	100											CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists predominantly of limestone fragments
80			C			23.5	24.4	95	103											COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown
	25																			CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists predominantly of limestone fragments
85																				COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown
90																				Boring completed at 24.4m below existing grade.
95																				
	30																			
100																				
105																				
110																				
115	35																			
120																				
	38																			

SOIL/ROCK SAMPLE DATA

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_r = virgin consolidation
C_c = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-05** Sheet **2** of **2**

Logged by:	D. Risley
Date Start/Finish:	06-03-99 / 06-04-99
Weather:	P. cloudy/rainy, 58±5 °F
Station: 34+903.510	Offset: 42.171
Coordinates: N: 175723	E: 604700.4 Elev.:1999.474
Groundwater Depth (m):	Unknown - hole caved at 3.7m
Depth to Bedrock (m):	Not encountered
Total Depth Drilled (m):	24.4
Drill Contractor:	Agapito Drilling, Inc.
Driller:	Jacob & Pat
Rig Type / Drilling Method:	SD 1500 Track Rig / Rotary
Hole Diameter (mm):	74
Orientation/Bearing:	Vertical / --
Core Barrel Length (m):	1.52

EXPLANATION

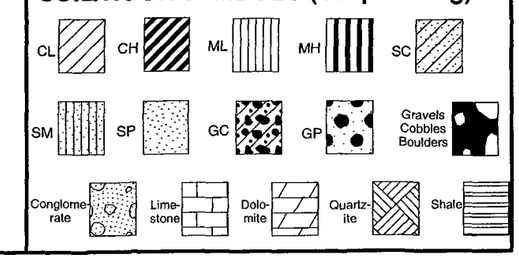
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS = Unified Soil Classification System
▽ = Groundwater depth
Blows/ 0.15m = number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist. = Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m= N-value data greater than 100 blows/0.3m
NR = Not Recorded
RQD = Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S = Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U = Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C = HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN.LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-06
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
0	0	TOPSOIL: Silty clay (CL), with sand, low to medium plasticity, dark brown, with organics	S	1-1-1	2	0.0	0.5	6	13											
		CLAYEY GRAVEL (GC): angular, consists predominantly of weathered limestone fragments	C			0.3	1.8	27	18											
5		LIMESTONE BEDROCK: moderately strong, moderately weathered, fractured, thinly bedded, with clay-filled fractures, bedding angle ranges from 30 to 50 degrees **note:** recovered sample (1.8-3.1m) contains at least 1 fracture at an angle of 60 degrees or more	C			1.8	3.1	92	75	76	63	70	2	49	49	244	0	40-50	R2	
10		**note:** recovered sample (3.1-4.6m) contains 4 fractures at angles of 60 degrees or more	C			3.1	4.6	101	66	31	20	61	5	21	0	40	0	30-40	R2	WW = 25.76 kN/m³, q_u = 18582 kN/m², μ = 0.103
15	5	**note:** grades with a change in dip of bedding planes; bedding angle ranges from approximately 10 to 15 degrees; recovered sample (4.6-6.3m) is predominantly breciated limestone and clay; clay is moderately plastic, brown, and contains angular limestone and quartzite fragments	C			4.6	6.2	34	20	14	8	12	1	12	0	21	0	15	R2	
20		**note:** grades strong; recovered sample (6.3-6.7m) contains numerous fractures at angles of 60 degrees or more	C			6.2	6.7	43	88	0	0	0	0	0	0	43	0		R3	
		note: recovered sample (6.7-7.3m) contains at least 1 fracture at an angle of 60 degrees or more	C			6.7	7.3	21	35	0	0	0	0	0	0	21	0	10	R3	
25		**note:** recovered sample (7.3-7.9m) contains 3 fractures at angles of 60 degrees or more	C			7.3	7.9	43	70	12	20	0	0	0	0	43	0	10	R3	
30		QUARTZITE BEDROCK: strong, massive, bedding angle ranges from approximately 25 to 40 degrees, fracture located approximately 1.6m from bottom of hole	C			7.9	9.5	116	76	85	56	79	2	67	67	0	37	25	R3	WW = 26.60 kN/m³, q_u = 52892 kN/m², μ = 0.257
	10	**note:** recovered sample (9.5-10.7m) contains 2 fractures at angles of 60 degrees or more	C			9.5	10.7	98	80	92	75	98	4	37	37	0	0	40	R3	
35		Boring completed at 10.7m below existing grade.																		
40																				
45																				
50	15																			
55																				
60	19																			

Lab Test Abbreviations
WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE GROUP — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-06** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-21-99 / 05-21-99**
Weather:	**P. cloudy, 65±5 °F**
Station: **35+095.117**	Offset: **13.08**
Coordinates: N: **175914.1**	E: **604696.3** Elev.:**1992.395**
Groundwater Depth (m):	**Unknown - hole caved at 3.8m**
Depth to Bedrock (m):	**0.9**
Total Depth Drilled (m):	**10.7**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-07
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	USCS CLASSIFICATION/ SAMPLE DESCRIPTION	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
	0	BOULDERS IN A CLAY MATRIX: loose to medium dense, slightly to moderately plastic, brown					0.0	0.3													
5				C			0.3	1.8	18	12											
		SANDY CLAY (CL): with gravel and trace cobbles, predominantly coarse-grained sand and fine-grained gravel, soft to medium stiff, moist to wet, medium plasticity, yellowish brown to brown, gravel and cobbles consist of limestone fragments (A-6)		C			1.8	3.4	6	4											
10		**note:** grades with trace gravel and trace cobbles		S	3-3-6	9	3.4	3.8	40	87											WC = 28.8%, PI = 16, PL = 21, LL = 37
				C			3.4	4.9	55	36											
15	5			C			4.9	6.4	21	14											
20		**note:** grades without gravel and cobbles		S	3-3-9	12	6.4	6.9	46	100											WC = 26.9%, #4 = 99.2%, #200 = 71.2%, 0.005mm = 22.4%
	6/3/1999			C			6.4	7.9	70	46											
25		COBBLES IN A CLAY MATRIX WITH BOULDERS: glacial till; very dense, moderately plastic, brown **note:** loss of water into formation at approximately 7.9m																			
30				C			7.9	9.5	46	30											
	10			C			9.5	9.9	40	87											
35				C			9.9	11.0	107	100											
40				C			11.0	12.0	49	46											
				C			12.0	13.4	92	67											
45		Boring completed at 13.7m below existing grade.		C			13.4	13.7	24	80											
50	15																				
55																					
60	19																				

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-07** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**06-02-99 / 06-02-99**
Weather:	**Cloudy, 68±5 °F**
Station: **36+068.349**	Offset: **19.975**
Coordinates: N: **176877.1**	E: **604832** Elev.:**2017.386**
Groundwater Depth (m):	**6.7**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**13.7**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Jacob & Pat**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

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Boring: LC-RC-08
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	USCS Classification / Sample Description	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
	0	TOPSOIL: Silty clay (CL), with trace sand, moist, low to medium plasticity, dark brown, with organics		S	>100/0.3m	>100/0.3m	0.0	0.5	6	13											
		SILTY CLAY (CL), with gravel, moist, low to medium plasticity, brown, gravel is fine grained (A-7-6)		C			0.3	1.8	95	62											
5		BOULDERS IN A CLAY MATRIX WITH SAND AND GRAVEL: very dense, moist to wet, moderately to highly plastic, brown to brownish yellow		C			1.8	3.4	104	68											
10		CLAY (CH): with trace sand and occasional fine-grained gravel, stiff, wet, high plasticity, brownish yellow, with trace organics (A-7-6) **note:** grades without organics		S	4-5-6	11	3.4	3.8	46	100											WC = 35.7%, #4 = 100%, #200 = 96.5%
				C			3.4	4.9	27	18											
15	5	**note:** grades medium stiff with trace gravel/boulder fragments		C			4.9	6.4	143	94											
20		**note:** grades without gravel/boulder fragments		S	2-3-4	7	6.4	6.9	46	100											WC = 42.7%, #4 = 100%, #200 = 96.5%, 0.005mm = 75.1%
				C			6.4	7.9	70	46											
25		**note:** grades soft to medium stiff		S	1-2-2	4	7.9	8.4	46	100											PI = 40, PL = 22, LL = 62
				C			7.9	9.5	110	72											
30		LIMESTONE BEDROCK: moderately strong, slightly weathered, slightly fractured, thinly bedded, with calcite- and clay-filled fractures, bedding angle is approximately 10 degrees **note:** recovered sample (9.0-9.5m) contains 1 fracture at an angle of 60 degrees or more		C			9.5	11.0	146	96	98	64	131	7	27	0	15	0	10	R4	
35	10	**note:** relatively slow drilling through bedrock, recovered sample (9.5-11.0m) contains 2 fractures at an angle of 60 degrees or more **note:** grades with a 10cm void, recovered sample (11.0-12.5m) contains 1 fracture at an angle of 60 degrees or more	5/20/1999	C			11.0	12.5	104	68	55	36	101	8	40	40	3	0	10	R4	WW = 25.64 kN/m³, q_u = 35951 kN/m², μ = 0.021
40		**note:** grades with a 15cm void		C			12.5	14.0	131	86	73	48	128	8	52	52	3	0	10	R4	
45		Boring completed at 14.0m below existing grade.																			
50	15																				
55																					
60	19																				

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-08** Sheet **1** of **1**

Logged by:	**M. Flint**
Date Start/Finish:	**05-19-99 / 05-19-99**
Weather:	**Cloudy, 65±5 °F**
Station: **36+940.034**	Offset: **-22.653**
Coordinates: N: **177734.2**	E: **604768.3** Elev.:**2036.6**
Groundwater Depth (m):	**10.8**
Depth to Bedrock (m):	**9.0**
Total Depth Drilled (m):	**14.0**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

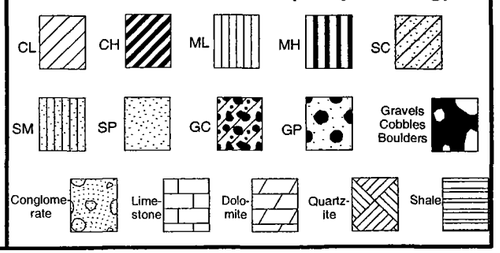
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN.LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-09
Sheet 1 of 2

SOIL/ROCK SAMPLE DATA

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	
TOPSOIL: Silty clay (CL), with sand, low to medium plasticity, dark brown, with organics		0					0.0	0.3													
DOLOMITE BEDROCK: strong, highly weathered, slightly fractured, with clay- and calcite-filled fractures, bedding angle ranges from approximately 8 to 20 degrees	5			C			0.3	1.8	113	74	55	36	70	7	31	31	46	0	15	R3	SD = 95.1
note: grades slightly weathered, less fractured, recovered sample (0.3-1.8m) contains 1 fracture at an angle of 60 degrees or more	10			C			1.8	3.4	189	124	146	96	189	10	43	73	0	0	15	R3	WW = 26.47 kN/m³, q_u = 52664 kN/m², μ = 0.034
note: grades massive, recovered sample (1.8-3.4m) contains 2 fractures at angles of 60 degrees or more	15			C			3.4	4.9	128	84	73	48	104	8	31	31	24	0	20	R3	
note: recovered sample (3.4-4.9m) contains 1 fracture at an angle of 60 degrees or more	20	5		C			4.9	6.4	153	100	143	94	143	4	43	92	9	0	15	R3	
note: recovered sample (4.9-6.4m) contains 1 fracture at an angle of 60 degrees or more	25			C			6.4	7.9	146	96	131	86	131	6	40	40	15	0	15	R3	
note: recovered sample (6.4-7.9m) contains 1 fracture at an angle of 60 degrees or more	30	10		C			7.9	9.5	149	98	149	98	149	3	76	137	0	0	10	R3	WC = 0.1%, SG_s = 2.97
note: recovered sample (7.9-9.5m) contains small clay nodule	35			C			9.5	11.0	134	88	122	80	134	8	34	64	0	0	8	R3	
note: recovered sample (9.5-11.0m) contains 1 fracture at an angle of 60 degrees or more	40			C			11.0	12.5	85	56	85	56	85	3	55	55	0	0	10	R3	
note: recovered sample (11.0-12.5m) contains 1 fracture at an angle of 60 degrees or more	45			C			12.5	14.0	61	40	40	26	40	2	24	0	21	0	10	R3	
note: grades with voids, clay-filled fractures, and/or weathered zones from 11.6-17.1m; loss of water into formation at approximately 11.6m	50	15		C			14.0	15.6	88	58	67	44	67	2	55	55	21	0	10	R3	
note: recovered sample (14.0-15.6m) contains 1 fracture at an angle of 60 degrees or more	55			C			15.6	17.1	15	10	0	0	6	1	6	0	9	0	15	R3	
note: recovered sample (14.0-15.6m) contains 1 fracture at an angle of 60 degrees or more	60	19		C			17.1	18.6	64	42	0	0	0	0	0	0	64	0	10	R3	
note: drill stem dropped during drilling, recovered sample (15.6-17.1m) contains 1 fracture at an angle of 60 degrees or more																					
note: grades with zone of highly weathered dolomite bedrock with sand and silt from approximately 17.1m to 18.6m; recovered sample (17.1-18.6m) contains at least 2 fractures at angles of 60 degrees or more																					

Lab Test Abbreviations

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LL = liquid limit
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#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-09** Sheet **1** of **2**

Logged by:	D. Risley
Date Start/Finish:	05-24-99 / 05-24-99
Weather:	P. cloudy, 72±5 °F
Station: 37+162.519	Offset: -35.43
Coordinates: N: 177943.4	E: 604855 Elev.:2051.439
Groundwater Depth (m):	19.9
Depth to Bedrock (m):	0.3
Total Depth Drilled (m):	27.7
Drill Contractor:	Agapito Drilling, Inc.
Driller:	Ron & Jacob
Rig Type / Drilling Method:	SD 1500 Track Rig / Rotary
Hole Diameter (mm):	74
Orientation/Bearing:	Vertical / --
Core Barrel Length (m):	1.52

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS = Unified Soil Classification System
▽ = Groundwater depth
Blows/ 0.15m = number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist. = Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
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NR = Not Recorded
RQD = Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S = Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U = Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C = HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

Boring: LC-RC-09
Sheet 2 of 2

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

note: recovered sample (18.6-20.1m) contains at least 1 fracture at an angle of 60 degrees or more

note: grades with occasional thin layers of sand and friable bedrock zones from approximately 20.7-23.2m; recovered sample (20.1-21.7m) contains 4 fractures at angles of 60 degrees or more

note: recovered sample (21.7-23.2m) contains 3 fractures at angles of 60 degrees or more

LIMESTONE BEDROCK: strong, slightly weathered, slightly fractured, massive, with calcite-filled fractures, bedding angle ranges from approximately 15 to 20 degrees
note: recovered sample (23.2-24.7m) contains 3 fractures at angles of 60 degrees or more
note: recovered sample (24.7-26.2m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (26.2-27.7m) contains 2 fractures at angles of 60 degrees or more

note: grades with thin layer of sand to bottom of hole

Boring completed at 27.7m below existing grade.

Depth (ft): 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120
Depth (m): 19, 20, 25, 30, 35, 38
5/26/1999

SOIL/ROCK SAMPLE DATA

Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness
C			18.6	20.1	15	10	0	0	0	0	0	0	15	0		R2
C			20.1	21.7	131	86	92	60	104	7	40	40	27	0	10	R2/R3
C			21.7	23.2	153	100	116	76	119	7	64	64	34	0	15-25	R3
C			23.2	24.7	134	88	128	84	125	3	76	76	9	0	20	R3/R4
C			24.7	26.2	125	82	95	62	116	3	73	73	9	0	15	R4
C			26.2	27.8	146	96	137	90	146	5	55	101	0	0	15	R4

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-09** Sheet **2** of **2**

Logged by:	**D. Risley**
Date Start/Finish:	**05-24-99 / 05-24-99**
Weather:	**P. cloudy, 72±5 °F**
Station: **37+162.519**	Offset: **-35.43**
Coordinates: N: **177943.4**	E: **604855** Elev.:**2051.439**
Groundwater Depth (m):	**19.9**
Depth to Bedrock (m):	**0.3**
Total Depth Drilled (m):	**27.7**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

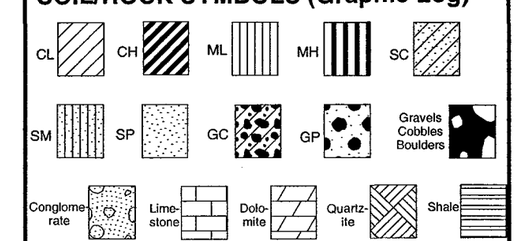
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS = Unified Soil Classification System
▽ = Groundwater depth
Blows/ 0.15m = number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist. = Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m= N-value data greater than 100 blows/0.3m
NR = Not Recorded
RQD = Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S = Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U = Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C = HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-10
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness
	0		S	1-1-1	2	0.0	0.5	9	20										
			C			0.3	1.8	15	10										
			S	NR	NR	1.8	2.3	31	67										
			C			1.8	3.4	49	32										
			C			3.4	4.9	46	30	0	0	9	1	9	0	37	0	25	R3
			C			4.9	6.4	55	36	0	0	15	3	9	0	40	0	30-35	R2/R3
			C			6.4	7.9	64	42	0	0	12	3	6	0	52	0	10	R2/R3
			C			7.9	9.2	122	100	52	43	116	17	18	0	6	0	10	R2/R3

TOPSOIL: Silty clay (CL), with trace sand, low to medium plasticity, dark brown, with organics

SILTY CLAY (CL): with some sand and trace gravel, moist to wet, medium plasticity, brown to yellowish brown

CONGLOMERATE: consists of dolomitic fragments, sand, and clay, moderately weak, weathered

DOLOMITE BEDROCK: moderately strong, highly weathered, fractured, thinly bedded, with shale- and calcite-filled fractures, bedding angle ranges from approximately 20 to 35 degrees
note: recovered sample (3.4-4.9m) contains 3 fractures at angles of 60 degrees or more
note: recovered sample (4.9-6.4m) contains at least 1 fracture at an angle of 60 degrees or more

SHALE: average hardness, slightly weathered to weathered, thinly bedded, bedding angle is approximately 10 degrees
note: recovered sample (6.4-7.9m) contains 2 fractures at angles of 60 degrees or more

Boring completed at 9.1m below existing grade.

Depth scale: (ft) 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60; (m) 5, 10, 15, 19

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_v = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

WC = 27.2%, PI = 21, PL = 20, LL = 41, #4 = 95.2%, #200 = 72.9%, 0.005mm = 34.2%

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-10** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-23-99 / 05-23-99**
Weather:	**Sunny, 68±5 °F**
Station: **37+782???**	Offset: **17.8??**
Coordinates: N: **178338.8**	E: **605342.3** Elev.:**2049.496**
Groundwater Depth (m):	**Unknown - hole caved at 3.8m**
Depth to Bedrock (m):	**3.0**
Total Depth Drilled (m):	**9.1**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

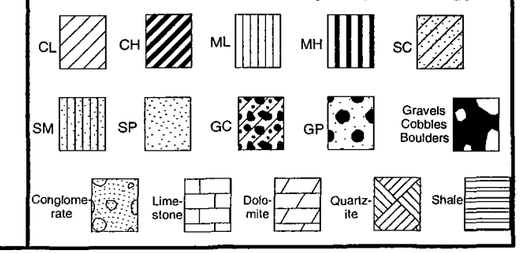
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS = Unified Soil Classification System
▽ = Groundwater depth
Blows/ 0.15m = number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist. = Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m= N-value data greater than 100 blows/0.3m
NR = Not Recorded
RQD = Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S = Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U = Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C = HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-11
Sheet 1 of 1

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

SOIL/ROCK SAMPLE DATA

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
LIMESTONE BEDROCK: moderately strong to strong, slightly weathered to moderately weathered, slightly fractured, with clay-filled fractures, occasionally thinly bedded, bedding angle generally ranges from 15 to 20 degrees **note:** recovered sample (0-1.5m) contains 3 fractures at angles of 60 degrees or more	0	0		C			0.0	1.5	61	40	37	24	40	3	21	0	21	0	15	R3	WW = wet weight DW = dry weight WC = water content PI = plasticity index PL = plastic limit LL = liquid limit #4 = %passing #200 = %passing 0.005mm = %passing P_c = preconsol. press. C_c = virgin consolidation C_r = recompression C_v = consolidation coeff. q_u = compressive strength μ = Poissons ratio SG_s = specif. grav. (solids) n = porosity SD = slake durability index SO_4 = sulfate content Salts = soluble salts MR = min. resistivity
note: recovered sample (1.5-1.8m) contains 2 fractures at angles of 60 degrees or more	5			C			1.5	1.8	34	110	31	100	12	1	12	0	21	0	20	R3	
note: recovered sample (1.8-2.7m) contains 2 fractures at angles of 60 degrees or more **note:** *loss of water into formation at approximately 2.4m*				C			1.8	2.7	79	87	24	27	27	2	21	0	52	0	20	R3	WW = 25.56 kN/m³, WC = 0.4%, q_u = 28780 kN/m², μ = 0 265, SG_s = 2 83
note: grades very thinly bedded with numerous clay-filled fractures from 2.7 to 3.7m, recovered sample (2.7-3.7m) contains at least 1 fracture at an angle of 60 degrees or more	10			C			2.7	3.7	58	63	0	0	0	0	9	0	58	0	20	R3	
note: recovered sample (3.7-4.9m) contains 4 fractures at angles of 60 degrees or more	15	5		C			3.7	4.9	70	58	12	10	21	2	9	0	49	0	20	R3	
note: recovered sample (4.9-6.4m) contains 2 fractures at angles of 60 degrees or more **note:** recovered sample (6.4-7.9m) contains at least 1 fracture at an angle of 60 degrees or more	20			C			4.9	6.4	24	16	15	10	12	1	12	0	49	0	20	R3	
note: grades with calcite- and clay-filled fractures, recovered sample (7.9-9.0m) contains 2 fractures at angles of 60 degrees or more	25			C			6.4	7.9	49	32	12	8	0	0	12	0	49	0	20	R3	
note: recovered sample (9.0-10.5m) contains 6 fractures at angles of 60 degrees or more	30	10		C			7.9	9.0	104	97	61	57	67	5	18	0	37	0	20	R3	
note: grades fractured to highly fractured from 10.5-12.5m, recovered sample (10.5-11.0m) contains numerous fractures at angles of 60 degrees or more **note:** recovered sample (11.0-12.5m) contains numerous fractures at angles of 60 degrees or more	35			C			9.0	10.5	137	90	95	62	73	4	27	0	64	0	20	R3	WW = 26.19 kN/m³, q_u = 49623 kN/m², μ = 0.339
note: recovered sample (12.5-13.4m) contains 3 fractures at angles of 60 degrees or more	40			C			10.5	11.0	24	53	0	0	0	0	3	0	24	0	20	R3	
note: recovered sample (13.4-14.0m) contains numerous fractures at angles of 60 degrees or more **note:** recovered sample (14.0-14.6m) contains numerous fractures at angles of 60 degrees or more **note:** grades with increasing calcite-filled fractures, recovered sample (14.6-15.1m) contains 2 fractures at angles of 60 degrees or more **note:** recovered sample (15.1-15.9m) contains 2 fractures at angles of 60 degrees or more **note:** grades with calcite-filled fractures, recovered sample (15.9-17.4m) contains 3 fractures at angles of 60 degrees or more				C			11.0	12.5	46	30	0	0	0	0	6	0	46	0	20	R3	
	45			C			12.5	13.4	82	90	27	30	34	3	15	0	49	0	30	R3	
				C			13.4	14.0	18	30	0	0	0	0	3	0	18	0		R3	
				C			14.0	14.6	40	65	0	0	9	2	6	0	31	0	20	R3	
		15		C			14.6	15.1	46	100	18	40	24	2	15	0	34	0	15	R3	
	50			C			15.1	15.9	55	72	12	16	6	1	6	0	49	0	15	R3	
	55			C			15.9	17.4	110	72	61	40	55	0	24	0	55	0	15	R3	
Boring completed at 17.4m below existing grade.	60	19																			

BORING LOG

Boring: **LC-RC-11** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-25-99 / 05-26-99**
Weather:	**P. cloudy, 68±5 °F**
Station: **26+600**	Offset: **57.365**
Coordinates: N: **177403.9**	E: **604782.7** Elev.:**2046.084**
Groundwater Depth (m):	**Unknown - hole caved at 1.0m**
Depth to Bedrock (m):	**0.0**
Total Depth Drilled (m):	**17.4**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

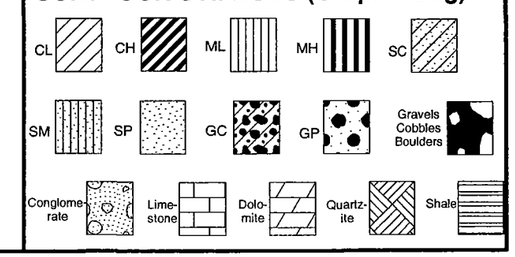
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN LOG FORM LOGCAN GPJ LOGCAN GDT 11/10/00

Boring: LC-RC-12
Sheet 1 of 2

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	USCS / Sample Description	Lab Test Results
	0		C			0.0	0.3	0	0											CLAYEY GRAVEL (GC): with sand, low to medium plasticity, yellowish red, gravel consists of limestone and quartzite fragments (A-2-7) **note:** no recovery of clay (0.3-1.8m)	
5			C			0.3	1.8	0	0												
			C			1.8	3.4	12	8											**note:** poor recovery of clay (1.8-3.4m) **note:** grades with occasional cobbles	PI = 28, PL = 21, LL = 49, #4 = 43.5%, #200 = 34.3%
10			C			3.4	4.3	46	50												
15	5		C			4.3	6.3	43	22											BOULDERS IN A CLAY MATRIX WITH SAND: dense, consist predominantly of quartzite, slightly to moderately plastic, yellowish red	
																				SILTY CLAY (CL): low to medium plasticity, yellowish red	
20			C			6.3	6.9	18	30											BOULDERS IN A CLAY MATRIX WITH SAND, GRAVELS, AND COBBLES: glacial deposit, morraine; very dense, slightly to moderately plastic, yellowish red	#4 = 54.5%, #200 = 29%
			C			6.9	7.0	24	160												
25			C			7.0	7.9	46	50												
30			C			7.9	9.5	67	44												
	10		C			9.5	10.4	24	27												
35			C			10.4	10.7	9	30												
			C			10.7	11.7	104	97												#4 = 83%, #200 = 49.3%
40			C			11.7	12.8	46	43												
45			C			12.8	13.7	40	43												
50	15		C			13.7	15.4	113	67												
55			C			15.4	17.1	70	42											**note:** loss of water into formation at approximately 16.2m	
			C			17.1	17.7	34	55												
60			C			17.7	18.6	76	83											CLAY (CH): with sand, medium to high plasticity, yellowish red, sand is predominantly fine grained	PI = 33, PL = 21, LL = 54, #4 = 100%, #200 = 77.8%, 0.005mm = 50.7%
	19																			CLAYEY SAND (SC): fine grained, strongly	

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-12** Sheet **1** of **2**

Logged by:	**D. Risley**
Date Start/Finish:	**06-04-99 / 06-06-99**
Weather:	**Rainy/snowy, 30-50±5 °F**
Station: **34+283???**	Offset: **31.5??**
Coordinates: N: **175109.4**	E: **604671.5** Elev.:**1985.722**
Groundwater Depth (m):	**Unknown - hole caved**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**21.6**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Jacob & Pat**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-12
Sheet 2 of 2

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
C			18.6	20.1	159	104											
C			20.1	21.7	40	26											#4 = 99.9%, #200 = 15.9%

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

Depth (ft)	Depth (m)	Graphic Log	Description
65	19		cemented, no to low plasticity, red/gray/brown, with imbedded layers (10 to 30cm thick) of fine grained sand
65–70	19–20		**note:** grades weakly cemented
70			Boring completed at 21.6m below existing grade.

Depth (ft): 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120
Depth (m): 19, 20, 25, 30, 35, 38

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-12** Sheet **2** of **2**

Logged by:	**D. Risley**
Date Start/Finish:	**06-04-99 / 06-06-99**
Weather:	**Rainy/snowy, 30-50±5 °F**
Station: **34+283???**	Offset: **31.5??**
Coordinates: N: **175109.4**	E: **604671.5** Elev..**1985.722**
Groundwater Depth (m):	**Unknown - hole caved**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**21.6**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Jacob & Pat**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing.	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value) no. of blows required to drive sampler the last 305mm or distance shown
>100/0 3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RC-13
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

Depth (ft)	Depth (m)	USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)
0	0	CLAYEY SAND (SC): moist to wet, with zones of cementation, medium to high plasticity, yellowish red **note:** recovered sample contained a 10cm-layer of fine grained sand, gray
5		
10		**note:** loss of water into formation at approximately 2.7 to 3.0m
		CONGLOMERATE: consists of gravel in a clay matrix, average hardness; clay is very stiff, yellowish red; gravel is predominantly limestone fragments
15	5	CLAY (CH): with sand and trace gravel, very stiff, high plasticity, yellowish red to brown (A-7-6)
20		
25		
30	10	CLAYEY SAND (SC): with gravel, dense to very dense, medium to high plasticity, yellowish red
35		
40		BOULDERS IN A CLAY MATRIX: dense, consist predominantly of quartzite, slightly to moderately plastic, yellowish red
		Boring completed at 12.2m below existing grade.
45		
50	15	
55		
60	19	

Graphic Log

SOIL/ROCK SAMPLE DATA

Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
			0.0	0.3													
C			0.3	1.8	76	50											
C			1.8	3.4	95	62											#4 = 100%, #200 = 48.1%
C			3.4	4.1	37	48											
C			4.1	4.9	15	20											
C			4.9	6.1	92	75											
C			6.1	7.5	104	76											PI = 49, PL = 27, LL = 76, #4 = 97.3%, #200 = 85.3%, 0.005mm = 50.6%
C			7.5	7.9	67	147											
C			7.9	9.5	0	0											
C			9.5	11.0	95	62											#4 = 67.1%, #200 = 44 7%
C			11.0	12.2	40	33											

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RC-13** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**06-07-99 / 06-08-99**
Weather:	**Rainy/cloudy, 58±10 °F**
Station: **34+024.383**	Offset: **15.373**
Coordinates: N: **174846.3**	E: **604649** Elev.:**1977.541**
Groundwater Depth (m):	**Unknown - hole caved**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**12.2**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Jacob & Pat**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN.LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RF-01
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	USCS Classification / Sample Description	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
0	0	TOPSOIL: Clayey Silt (ML), with some sand, wet, low plasticity, dark brown, with organics (A-4)		S	NR	NR	0.0	0.3	15	50											WC = 40.4%, PI = 10, PL = 25, LL = 35, #4 = 99.1%, #200 = 89.8%
				C			0.0	0.9	0	0											
5		GRAVELS, COBBLES, AND BOULDERS: consists of weathered limestone, hard/dense		C			0.9	1.8	31	33											
				C			1.8	3.4	107	70											
10		LIMESTONE BEDROCK: moderately strong, slightly weathered, slightly fractured, thinly bedded, with calcite-filled fractures, bedding angle ranges from 8 to 15 degrees **note:** recovered sample (3.4-4.9m) contains 2 fractures at angles of 60 degrees or more **note:** loss of water into formation at approximately 4.3m		C			3.4	4.9	149	98	85	56	125	14	37	37	85	24	10	R3	
15 / 5		**note:** recovered sample (4.9-6.4m) contains 3 fractures at angles of 60 degrees or more		C			4.9	6.4	149	98	55	36	119	19	15	0	46	0	15	R3	
20		**note:** recovered sample (6.4-7.9m) contains 1 fracture at an angle of 60 degrees or more		C			6.4	7.9	153	100	119	78	153	11	31	31	119	0	10	R3	WC = 0.6%, SG_s = 2.75
25 / 5/13/1999		**note:** recovered sample (7.9-9.5m) contains 5 fractures at angles of 60 degrees or more		C			7.9	9.5	159	104	73	48	104	14	34	34	55	0	10	R3	
30 / 10		Boring completed at 9.4m below existing grade.																			
35																					
40																					
45 / 15																					
50																					
55																					
60 / 19																					

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
GROUP — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RF-01** Sheet **1** of **1**

Logged by:	**C. Nelson / M. Flint**
Date Start/Finish:	**05-12-99 / 05-12-99**
Weather:	**P. cloudy, 65±5 °F**
Station: **22+906.268**	Offset: **-14.543**
Coordinates: N: **166498.8**	E: **601316.2** Elev.:**1749.429**
Groundwater Depth (m):	**8.6**
Depth to Bedrock (m):	**2.7**
Total Depth Drilled (m):	**9.4**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

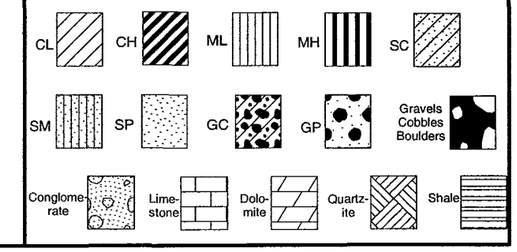
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN.LOG.FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RR-01
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

Depth (ft)	Depth (m)	USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)
0	0	TOPSOIL: Silty clay (CL), with sand and gravel, soft, moist to wet, low to medium plasticity, dark brown, with organics (A-7-6)
		SILTY CLAY (CL): with sand and gravel, moist, medium plasticity, brown to dark brown, with trace organics
5		BOULDERS IN A CLAY MATRIX WITH GRAVELS AND COBBLES: very dense
10		
15	5	LIMESTONE BEDROCK: moderately strong, fractured, thinly bedded, with calcite-filled fractures, bedding angle ranges from 8 to 25 degrees **note:** recovered sample (4.1-4.9m) contains 3 fractures at angles of 60 degrees or more **note:** grades highly fractured from approximately 4.9 to 7m, recovered sample (4.9-6.1m) contains numerous fractures at angles of 60 degrees or more **note:** recovered sample (6.1-7.0m) contains 4 fractures at angles of 60 degrees or more **note:** recovered sample (7.0-7.9m) contains 3 fractures at angles of 60 degrees or more
20		
25		▽ 5/14/1999 **note:** recovered sample (7.9-9.5m) contains 4 fractures at angles of 60 degrees or more
30		**note:** recovered sample (9.5-11.0m) contains 2 fractures at angles of 60 degrees or more
35	10	
40		**note:** recovered sample (11.0-12.5m) contains 5 fractures at angles of 60 degrees or more
45		**note:** recovered sample (12.5-14.0m) contains 3 fractures at angles of 60 degrees or more
50	15	**note:** recovered sample (14.0-15.6m) contains 3 fractures at angles of 60 degrees or more
55		**note:** recovered sample (15.6-17.1m) contains at least 1 fracture at an angle of 60 degrees or more
60	19	Boring completed at 17.1m below existing grade.

Graphic Log

SOIL/ROCK SAMPLE DATA

Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness
U	2-2-3	5	0.0	0.5	18	40										
U	2-2-2	4	0.5	0.9	18	40										
U	3-5-15	20	0.9	1.4	9	20										
C			1.4	1.8	31	67										
C			1.8	3.4	122	80										
C			3.4	4.1	52	68										
C			4.1	4.9	76	100	23	30	31	3	9	0	46	0	18	R3
C			4.9	6.1	104	85	12	10	58	9	12	0	31	15	25	R3
C			6.1	7.0	92	100	0	0	34	5	9	0	58	0	18	R3
C			7.0	7.9	88	97	55	60	55	4	24	0	34	0	15	R3
C			7.9	9.5	153	100	15	10	70	11	15	0	82	0	20	R3
C			9.5	11.0	137	90	79	52	110	12	31	31	27	0	22	R3
C			11.0	12.5	159	104	85	56	101	12	21	0	58	0	15	R3
C			12.5	14.0	149	98	101	66	101	12	24	0	49	0	15	R3
C			14.0	15.6	146	96	119	78	140	10	24	0	6	0	8	R3
C			15.6	17.1	162	106	122	80	143	7	49	55	18	0	10	R3

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_v = virgin consolidation
C_r = recompression
C_c = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

WC = 23.3%, PI = 16, PL = 25, LL = 41,
#4 = 74.6%, #200 = 60.5%

WW = 19.45 kN/m^3, DW = 16.43 kN/m^3,
WC = 18.4%, P_p = 229.8 kPa, C_c = 0.096,
C_r = 0.017, C_v = 0.0047
cm/s^2 @ 306.4 kPa, C_v = 0.0052
cm/s^2 @ 612.9 kPa, C_v = 0.0048
cm/s^2 @ 1225.7 kPa, SO_4 = <80 mg/kg

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RR-01** Sheet **1** of **1**

Logged by:	**M. Flint**
Date Start/Finish:	**05-12-99 / 05-13-99**
Weather:	**Cloudy/rainy, 60±5 °F**
Station: **22+961.934**	Offset: **-9.215**
Coordinates: N: **166511.1**	E: **601373.4** Elev.:**1751.583**
Groundwater Depth (m):	**7.7**
Depth to Bedrock (m):	**4.1**
Total Depth Drilled (m):	**17.1**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN.LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-RR-02
Sheet 1 of 1

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-RR-02** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-22-99 / 05-22-99**
Weather:	**Sunny, 66±5 °F**
Station: **35+956.795**	Offset: **-7.4**
Coordinates: N: **176762.6**	E: **604819.1** Elev.:**2007.647**
Groundwater Depth (m):	**0.0**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**12.2**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
SANDY SILT (MH): with some clay and gravel, medium stiff, wet, medium plasticity, dark brown, with organics (A-7-6)	5/23/9999		U	8-7-4	11	0.0	0.5	18	40											PI = 20, PL = 35, LL = 55
						0.5	0.9													
SILTY CLAY (CL): with sand seams, medium stiff, wet, low to medium plasticity, brown to brownish yellow			U	3-5-4	9	0.9	1.4	15	33											WW = 20.03 kN/m³, DW = 16.15 kN/m³, WC = 24.0%, C_c = 0.093, C_r = 0.015, C_v = 0.0017 cm/s² @ 306.4 kPa, C_v = 0.0018 cm/s² @ 612.9 kPa, C_v = 0.0016 cm/s² @ 1225.7 kPa, SO_4 = <40 mg/kg, Salts = .2 mmhos/cm, MR = 4000 ohm-cm, pH = 9.3
5			C			1.4	1.8	6	13											
BOULDERS IN A CLAY MATRIX WITH GRAVELS AND COBBLES: unsorted glacial till; boulders are hard/dense and consist predominantly of quartzite; gravel consists of limestone, sandstone, and quartzite; silty clay is slightly to moderately plastic, brownish yellow			C			1.8	3.4	85	56											
10			S	8-4-11	15	3.4	3.8	9	20											WC = 14.4%, #4 = 47%, #200 = 13.3%
note: poor recovery of clay			C			3.4	4.3	24	27											
note: grades with angular gravel																				
BOULDERS: very hard/very dense, consist predominantly of quartzite			C			4.3	4.9	61	100											
15	5		C			4.9	5.3	37	80											
note: relatively slow core advance																				
			C			5.3	6.4	85	80											
20			C			6.4	7.0	52	85											
			C			7.0	7.3	24	80											
SANDY CLAY (CH): with trace gravel, very stiff to hard, high plasticity, gray to greenish gray, gravel is predominantly fine-grained (A-7-6)			C			7.3	7.9	46	75											
25																				
			C			7.9	9.5	153	100											PI = 40, PL = 26, LL = 66, #4 = 94.8%, #200 = 59.6%
30	10																			
			C			9.5	11.0	153	100											PI = 51, PL = 29, LL = 80
note: grades to clay with sand																				
35			C			11.0	12.2	95	78											#4 = 100%, #200 = 90.2%, 0.005mm = 53.4%
40																				
Boring completed at 12.2m below existing grade.																				
45																				
50	15																			
55																				
60	19																			

EXPLANATION

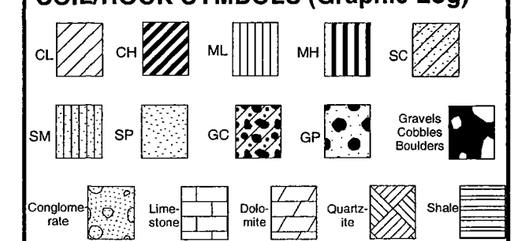
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-S-01
Sheet 1 of 1

SOIL/ROCK SAMPLE DATA

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
FILL: Sandy gravel (GP) with clay, consists of limestone and chert (A-1) **note:** washing of fines, no recovery of sample		0		C			0.0	1.5	0	0											
FILL: Clayey gravel (GC), with sand, loose, low to medium plasticity (A-2-6)	5			S	6-6-3	9	1.5	2.0	15	33											WC = 8.5%, PI = 15, PL = 16, LL = 31, #4 = 49.9%, #200 = 17.4%
FILL: Boulders, consist predominantly of quartzite, hard/dense				C			1.8	3.4	18	12											
note: no recovery of SPT sample	10			S	3-2-2	4	3.4	3.8	0	0											
				C			3.4	4.9	55	36											
LIMESTONE BEDROCK: moderately weak to weak, fractured, thinly bedded, brecciated, with calcite- and clay-filled fractures, bedding angle ranges from 15 to 30 degrees, moderately to highly weathered **note:** recovered sample (4.9-6.4m) contains 3 fractures at angles of 60 degrees or more	15	5		C			4.9	6.4	40	26	0	0	24	4	9	0	15	0	20-30	R2	
note: grades with trace limonite, recovered sample (6.4-7.5m) contains 2 fractures at angles of 60 degrees or more	20			C			6.4	7.5	107	100	107	100	82	6	40	40	24	0	15-20	R2	WW = 24.82 kN/m³, q_u = 10860 kN/m², μ = 0.198
note: recovered sample (7.5-7.9m) contains 3 fractures at angles of 60 degrees or more **note:** recovered sample (7.9-9.5m) contains 3 fractures at angles of 60 degrees or more	25			C			7.5	7.9	46	100	46	100	34	5	9	0	12	0	15-30	R2	
	30	10		C			7.9	9.5	143	94	104	68	110	7	37	67	34	0	20-30	R2	WC = 0.2%, SG_s = 2.91
				C			9.5	10.7	125	103	85	70	101	4	37	37	24	0	30	R2	
note: recovered sample (10.7-11.3m) contains 1 fracture at an angle of 60 degrees or more **note:** recovered sample (11.3-12.5m) contains 1 fracture at an angle of 60 degrees or more	35			C			10.7	11.3	46	75	0	0	18	2	9	0	18	9	30	R2	
	40			C			11.3	12.5	125	103	70	58	85	6	27	0	31	9	30	R1	WW = 25.29 kN/m³, q_u = 4723 kN/m², μ = 0.073
note: grades less brecciated, with less calcite- and clay-filled fractures, recovered sample (12.5-13.7m) contains 4 fractures at angles of 60 degrees or more				C			12.5	13.7	122	100	40	33	49	5	15	0	24	9	30	R1	
note: grades without limonite **note:** grades very thinly bedded from approximately 14 to 16.5m, recovered sample (14.0-15.6m) contains 2 fractures at angles of 60 degrees or more	45			C			13.7	14.0	18	60	0	0	6	1	6	0	12	0	30	R1	
	50	15		C			14.0	15.6	149	98	0	0	55	16	9	0	64	31	30	R1	
note: recovered sample (15.6-16.5m) contains 1 fracture at an angle of 60 degrees or more				C			15.6	16.5	85	93	12	13	43	7	12	0	34	9	30	R1	
note: recovered sample (16.5-17.1m) contains 1 fracture at an angle of 60 degrees or more **note:** grades less thinly bedded, recovered sample (17.1-18.6m) contains 2 fractures at angles of 60 degrees or more	55			C			16.5	17.1	64	105	9	15	40	5	9	0	21	3	25	R1	
	60	19		C			17.1	18.6	153	100	46	30	119	13	21	0	31	3	25	R1	

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-S-01** Sheet **1** of **1**

Logged by:	**C. Nelson**
Date Start/Finish:	**05-11-99 / 05-11-99**
Weather:	**Sunny, 40±5 °F**
Station: **23+026.282**	Offset: **5.787**
Coordinates: N: **166500.9**	E: **601439.4** Elev.:**1750.066**
Groundwater Depth (m):	**Unknown - hole caved at 1.5m**
Depth to Bedrock (m):	**4.3**
Total Depth Drilled (m):	**18.6**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

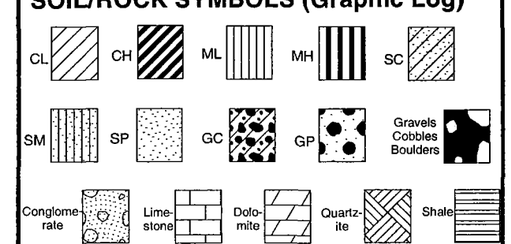
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



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Boring: LC-S-02
Sheet 1 of 1

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

SOIL/ROCK SAMPLE DATA

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Results
TOPSOIL: Silty sand (SM), with some gravel, loose to medium dense, moist, low plasticity, dark brown (A-5)		0		U	>100/0.3m	>100/0.3m	0.0	0.2	9	60											WC = 26.5%, PI = 8, PL = 44, LL = 52, #4 = 88.9%, #200 = 36.7%
BOULDERS: consist predominantly of quartzite, hard/dense				C			0.0	1.7	46	27											
LIMESTONE BEDROCK: moderately strong, slightly fractured, thinly bedded, with trace limonite and calcite-filled fractures, bedding angle ranges from 5 to 15 degrees **note:** recovered sample (1.7-3.1m) contains 2 fractures at angles of 60 degrees or more **note:** recovered sample (3.1-4.6m) contains 3 fractures at angles of 60 degrees or more	5			C			1.7	3.1	131	96	73	53	101	13	18	0	31	0	5-10	R2	
note: grades highly fractured in relatively thin zones from approximately 4.5 to 6m, recovered sample (4.6-6.1m) contains 2 fractures at angles of 60 degrees or more	10			C			3.1	4.6	146	96	95	62	119	11	21	0	58	0	8	R2	WW = 26.00 kN/m³, q_u = 20195 kN/m², μ = 0.077
note: grades less fractured, recovered sample (6.1-7.6m) contains 5 fractures at angles of 60 degrees or more	15	5		C			4.6	6.1	149	98	49	32	95	10	21	0	55	0	8-20	R2	
note: recovered sample (7.6-7.9m) contains 1 fracture at an angle of 60 degrees or more **note:** recovered sample (7.9-9.5m) contains 1 fracture at an angle of 60 degrees or more	20			C			6.1	7.6	149	98	95	62	116	13	21	0	34	0	8	R2	
note: grades less thinly bedded, recovered sample (9.5-11.0m) contains 3 fractures at angles of 60 degrees or more	25			C			7.6	7.9	31	100	15	50	24	3	15	0	6	0	8	R2	
note: recovered sample (11.0-12.5m) contains 2 fractures at angles of 60 degrees or more	30	10		C			7.9	9.5	159	104	116	76	156	15	24	0	3	0	8-10	R2	WW = 26.14 kN/m³, q_u = 15686 kN/m², μ = 0.070
note: recovered sample (12.5-14.0m) contains 1 fracture at an angle of 60 degrees or more	35			C			9.5	11.0	153	100	119	78	131	6	49	49	21	0	10	R2	
note: recovered sample (14.0-15.6m) contains 3 fractures at angles of 60 degrees or more	40			C			11.0	12.5	153	100	101	66	104	5	40	40	49	0	10	R2	
note: recovered sample (15.6-17.1m) contains 3 fractures at angles of 60 degrees or more	45			C			12.5	14.0	146	96	143	94	146	10	31	31	0	0	10	R2	WC = 0.3%, SG_s = 2.87
note: grades hard to very hard, recovered sample (17.1-18.6m) contains 1 fracture at an angle of 60 degrees or more	50	15		C			14.0	15.6	162	106	131	86	140	10	24	0	21	0	8	R2	
	55			C			15.6	17.1	153	100	119	78	104	7	24	0	49	0	8-15	R2	
	60	19		C			17.1	18.6	159	104	146	96	156	6	40	70	3	0	8	R2	WW = 26.11 kN/m³, q_u = 23312 kN/m², μ = 0.060

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

BORING LOG

Boring: **LC-S-02** Sheet **1** of **1**

Logged by:	**M. Flint**
Date Start/Finish:	**05-14-99 / 05-15-99**
Weather:	**Sunny/snowy, 35-50±5 °F**
Station: **23+066.944**	Offset: **2.577**
Coordinates: N: **166505.2**	E: **601479.9** Elev.:**1747.84**
Groundwater Depth (m):	**Unknown - hole caved at 1.6m**
Depth to Bedrock (m):	**1.5**
Total Depth Drilled (m):	**18.6**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

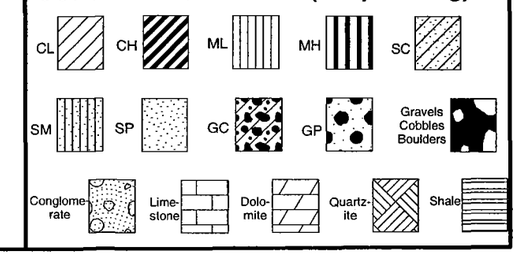
See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)



LOGCAN.LOG.FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-S-03
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	USCS Classification / Sample Description	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
	0	FILL: Silty sand (SM) with gravel, predominantly fine to medium-grained, medium dense, moist, low plasticity, dark brown with trace organics (A-1-b)		U	8-4->100	>100/0.3m	0.0	0.3	27	90											WC = 12.8%, #4 = 81.8%, #200 = 13.9%
		SILTY CLAY WITH COBBLES, BOULDERS, GRAVEL, SAND, AND TRACE ORGANICS: soft to medium stiff, wet, dark gray to brownish yellow (A-4)		C			0.3	1.8	70	46											
5		5/21/19		S	3-1-2	3	1.8	2.3	24	53											WC = 30.8%, SO_4 = <40 mg/kg, Salts = 1.1 mmhos/cm, MR = 999 ohm-cm, pH = 7.8
				C			1.8	3.4	21	14											
10				S	2-3-2	5	3.4	3.8	31	67											WC = 27.4%, PI = 6, PL = 19, LL = 25, #4 = 100%, #200 = 73.4%
				C			3.4	4.9	37	24											
15		LIMESTONE BEDROCK: moderately strong, highly fractured, thinly bedded, brecciated, with numerous clay-filled fractures and occasional calcite-filled fractures, chrystalline, black, bedding angle ranges from approximately 15 to 25 degrees		S	10-13-15	28	4.9	5.3	9	20											
	5			C			4.9	6.1	21	18	0	0	0	0	0	0	21	0	20	R2	
20		**note:** recovered sample (4.9-6.1m) contains 3 fractures at angles of 60 degrees or more		C			6.1	6.4	12	40	0	0	0	0	0	0	12	0	20	R2	
		note: recovered samples from 6.1 to 10.1m contain numerous fractures at angles of 60 degrees or more		C			6.4	6.7	27	90	0	0	0	0	0	0	27	0	25	R2	
				C			6.7	7.9	40	33	0	0	0	0	0	0	40	0	20	R2	WC = 1.1%, SG_s = 2.78
25		**note:** recovered sample (contains numerous fractures at angles of 60 degrees or more		C			7.9	8.5	31	50	0	0	0	0	0	0	31	0	20	R2	
		note: relatively slow core advance		C			8.5	9.0	24	53	0	0	6	0	6	0	18	0	20	R2	
30				C			9.0	9.8	49	64	0	0	0	0	0	0	49	0	20	R3	
	10			C			9.8	10.1	21	70	0	0	0	0	0	0	21	0	20	R3	
		note: grades very thinly bedded, recovered sample contains 3 fractures at angles of 60 degrees or more		C			10.1	10.7	61	100	0	0	18	0	9	0	43	0	15-20	R2	
35		Boring completed at 10.7m below existing grade.																			
40																					
45																					
50	15																				
55																					
60	19																				

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-S-03** Sheet **1** of **1**

Logged by:	**M. Flint / D. Risley**
Date Start/Finish:	**05-20-99 / 05-20-99**
Weather:	**P. cloudy, 59±5 °F**
Station: **36+647.589**	*Offset:* **4.34**
Coordinates: N: **177445.9**	E: **604726.6** Elev.:**2022.631**
Groundwater Depth (m):	**1.8**
Depth to Bedrock (m):	**4.6**
Total Depth Drilled (m):	**10.7**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-S-04
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION
(ASTM D-2487/D-2488)

Depth (ft)	Depth (m)	USCS CLASSIFICATION/ SAMPLE DESCRIPTION
0	0	CLAYEY SAND (SC): with gravel, medium stiff to stiff, high plasticity, brown to dark brown
	6/8/199	BOULDERS IN A CLAY MATRIX WITH GRAVELS AND COBBLES: glacial till, very dense
5		
		CONGLOMERATE: gravels and cobbles in a cemented sand matrix; clasts are generally limestone fragments with some siltstone and sandstone fragments, moderately strong, highly weathered **note:** grades strongly cemented at approximately 3.5m
10		
15	5	
20		
25		
30	10	
35		SANDY CLAY (CL), with gravel, stiff, medium plasticity, yellowish red
40		CONGLOMERATE: gravels and cobbles in a cemented sand matrix; clasts are generally limestone fragments with some siltstone and sandstone fragments, moderately strong, highly weathered
45		
50	15	Boring completed at 15.2m below existing grade.
55		
60	19	

SOIL/ROCK SAMPLE DATA

Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Abbreviations
U	6-7-10	17	0.0	0.5	46	100											WC = 12.9%, #4 = 77.4%, #200 = 48.7%
C			0.3	1.8	82	54											
C			1.8	3.4	113	74											
C			3.4	4.9	107	70											
C			4.9	6.4	153	100											
C			6.4	7.9	153	100											
C			7.9	8.8	55	60											
C			8.8	9.5	37	60											
C			9.5	11.0	122	80											WW = 19.31 kN/m³, DW = 18.54 kN/m³, WC = 4.2%, SG_s = 2.78, n = 31.9%
C			11.0	12.5	122	80											
C			12.5	14.0	107	70											
C			14.0	15.3	122	100											

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_p = preconsol. press.
C_r = virgin consolidation
C_c = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DCM GROUP — DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-S-04** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-26-99 / 05-26-99**
Weather:	**P. cloudy, 64±5 °F**
Station: **32+866.034**	Offset: **7.329**
Coordinates: N: **173704**	E: **604475.7** Elev.:**1929.259**
Groundwater Depth (m):	**0.6**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**15.2**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Lime-stone, Dolo-mite, Quartz-ite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

Boring: LC-S-05
Sheet 1 of 1

USCS CLASSIFICATION/ SAMPLE DESCRIPTION (ASTM D-2487/D-2488)

SOIL/ROCK SAMPLE DATA

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Drill Run (m) From	Drill Run (m) To	Recovery (cm)	Recovery (%)	Len. Whole Pieces >= 10.2cm (cm)	RQD (%)	Whole Core Length (cm)	No. of Whole Pieces	Length Longest Piece (cm)	Length +30.5cm Fraction (cm)	Broken Zone Length (cm)	Rubble Zone Length (cm)	Bedding Angle (deg.)	Average Hardness	Lab Test Results
						0.0	0.3													
			C			0.3	1.8	82	54											
			C			1.8	2.0	15	100											WW = 25.25 kN/m³, q_u = 45617 kN/m², μ = 0.208
			C			2.0	3.4	137	100											
			C			3.4	4.9	131	86											
			C			4.9	6.4	153	100											WW = 26.05 kN/m³, q_u = 48465 kN/m², μ = 0.183
			C			6.4	7.5	95	89											
			C			7.5	9.0	61	40											
			C			9.0	9.5	58	127											WC = 7.0%, SO_4 = <40 mg/kg, Salts = 0.1 mmhos/cm, MR = 800 ohm-cm, pH = 8.0

BOULDERS IN A CLAY MATRIX: mainly glacial till; very dense, consist of quartzite, moderate plasticity, brownish yellow

▽ 6/8/1999

note: loss of water into formation at approximately 1.7m

CONGLOMERATE: consists of moderately strong to strong sand and gravel with cobbles and clay, materials include predominantly limestone fragments, with siltstone and sandstone fragments in a yellowish red, silty quartz matrix, iron oxide staining, gray/yellowish red/brown

note: grades weakly cemented with increasing clay content from approximately 7.5m

SILTY CLAY (CL), stiff, medium plasticity, yellowish red

Boring completed at 9.4m below existing grade.

Lab Test Abbreviations

WW = wet weight
DW = dry weight
WC = water content
PI = plasticity index
PL = plastic limit
LL = liquid limit
#4 = %passing
#200 = %passing
0.005mm = %passing
P_c = preconsol. press.
C_c = virgin consolidation
C_r = recompression
C_v = consolidation coeff.
q_u = compressive strength
μ = Poissons ratio
SG_s = specif. grav. (solids)
n = porosity
SD = slake durability index
SO_4 = sulfate content
Salts = soluble salts
MR = min. resistivity

UDOT SR-89 LOGAN CANYON TONY GROVE TO FRANKLIN BASIN

DAMES & MOORE
GROUP — A DAMES & MOORE GROUP COMPANY

BORING LOG

Boring: **LC-S-05** Sheet **1** of **1**

Logged by:	**D. Risley**
Date Start/Finish:	**05-27-99 / 05-27-99**
Weather:	**Sunny, 64±5 °F**
Station: **32+841.669**	Offset: **-7.473**
Coordinates: N: **173683.6**	E: **604455.8** Elev.:**1928.862**
Groundwater Depth (m):	**1.1**
Depth to Bedrock (m):	**Not encountered**
Total Depth Drilled (m):	**9.4**
Drill Contractor:	**Agapito Drilling, Inc.**
Driller:	**Ron & Jacob**
Rig Type / Drilling Method:	**SD 1500 Track Rig / Rotary**
Hole Diameter (mm):	**74**
Orientation/Bearing:	**Vertical / --**
Core Barrel Length (m):	**1.52**

EXPLANATION

See Explanation to Boring Logs for a full list of abbreviations and test descriptions

USCS	=	Unified Soil Classification System
▽	=	Groundwater depth
Blows/ 0.15m	=	number of blows required to drive split spoon sampler each 152mm or distance shown
Pen. Resist.	=	Penetration Resistance (N-value): no. of blows required to drive sampler the last 305mm or distance shown
>100/0.3m	=	N-value data greater than 100 blows/0.3m
NR	=	Not Recorded
RQD	=	Rock Quality Designation: length of whole pieces >= 10 cm divided by drill run

SAMPLE TYPE

S	=	Standard Penetration Test, 38mm ID and 51mm OD split spoon sampler
U	=	Dames & Moore "U" sampler, 63.5mm ID and 89mm OD
C	=	HX Core, 61 mm ID and 74mm OD

SOIL/ROCK SYMBOLS (Graphic Log)

CL, CH, ML, MH, SC, SM, SP, GC, GP, Gravels Cobbles Boulders, Conglomerate, Limestone, Dolomite, Quartzite, Shale

LOGCAN LOG FORM LOGCAN.GPJ LOGCAN.GDT 11/10/00

APPENDIX C

Appendix C

Soil Data Sheets

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-01
ELEVATION: 1771.4
Sheet 1 of 1

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
	0		C		
			C		
5			C		
10			C		
			C		
15			C		
	5		C		
			C		
20			C		
25			C		
30			C		
	10		C		
35			C		
40			C		
45			C		
	15				
50					
55					
60					
	19				

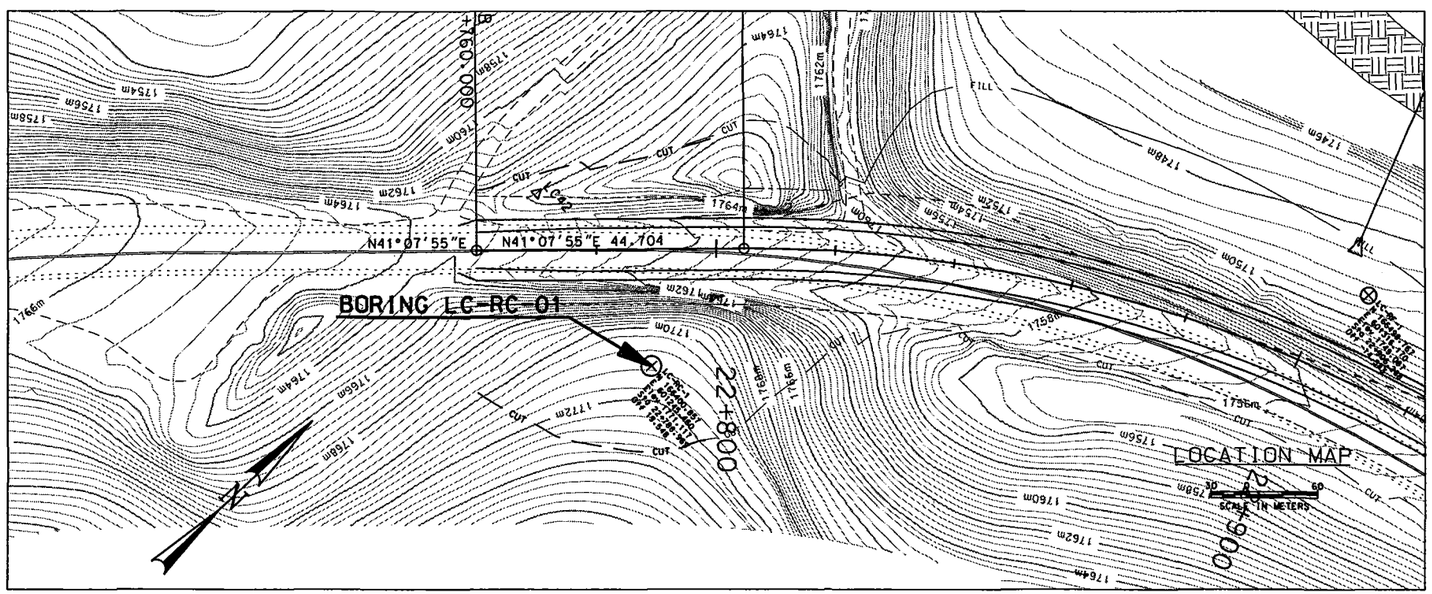
TOPSOIL: Silty clay (CL), moist to wet, low to medium plasticity, dark brown, with organics

CLAYEY BOULDERS WITH GRAVEL AND COBBLES: very dense, contains quartzite and limestone fragments

LIMESTONE BEDROCK: moderately strong, weathered, highly fractured, thinly bedded, brecciated, with calcite- and clay-filled fractures, bedding angle ranges from 8 to 15 degrees, moderately to highly weathered
note: recovered sample (4.9-5.3m) contains numerous fractures at angles of 60 degrees or more
note: recovered sample (5.3-5.6m) contains 2 fractures at angles of 60 degrees or more
note: recovered sample (5.6-6.4m) contains 3 fractures at angles of 60 degrees or more
note: recovered sample (6.4-7.6m) contains 5 fractures at angles of 60 degrees or more
note: grades with occasional voids approxomately 3 to 6cm thick: recovered sample (7.6-9.3m) contains 4 fractures at angles of 60 degrees or more
note: grades very strong with weak zones: highly fractured from approximately 9.5 to 11.0m below existing grade: relatively small voids are present: recovered sample (9.3-11.0m) contains numerous fractures at angles of 60 degrees or more
note: recovered sample (11.0-11.3m) contains 1 fracture at an angle of 60 degrees or more
note: grades with some reddish coloration, recovered sample (11.3-12.5m) contains 4 fractures at angles of 60 degrees or more
note: recovered sample (12.5-14.0m) contains 4 fractures at angles of 60 degrees or more

Boring completed at 14.0m below existing grade.
Groundwater not measured.

SOIL_DATA_SHEET2 LOGCAN.RPJ LOGCAN.GDT 5/9/00



GENERAL NOTES

1. THE SUBSURFACE EXPLORATIONS SHOWN WERE CONDUCTED BETWEEN 5-11-99 AND 6-8-99 BY DAMES & MOORE.

2. THESE BORING LOGS REPRESENT A SYNOPSIS OF THE SOIL DEPOSITS ENCOUNTERED WITHIN EACH 74 mm DIAMETER BORING AND ARE BASED ON SOUND GEOLOGICAL AND ENGINEERING JUDGEMENT. BECAUSE SOIL IS A COMPLEX MEDIUM, THESE BORING LOGS MAY OR MAY NOT REPRESENT THE SOIL CONDITIONS AT THIS SITE. THIS SUBSURFACE INTERPRETATION IS PRESENTED IN GOOD FAITH AND IS NOT INTENDED AS A SUBSTITUTE FOR PERSONAL INVESTIGATION AND JUDGEMENT OF THE CONTRACTOR.

3. THE WATER LEVELS AND CONDITIONS INDICATED ON THE BORING LOGS REPRESENT HOLE CONDITIONS ON THE DATE SHOWN. IT SHOULD BE NOTED, HOWEVER, THAT AT LOCATIONS AWAY FROM THE BORINGS OR AT OTHER TIMES OF THE YEAR THE WATER LEVELS AND CONDITIONS MAY VARY SIGNIFICANTLY.

4. THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

5. COBBLE - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION BETWEEN 76 mm AND 305 mm

6. BOULDER - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION OF 305 mm

NOTE:

RIG USED: SD 1500 TRACK RIG

GEOTECHNICAL ENGINEER

KEY TO BORING LOG

WHEN APPLICABLE

RELATIVE DENSITY
(NON-PLASTIC SAND & SILT)

VERY LOOSE - N LESS THAN 4
LOOSE - N 4 TO 10
MEDIUM - N 10 TO 30
DENSE - N 30 TO 50
VERY DENSE - N MORE THAN 50

CONSISTENCY
(PLASTIC - SILT & CLAY)

VERY SOFT - N LESS THAN 2
SOFT - N 2 TO 4
MEDIUM - N 4 TO 8
STIFF - N 8 TO 15
VERY STIFF - N 15 TO 30
HARD - N MORE THAN 30

GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

BOULDERS, CLAYEY BOULDERS, BOULDERS AND COBBLES IN A CLAY MATRIX.
GRAVELS, COBBLES AND BOULDERS SEE "GRADATION" SECTION ON EXPLANATION SHEET FOR PARTICLE SIZE RANGES
CONGLOMERATE
CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT
LIMESTONE
DOLOMITE
QUARTZITE
SHALE

ABBREVIATIONS

C - HX CORE BARREL, 61 mm ID & 74 mm OD

>100 - N VALUE GREATER THAN 100 BLOWS PER 0.3 M

NR - NOT RECORDED

AASHTO - SOIL CLASSIFICATION SYSTEM SYMBOL

USCS - UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL

NO.	DATE	BY	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____ PIN#
C.I.D.
APPROVAL RECOMM. DATE CHIEF GEOTECHNICAL ENGR.
RECEIVED DATE CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET
PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 1 OF 17

Date: 24 OCT 100 Time: 16:12:47 Username: $$$$username$$$$

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UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RF-01
ELEVATION: 1749.4

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
TOPSOIL: Clayey Silt (ML), with some sand, wet, low plasticity, dark brown, with organics (A-4)	0	0	S	NR	NR
GRAVELS, COBBLES, AND BOULDERS: consists of weathered limestone, hard/dense	5	5	C		
LIMESTONE BEDROCK: moderately strong, slightly weathered, slightly fractured, thinly bedded, with calcite-filled fractures, bedding angle ranges from 8 to 15 degrees note: recovered sample (3.4-4.9m) contains 2 fractures at angles of 60 degrees or more note: loss of water into formation at approximately 4.3m note: recovered sample (4.9-6.4m) contains 3 fractures at angles of 60 degrees or more	10	5/13/199	C		
note: recovered sample (6.4-7.9m) contains 1 fracture at an angle of 60 degrees or more	15	5	C		
note: recovered sample (7.9-9.5m) contains 5 fractures at angles of 60 degrees or more	20	6	C		
Boring completed at 9.4m below existing grade.	25	7	C		
	30	10	C		
	35				
	40				
	45	15			
	50				
	55				
	60	19			

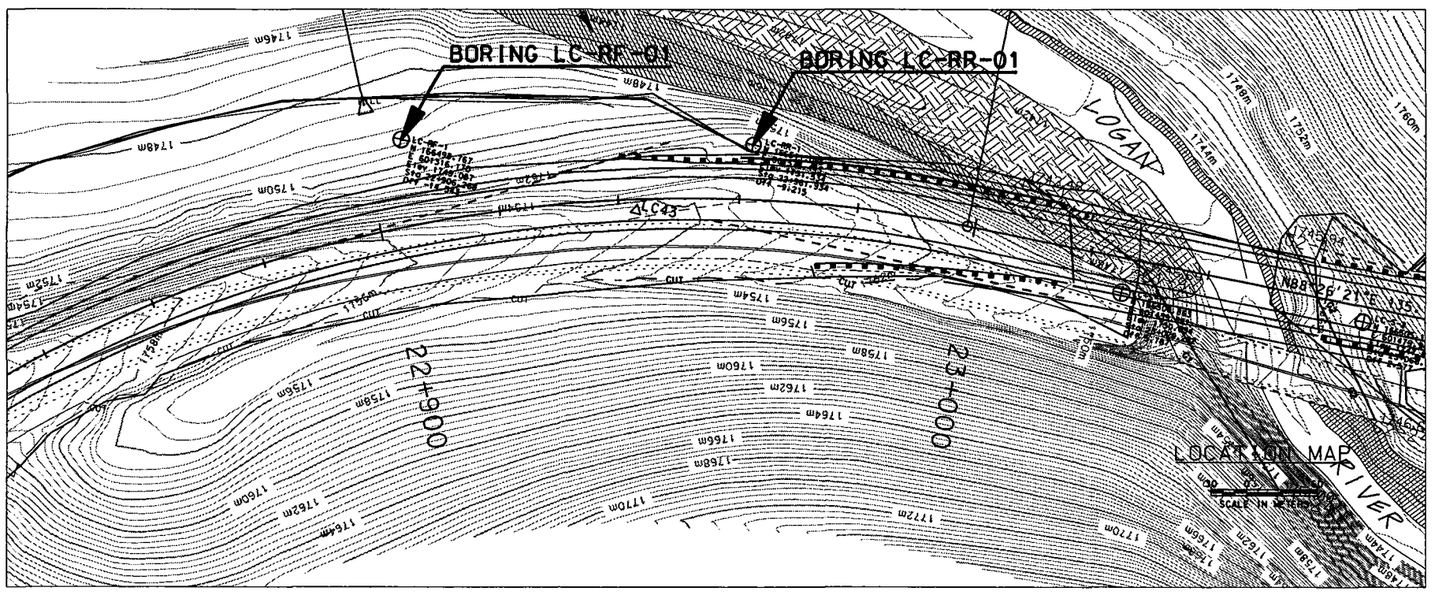
SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RR-01
ELEVATION: 1751.6

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
TOPSOIL: Silty clay (CL), with sand and gravel, soft, moist to wet, low to medium plasticity, dark brown, with organics (A-7-6)	0	0	U	2-2-3	5
SILTY CLAY (CL): with sand and gravel, moist, medium plasticity, brown to dark brown, with trace organics			U	2-2-2	4
BOULDERS IN A CLAY MATRIX WITH GRAVELS AND COBBLES: very dense	5		U	3-5-15	20
LIMESTONE BEDROCK: moderately strong, fractured, thinly bedded, with calcite-filled fractures, bedding angle ranges from 8 to 25 degrees note: recovered sample (4.1-4.9m) contains 3 fractures at angles of 60 degrees or more note: grades highly fractured from approximately 4.9 to 7m, recovered sample (4.9-6.1m) contains numerous fractures at angles of 60 degrees or more note: recovered sample (6.1-7.0m) contains 4 fractures at angles of 60 degrees or more note: recovered sample (7.0-7.9m) contains 3 fractures at angles of 60 degrees or more note: recovered sample (7.9-9.5m) contains 4 fractures at angles of 60 degrees or more	10	5/14/199	C		
note: recovered sample (9.5-11.0m) contains 2 fractures at angles of 60 degrees or more	15	5	C		
note: recovered sample (11.0-12.5m) contains 5 fractures at angles of 60 degrees or more	20	6	C		
note: recovered sample (12.5-14.0m) contains 3 fractures at angles of 60 degrees or more	25	7	C		
note: recovered sample (14.0-15.6m) contains 3 fractures at angles of 60 degrees or more	30	10	C		
note: recovered sample (15.6-17.1m) contains at least 1 fracture at an angle of 60 degrees or more	35		C		
Boring completed at 17.1m below existing grade.	40				
	45	15			
	50				
	55				
	60	19			

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00



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6. BOULDER - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION OF 305 mm

NOTE:

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GEOTECHNICAL ENGINEER

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RELATIVE DENSITY
(NON-PLASTIC SAND & SILT)

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GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

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GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____ PIN# ____
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APPROVAL RECOMM. ____ DATE ____ CHIEF GEOTECHNICAL ENGR.
RECEIVED ____ DATE ____ CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 2 OF 17

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Date: 24 OCT 100 Time: 16:02:55 Username: $$usernames$$

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-S-01
ELEVATION: 1750.0

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
FILL: Sandy gravel (GP) with clay, consists of limestone and chert (A-1) note: washing of fines, no recovery of sample		0	C		
FILL: Clayey gravel (GC), with sand, loose, low to medium plasticity (A-2-6)	5		S	6-6-3	9
FILL: Boulders, consist predominantly of quartzite, hard/dense			C		
note: no recovery of SPT sample	10		S	3-2-2	4
LIMESTONE BEDROCK: moderately weak to weak, fractured, thinly bedded, brecciated, with calcite- and clay-filled fractures, bedding angle ranges from 15 to 30 degrees, moderately to highly weathered note: recovered sample (4.9-6.4m) contains 3 fractures at angles of 60 degrees or more	15	5	C		
note: grades with trace limonite, recovered sample (6.4-7.5m) contains 2 fractures at angles of 60 degrees or more	20		C		
note: recovered sample (7.5-7.9m) contains 3 fractures at angles of 60 degrees or more note: recovered sample (7.9-9.5m) contains 3 fractures at angles of 60 degrees or more	25		C		
note: recovered sample (10.7-11.3m) contains 1 fracture at an angle of 60 degrees or more note: recovered sample (11.3-12.5m) contains 1 fracture at an angle of 60 degrees or more	30	10	C		
note: grades less brecciated, with less calcite- and clay-filled fractures, recovered sample (12.5-13.7m) contains 4 fractures at angles of 60 degrees or more	35		C		
note: grades without limonite note: grades very thinly bedded from approximately 14 to 16.5m, recovered sample (14.0-15.6m) contains 2 fractures at angles of 60 degrees or more	40		C		
note: recovered sample (15.6-16.5m) contains 1 fracture at an angle of 60 degrees or more	45		C		
note: recovered sample (16.5-17.1m) contains 1 fracture at an angle of 60 degrees or more note: grades less thinly bedded, recovered sample (17.1-18.6m) contains 2 fractures at angles of 60 degrees or more	50	15	C		
	55		C		
	60		C		

Groundwater not measured.

19

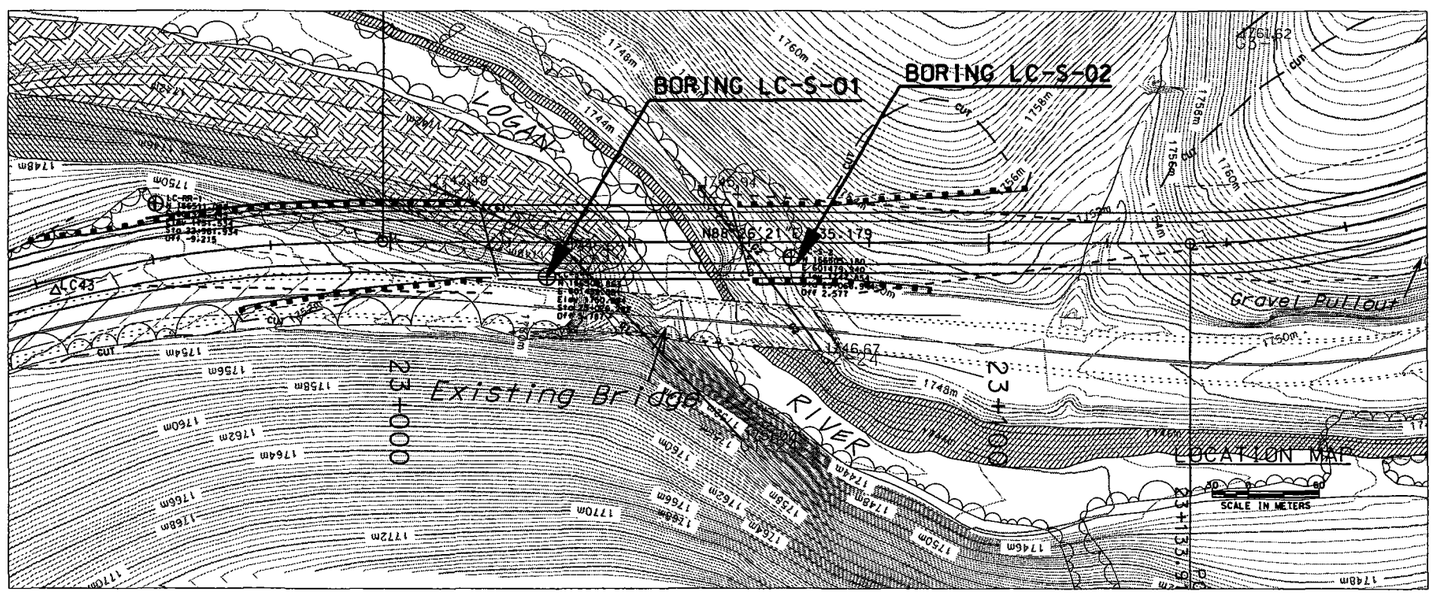
UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-S-02
ELEVATION: 1747.8

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
TOPSOIL: Silty sand (SM), with some gravel, loose to medium dense, moist, low plasticity, dark brown (A-5)		0	C		
BOULDERS: consist predominantly of quartzite, hard/dense	5		C		
LIMESTONE BEDROCK: moderately strong, slightly fractured, thinly bedded, with trace limonite and calcite-filled fractures, bedding angle ranges from 5 to 15 degrees note: recovered sample (1.7-3.1m) contains 2 fractures at angles of 60 degrees or more note: recovered sample (3.1-4.6m) contains 3 fractures at angles of 60 degrees or more	10		C		
note: grades highly fractured in relatively thin zones from approximately 4.5 to 6m, recovered sample (4.6-6.1m) contains 2 fractures at angles of 60 degrees or more	15	5	C		
note: grades less fractured, recovered sample (6.1-7.6m) contains 5 fractures at angles of 60 degrees or more	20		C		
note: recovered sample (7.6-7.9m) contains 1 fracture at an angle of 60 degrees or more note: recovered sample (7.9-9.5m) contains 1 fracture at an angle of 60 degrees or more	25		C		
note: grades less thinly bedded, recovered sample (9.5-11.0m) contains 3 fractures at angles of 60 degrees or more	30	10	C		
note: recovered sample (11.0-12.5m) contains 2 fractures at angles of 60 degrees or more	35		C		
note: recovered sample (12.5-14.0m) contains 1 fracture at an angle of 60 degrees or more	40		C		
note: recovered sample (14.0-15.6m) contains 3 fractures at angles of 60 degrees or more	45		C		
note: recovered sample (15.6-17.1m) contains 3 fractures at angles of 60 degrees or more	50	15	C		
note: grades hard to very hard, recovered sample (17.1-18.6m) contains 1 fracture at an angle of 60 degrees or more	55		C		
	60		C		

Groundwater not measured.

19



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5. COBBLE - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION BETWEEN 76 mm AND 305 mm
6. BOULDER - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION OF 305 mm

NOTE:

RIG USED: SD 1500 TRACK RIG

GEOTECHNICAL ENGINEER

KEY TO BORING LOG

WHEN APPLICABLE
RELATIVE DENSITY
(NON-PLASTIC SAND & SILT)

VERY LOOSE - N LESS THAN 4
LOOSE - N 4 TO 10
MEDIUM - N 10 TO 30
DENSE - N 30 TO 50
VERY DENSE - N MORE THAN 50

CONSISTENCY
(PLASTIC - SILT & CLAY)

VERY SOFT - N LESS THAN 2
SOFT - N 2 TO 4
MEDIUM - N 4 TO 8
STIFF - N 8 TO 15
VERY STIFF - N 15 TO 30
HARD - N MORE THAN 30

GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
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BOULDERS, CLAYEY BOULDERS, BOULDERS AND COBBLES IN A CLAY MATRIX.
GRAVELS, COBBLES AND BOULDERS
SEE "GRADATION" SECTION ON EXPLANATION SHEET FOR PARTICLE SIZE RANGES

CONGLOMERATE
CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT

LIMESTONE

DOLOMITE

QUARTZITE

SHALE

ABBREVIATIONS

C - HX CORE BARREL, 61 mm ID & 74 mm OD

>100 - N VALUE GREATER THAN 100 BLOWS PER 0.3 M

NR - NOT RECORDED

AASHTO - SOIL CLASSIFICATION SYSTEM SYMBOL

USCS - UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL

NO.	DATE	BY	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

DRAWN ____ GEOLOGIST ____ C.I.D. ____ PIN# ____

APPROVAL RECOMM. ____ DATE ____ CHIEF GEOTECHNICAL ENGR.
RECEIVED ____ DATE ____ CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 3 OF 17

Date:24 OCT 00 Time:16:04:07 Username:s&usernames&

Filename:s:\common\greg\remet\584.97\soildata sheets\soildata sheet files\lc-s-1&lc-s-2.dgn

SOIL_DATA_SHEET2 LOGCAN.DGN LOGCAN.CBT 5/9/00

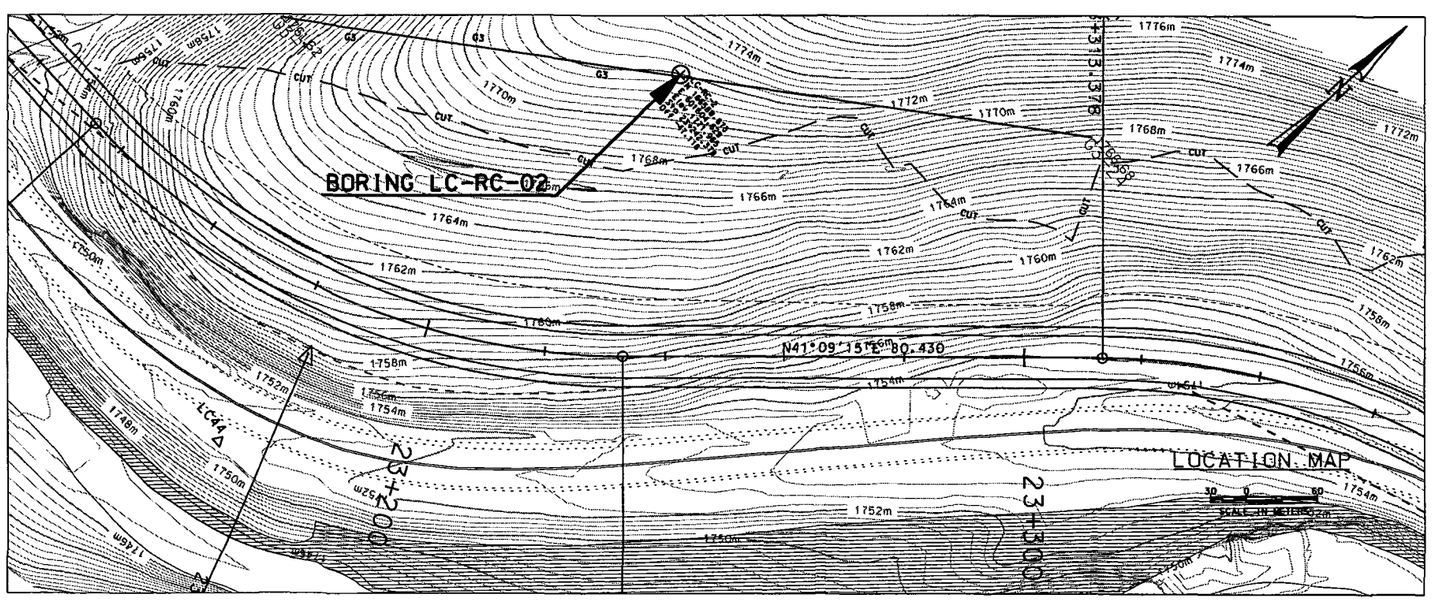
Date:24 OCT 100 Time:1558h05 Username:s&usernames

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-02
ELEVATION: 1772.0

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
TOPSOIL: Silty clay (CL), with trace sand and gravel, soft, moist, low plasticity, dark brown, with organics	0	0	S	2-2-3	5
SILTY CLAY (CL): with some gravel, wet, medium to high plasticity, brown			C		
BOULDERS IN A CLAY MATRIX, very dense, consists primarily of quartzite and limestone; wet, moderately plastic, yellowish red, with calcareous deposits, sand, and gravel	5	5	C		
note: grades with occasional clayey gravel layers and less calcareous deposits	10	5	C		
note: grades very soft/very loose, with red coloration; loss of water indicates a void at about 6.1m below existing grade	15	5	C		
LIMESTONE BEDROCK: moderately strong, fractured, thinly bedded, with calcite- and clay-filled fractures, bedding angle ranges from 5 to 10 degrees note: recovered sample (6.4-7.9m)contains 4 fractures at angles of 60 degrees or more note: recovered sample (7.9-9.5m) contains 4 fractures at angles of 60 degrees or more	20	5	C		
note: grades moderately weak to weak and highly fractured from approximately 9.5 to 11.0m below existing grade, recovered sample contains (9.5-11.0m) at least 6 fractures at angles of 60 degrees or more	25	5	C		
note: grades moderately strong, slightly fractured, recovered sample (11.0-12.5m) contains 4 fractures at angles of 60 degrees or more	30	10	C		
note: recovered sample (12.5-14.0m) contains 2 fractures at angles of 60 degrees or more	35	10	C		
note: recovered sample (14.0-15.6m) contains 1 fracture at an angle of 60 degrees or more	40	10	C		
note: recovered sample (15.6-17.1m) contains 3 fractures at angles of 60 degrees or more	45	15	C		
Boring completed at 17.1m below existing grade. Groundwater not measured.	50	15	C		
	55	15	C		
	60	19			

SOIL_DATA_SHEET2 LOGCAN.OPJ LOGCAN.GDT 5/9/00



GENERAL NOTES

1. THE SUBSURFACE EXPLORATIONS SHOWN WERE CONDUCTED BETWEEN 5-11-99 AND 6-8-99 BY DAMES & MOORE.
2. THESE BORING LOGS REPRESENT A SYNOPSIS OF THE SOIL DEPOSITS ENCOUNTERED WITHIN EACH 74 mm DIAMETER BORING AND ARE BASED ON SOUND GEOLOGICAL AND ENGINEERING JUDGEMENT. BECAUSE SOIL IS A COMPLEX MEDIUM, THESE BORING LOGS MAY OR MAY NOT REPRESENT THE SOIL CONDITIONS AT THIS SITE. THIS SUBSURFACE INTERPRETATION IS PRESENTED IN GOOD FAITH AND IS NOT INTENDED AS A SUBSTITUTE FOR PERSONAL INVESTIGATION AND JUDGEMENT OF THE CONTRACTOR.
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5. COBBLE - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION BETWEEN 76 mm AND 305 mm
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NOTE:

RIG USED: SD 1500 TRACK RIG

GEOTECHNICAL ENGINEER

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ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
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LIMESTONE

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NO.	DATE	BY	REVISIONS	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST: C.I.D. | DRAWN: | PIN#

APPROVAL RECOMM. DATE CHIEF GEOTECHNICAL ENGR. | RECEIVED DATE CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 4 OF 17

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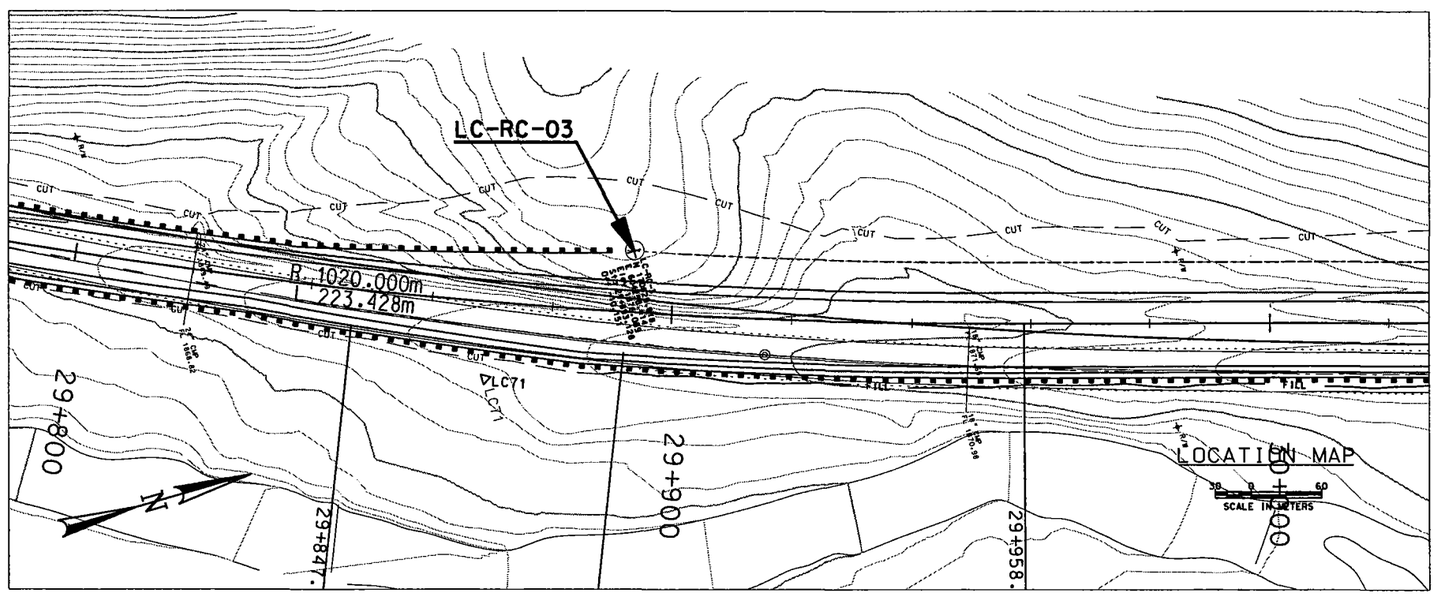
UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-03
ELEVATION: 1876.1
Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/0.15m	Pen. Resist. (Blows/0.305m)
BOULDERS IN A CALY MATRIX WITH COBBLES: glacial till, very hard/very dense, consists primarily of quartzite, moderately plastic	0–15	0–5		C, C, C		
SILTY CLAY (CL): glacial till with sand and numerous interbedded gravels, cobbles, and boulders, low to medium plasticity, brownish yellow	15–20	5–6		S, C	14-6-7	13
SANDY BOULDERS WITH GRAVELS AND COBBLES: glacial till, very hard/very dense, consists primarily of quartzite	20–25	6–7.6		C, C		
Boring completed at 7.6m below existing grade. Groundwater not measured.	25–60	7.6–19				

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00



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CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT

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SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____
C.I.D. ____ *PIN# ____

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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET
PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 5 OF 17

Filename: st\common\greg\remet\584_97\soil data sheets\soil data sheet files\lc-rc-3.dgn
Date: 24 OCT 100 Time: 15:58:44 Username: $$username$$

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-S-05
ELEVATION: 1928.8

Sheet 1 of 1

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
0	0				
5	5		C		
10	10		C		
15	15		C		
20	20		C		
25	25		C		
30	30		C		
35	35				
40	40				
45	45				
50	50				
55	55				
60	60				
	19				

BOULDERS IN A CLAY MATRIX: mainly glacial till: very dense, consist of quartzite, moderate plasticity, brownish yellow

note: loss of water into formation at approximately 1.7m

CONGLOMERATE: consists of moderately strong to strong sand and gravel with cobbles and clay, materials include predominantly limestone fragments, with siltstone and sandstone fragments in a yellowish red, silty quartz matrix, iron oxide staining, gray/yellowish red/brown

note: grades weakly cemented with increasing clay content from approximately 7.5m

SILTY CLAY (CL), stiff, medium plasticity, yellowish red

Boring completed at 9.4m below existing grade.

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/5/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-S-04
ELEVATION: 1929.3

Sheet 1 of 1

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
0	0		U	6-7-10	17
5	5		C		
10	10		C		
15	15		C		
20	20		C		
25	25		C		
30	30		C		
35	35		C		
40	40		C		
45	45		C		
50	50		C		
55	55				
60	60				
	19				

CLAYEY SAND (SC): with gravel, medium stiff to stiff, high plasticity, brown to dark brown

BOULDERS IN A CLAY MATRIX WITH GRAVELS AND COBBLES: glacial till, very dense

CONGLOMERATE: gravels and cobbles in a cemented sand matrix: clasts are generally limestone fragments with some siltstone and sandstone fragments, moderately strong, highly weathered

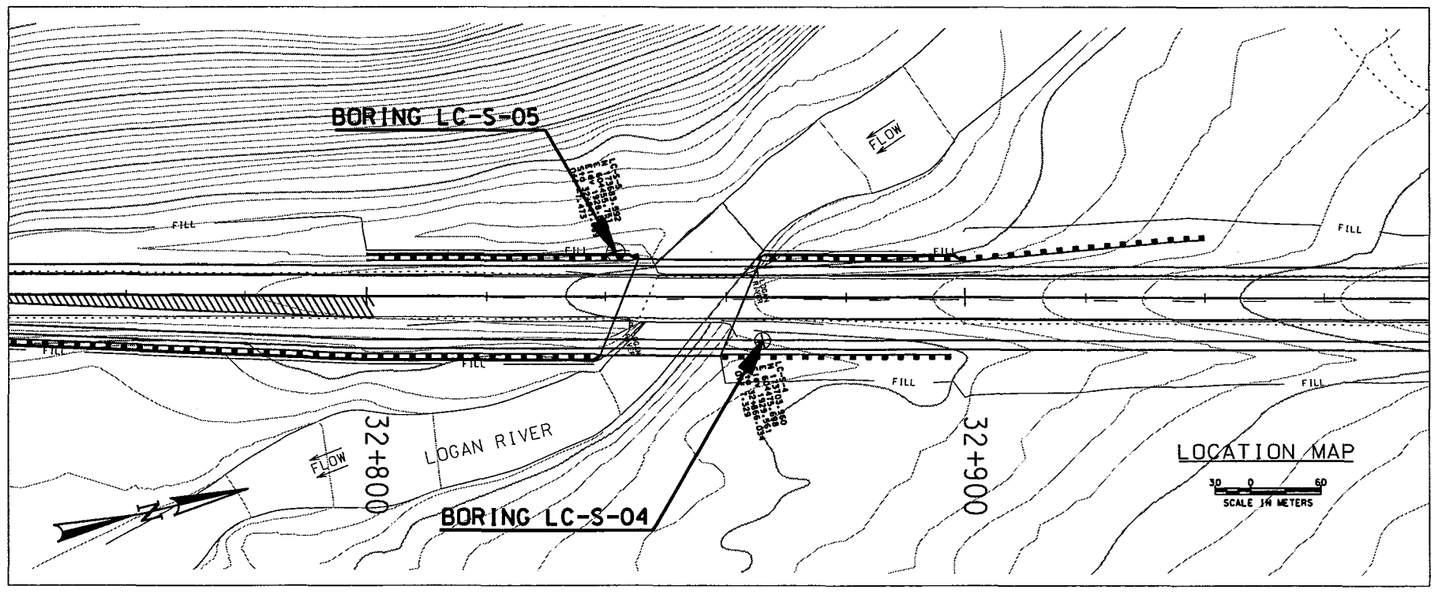
note: grades strongly cemented at approximately 3.5m

SANDY CLAY (CL), with gravel, stiff, medium plasticity, yellowish red

CONGLOMERATE: gravels and cobbles in a cemented sand matrix: clasts are generally limestone fragments with some siltstone and sandstone fragments, moderately strong, highly weathered

Boring completed at 15.2m below existing grade.

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/5/00



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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(291)393

SUMMIT
COUNTY

DRG. NO.

SHT. 6 OF 17

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Date:24 OCT 100 Time:15:59:05 Username:$$usernames$$

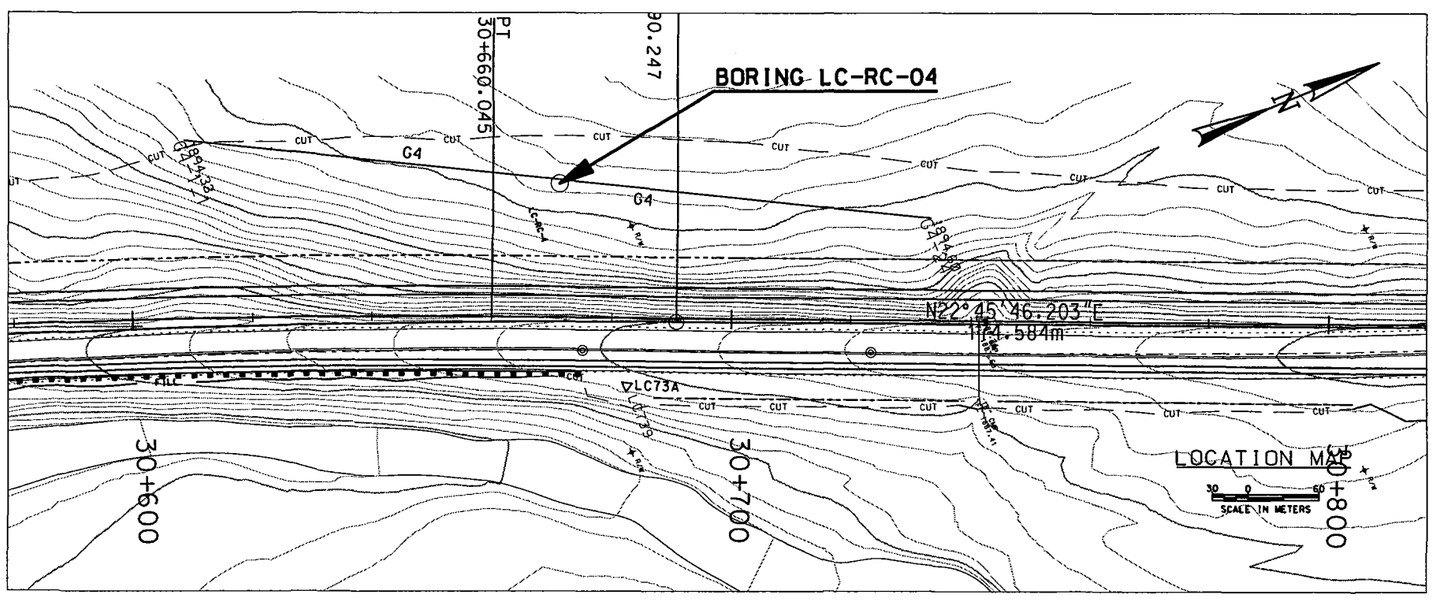
Filename:s:\common\greg\r-emet\584.97\soldata sheets\soldata sheet files\lc-rc-4.dgn

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-04
ELEVATION: 1895.6

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
TOPSOIL: Silty clay (CL), with trace sand, moist to wet, low to medium plasticity, dark brown, with organics	0	0			
BOULDERS IN A CLAY MATRIX WITH SAND, GRAVEL AND BOULDERS: very dense, moist to wet, moderately plastic, brown to yellowish red	5	1.5	C		
	10	3	C		
GRAVEL (GP): with interbeds of cemented sand, gravelly sand, silty clay, and occasional boulders, loose to dense, moist, brown/multi-colored note: relatively fast core advance: relatively soft zones indicate presence of silty clay interbeds	15	4.5	C		
	20	6	C		
SILTY SAND (SM): with gravel, predominantly coarse-grained, brown to yellowish red, with mica and thin layers (10cm thick) of cemented fine grained sand (A-1-b)			S	19-14-15	29
			C		
SANDY GRAVEL (GP): with thin layers of cemented fine sand and boulder fragments, predominantly fine grained gravel and fine to medium grained sand, brown/multi-colored	25	7.5	S	7-9-17	26
			C		
GRAVEL (GP): with occasional boulder fragments, cobbles, and boulders, predominantly coarse grained, medium dense to very dense, multi-colored note: SPT sampler refusal at 9.5m	30	9	S	>100	>100
			C		
note: grades with cobbles and boulders	35	10.5	C		
	40	12	C		
			C		
Boring completed at 13.4m below existing grade. Groundwater not measured.	45	13.5			
	50	15			
	55	16.5			
	60	18			

SOIL_DATA_SHEET2 LOGCAN.CPJ LOGCAN.GDT 5/9/00



GENERAL NOTES

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5. COBBLE - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION BETWEEN 76 mm AND 305 mm
6. BOULDER - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION OF 305 mm

NOTE:

RIG USED: SD 1500 TRACK RIG

GEOTECHNICAL ENGINEER

KEY TO BORING LOG

WHEN APPLICABLE

RELATIVE DENSITY (NON-PLASTIC SAND & SILT)

VERY LOOSE - N LESS THAN 4
LOOSE - N 4 TO 10
MEDIUM - N 10 TO 30
DENSE - N 30 TO 50
VERY DENSE - N MORE THAN 50

CONSISTENCY (PLASTIC - SILT & CLAY)

VERY SOFT - N LESS THAN 2
SOFT - N 2 TO 4
MEDIUM - N 4 TO 8
STIFF - N 8 TO 15
VERY STIFF - N 15 TO 30
HARD - N MORE THAN 30

GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY
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PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

BOULDERS, CLAYEY BOULDERS, BOULDERS AND COBBLES IN A CALY MATRIX, GRAVELS, COBBLES AND BOULDERS

CONGLOMERATE
CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT

LIMESTONE

DOLOMITE

QUARTZITE

SHALE

ABBREVIATIONS

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>100 - N VALUE GREATER THAN 100 BLOWS PER 0.3 M

NR - NOT RECORDED

AASHTO - SOIL CLASSIFICATION SYSTEM SYMBOL

USCS - UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL

NO.	DATE	BY	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

DRAWN ____ GEOLOGIST ____
C.I.D. ____ .PIN# ____

APPROVAL RECOMM. ____ DATE ____ CHIEF GEOTECHNICAL ENGR.
RECEIVED ____ DATE ____ CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET
PROJECT NUMBER *NH-0089(291)393

SUMMIT
COUNTY

DRG. NO.

SHT. 7 OF 17

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-05
ELEVATION: 1999.5
Sheet 1 of 2

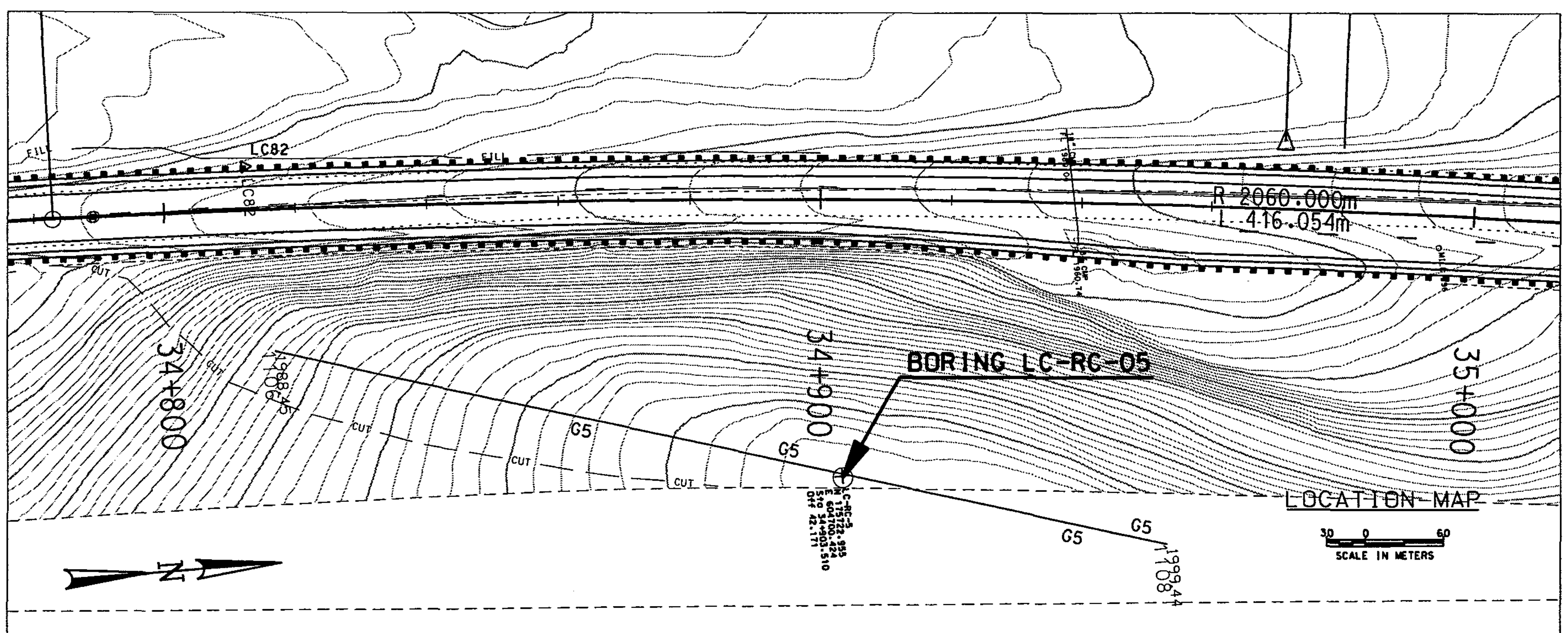
Description	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
SANDY CLAY (CL): with gravel, low to medium plasticity, brown with trace organics; gravel is fine-grained and angular	0–5	0		C		
BOULDERS IN A CLAY MATRIX: limestone with gravel fragments and calcite-filled fractures				C		
CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, brown; gravel is fine to coarse grained, angular, vertically oriented, consists of shale and/or limestone fragments	10			C		
GRAVEL (GP): with clay, fine-grained, angular, consists of shale and/or limestone fragments	15	5				
CLAYEY SAND (SC): with silt, gravel, and trace cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, vertically oriented, consists of shale and/or limestone fragments	20			C		
GRAVEL (GP): fine-grained, angular, vertically oriented, with limonite, consists of shale and/or limestone fragments				C		
CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists of shale and/or limestone fragments	25–35	10		C, C		
BOULDER: limestone				C		
CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown; gravel is fine to coarse grained, angular, randomly oriented, consists of limestone fragments	40			C		
BOULDER: limestone	45			C		
COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown	50–60	15–19		C, C, C		

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-05
Sheet 2 of 2

Description	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
	65	19–20		C		
CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists predominantly of limestone fragments	70			C		
COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown				C		
CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists predominantly of limestone fragments	75			C		
COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown	80			C		
CLAYEY SAND (SC): with silt, gravel, and occasional cobbles, low plasticity, light brown to brown; gravel is fine to coarse grained, angular, randomly oriented, consists predominantly of limestone fragments		25				
COBBLES IN A CLAY MATRIX WITH SAND, GRAVEL, AND BOULDERS: very dense, light brown to brown	85					
Boring completed at 24.4m below existing grade. Groundwater not measured.	90–120	30–38				

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00



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GEOTECHNICAL ENGINEER

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UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST | DRAWN | C.I.D. | .PIN#
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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 8 OF 17

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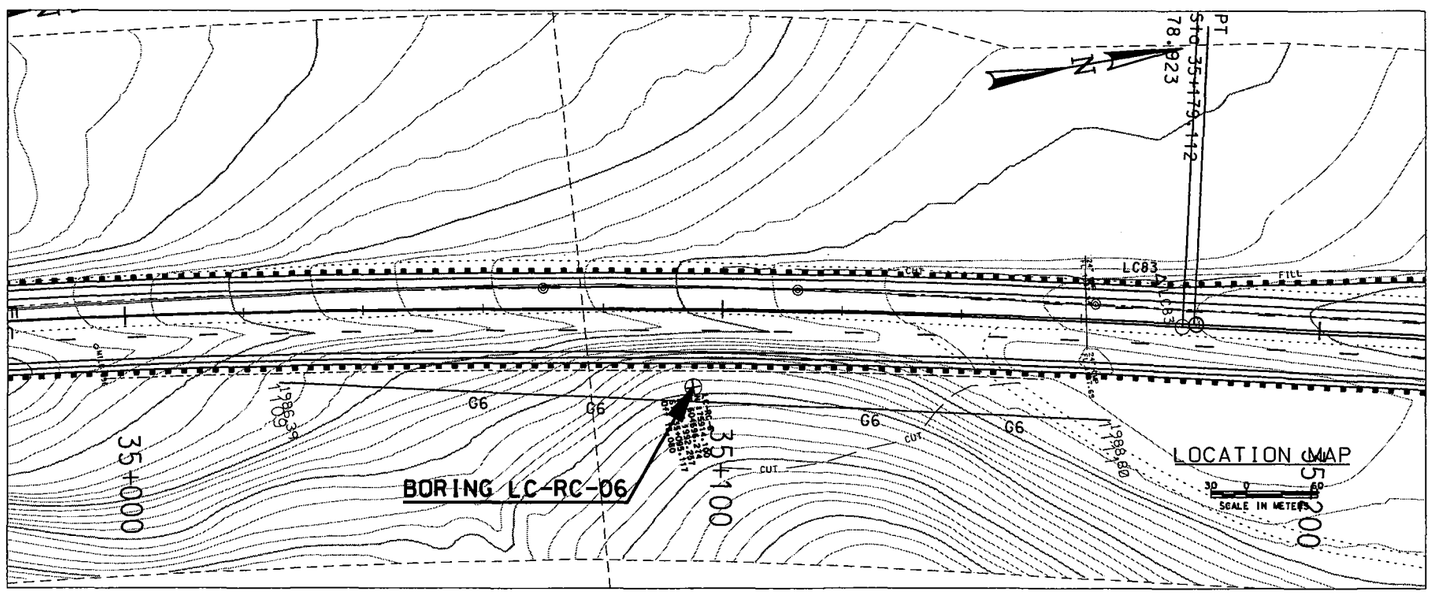
UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-06
ELEVATION: 1992.4

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/0.15m	Pen. Resist. (Blows/0.305m)
TOPSOIL: Silty clay (CL), with sand, low to medium plasticity, dark brown, with organics	0	0		S	1-1-1	2
CLAYEY GRAVEL (GC): angular, consists predominantly of weathered limestone fragments						
LIMESTONE BEDROCK: moderately strong, moderately weathered, fractured, thinly bedded, with clay-filled fractures, bedding angle ranges from 30 to 50 degrees				C		
note: recovered sample (1.8-3.1m) contains at least 1 fracture at an angle of 60 degrees or more	5	1.5				
note: recovered sample (3.1-4.6m) contains 4 fractures at angles of 60 degrees or more				C		
	10	3				
				C		
note: grades with a change in dip of bedding planes: bedding angle ranges from approximately 10 to 15 degrees: recovered sample (4.6-6.3m) is predominantly brecciated limestone and clay: clay is moderately plastic, brown, and contains angular limestone and quartzite fragments	15	4.5				
				C		
note: grades strong: recovered sample (6.3-6.7m) contains numerous fractures at angles of 60 degrees or more	20	6		C		
note: recovered sample (6.7-7.3m) contains at least 1 fracture at an angle of 60 degrees or more				C		
note: recovered sample (7.3-7.9m) contains 3 fractures at angles of 60 degrees or more	25	7.5		C		
QUARTZITE BEDROCK: strong, massive, bedding angle ranges from approximately 25 to 40 degrees, fracture located approximately 1.6m from bottom of hole				C		
note: recovered sample (9.5-10.7m) contains 2 fractures at angles of 60 degrees or more	30	9		C		
Boring completed at 10.7m below existing grade. Groundwater not measured.	35	10.5				
	40	12				
	45	13.5				
	50	15				
	55	16.5				
	60	19				

SOIL DATA_SHEET2 LOGCAN.CPJ LOGCAN.GDT 5/9/00



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NOTE:

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SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____ C.I.D. ____ *PIN#

APPROVAL RECOMM. DATE CHIEF GEOTECHNICAL ENGR.

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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 9 OF 17

Filename: s:\common\greg\remet\584_97\soil data sheets\soil data sheet files\lc-rc-6.dgn
Date: 24 OCT 100 Time: 15:59:59 Username: $$username$$

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RR-02
ELEVATION: 2007.6

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/0.15m	Pen. Resist. (Blows/0.305m)
SANDY SILT (MH): with some clay and gravel, medium stiff, wet, medium plasticity, dark brown, with organics (A-7-6)		5/23/199	U	8-7-4	11
SILTY CLAY (CL): with sand seams, medium stiff, wet, low to medium plasticity, brown to brownish yellow			U	3-5-4	9
BOULDERS IN A CLAY MATRIX WITH GRAVELS AND COBBLES: unsorted glacial till: boulders are hard/dense and consist predominantly of quartzite: gravel consists of limestone, sandstone, and quartzite: silty clay is slightly to moderately plastic, brownish yellow	5		C		
note: poor recovery of clay			C		
note: grades with angular gravel	10		S	8-4-11	15
BOULDERS: very hard/very dense, consist predominantly of quartzite			C		
note: relatively slow core advance	15	5	C		
	20		C		
SANDY CLAY (CH): with trace gravel, very stiff to hard, high plasticity, gray to greenish gray, gravel is predominantly fine-grained (A-7-6)			C		
	25		C		
	30		C		
note: grades to clay with sand	35	10	C		
	40		C		
Boring completed at 12.2m below existing grade.	45				
	50	15			
	55				
	60				

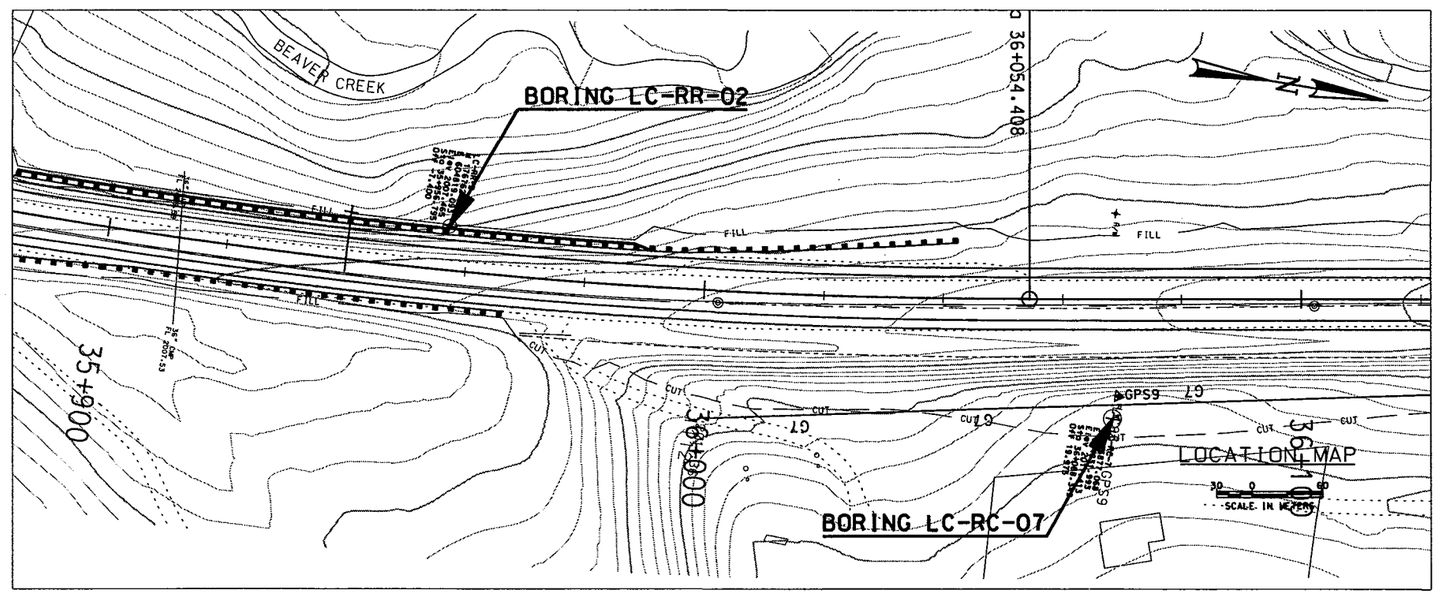
SOIL_DATA_SHEET2 LOGCAN.DPJ LOGCAN.GDT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-07
ELEVATION: 2017.4

Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/0.15m	Pen. Resist. (Blows/0.305m)
BOULDERS IN A CLAY MATRIX: loose to medium dense, slightly to moderately plastic, brown		0			
	5		C		
SANDY CLAY (CL): with gravel and trace cobbles, predominantly coarse-grained sand and fine-grained gravel, soft to medium stiff, moist to wet, medium plasticity, yellowish brown to brown, gravel and cobbles consist of limestone fragments (A-6)		6/5/199	C		
note: grades with trace gravel and trace cobbles	10		S	3-3-6	9
			C		
	15		C		
	20	5			
note: grades without gravel and cobbles			S	3-3-9	12
COBBLES IN A CLAY MATRIX WITH BOULDERS: glacial till: very dense, moderately plastic, brown	25		C		
note: loss of water into formation at approximately 7.9m			C		
	30		C		
	35	10	C		
	40		C		
Boring completed at 13.7m below existing grade.	45		C		
	50	15			
	55				
	60				

SOIL_DATA_SHEET2 LOGCAN.DPJ LOGCAN.GDT 5/9/00



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RIG USED: SD 1500 TRACK RIG

GEOTECHNICAL ENGINEER

KEY TO BORING LOG

WHEN APPLICABLE

RELATIVE DENSITY (NON-PLASTIC SAND & SILT)

VERY LOOSE - N LESS THAN 4
LOOSE - N 4 TO 10
MEDIUM - N 10 TO 30
DENSE - N 30 TO 50
VERY DENSE - N MORE THAN 50

CONSISTENCY (PLASTIC - SILT & CLAY)

VERY SOFT - N LESS THAN 2
SOFT - N 2 TO 4
MEDIUM - N 4 TO 8
STIFF - N 8 TO 15
VERY STIFF - N 15 TO 30
HARD - N MORE THAN 30

GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

BOULDERS, CLAYEY BOULDERS, BOULDERS AND COBBLES IN A CALY MATRIX, GRAVELS, COBBLES AND BOULDERS

CONGLOMERATE — CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT

LIMESTONE

DOLOMITE

QUARTZITE

SHALE

ABBREVIATIONS

C - HX CORE BARREL, 61 mm ID & 74 mm OD

>100 - N VALUE GREATER THAN 100 BLOWS PER 0.3 M

NR - NOT RECORDED

AASHTO - SOIL CLASSIFICATION SYSTEM SYMBOL

USCS - UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL

NO.	DATE	BY	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____ PIN# ____ C.I.D. ____

APPROVAL RECOMM. ____ DATE ____ CHIEF GEOTECHNICAL ENGR.
RECEIVED ____ DATE ____ CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(291)393

SUMMIT
COUNTY

DRG. NO.

SHT. 10 OF 17

Filename: s:\common\greg\remet\584.97\soildata sheets\soildata sheet files\lc-rr-2&lc-rc-7.dgn
Date: 24 OCT 100 Time: 16:03:30 Username: $$username$$

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-S-03
ELEVATION: 2022.6
Sheet 1 of 1

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
	0		U	8-4-C100	C100
	5/21/19		C		
5			S	3-1-2	3
			C		
10			S	2-3-2	5
			C		
15	5		S	10-13-15	28
			C		
20			C		
			C		
25			C		
			C		
30			C		
	10		C		
35			C		
40					
45					
50	15				
55					
60	19				

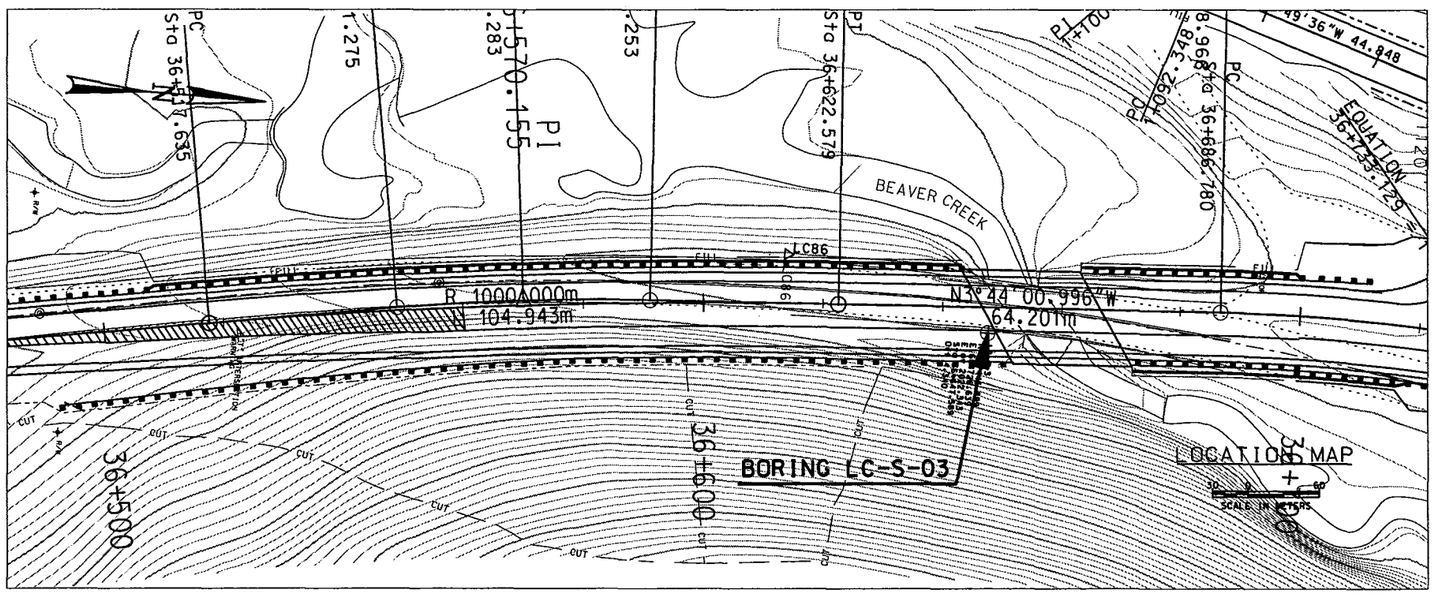
FILL: Silty sand (SM) with gravel, predominantly fine to medium-grained, medium dense, moist, low plasticity, dark brown with trace organics (A-1-b)
SILTY CLAY WITH COBBLES, BOULDERS,
GRAVEL, SAND, AND TRACE ORGANICS: soft to medium stiff, wet, dark gray to brownish yellow (A-4)

LIMESTONE BEDROCK: moderately strong, highly fractured, thinly bedded, brecciated, with numerous clay-filled fractures and occasional calcite-filled fractures, chrystalline, black, bedding angle ranges from approximately 15 to 25 degrees
note: recovered sample (4.9-6.1m) contains 3 fractures at angles of 60 degrees or more
note: recovered samples from 6.1 to 10.1m contain numerous fractures at angles of 60 degrees or more

note: recovered sample (contains numerous fractures at angles of 60 degrees or more
note: relatively slow core advance

note: grades very thinly bedded, recovered sample contains 3 fractures at angles of 60 degrees or more

Boring completed at 10.7m below existing grade.



GENERAL NOTES

1. THE SUBSURFACE EXPLORATIONS SHOWN WERE CONDUCTED BETWEEN 5-11-99 AND 6-8-99 BY DAMES & MOORE.
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5. COBBLE - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION BETWEEN 76 mm AND 305 mm
6. BOULDER - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION OF 305 mm

NOTE:

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GEOTECHNICAL ENGINEER

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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET
PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

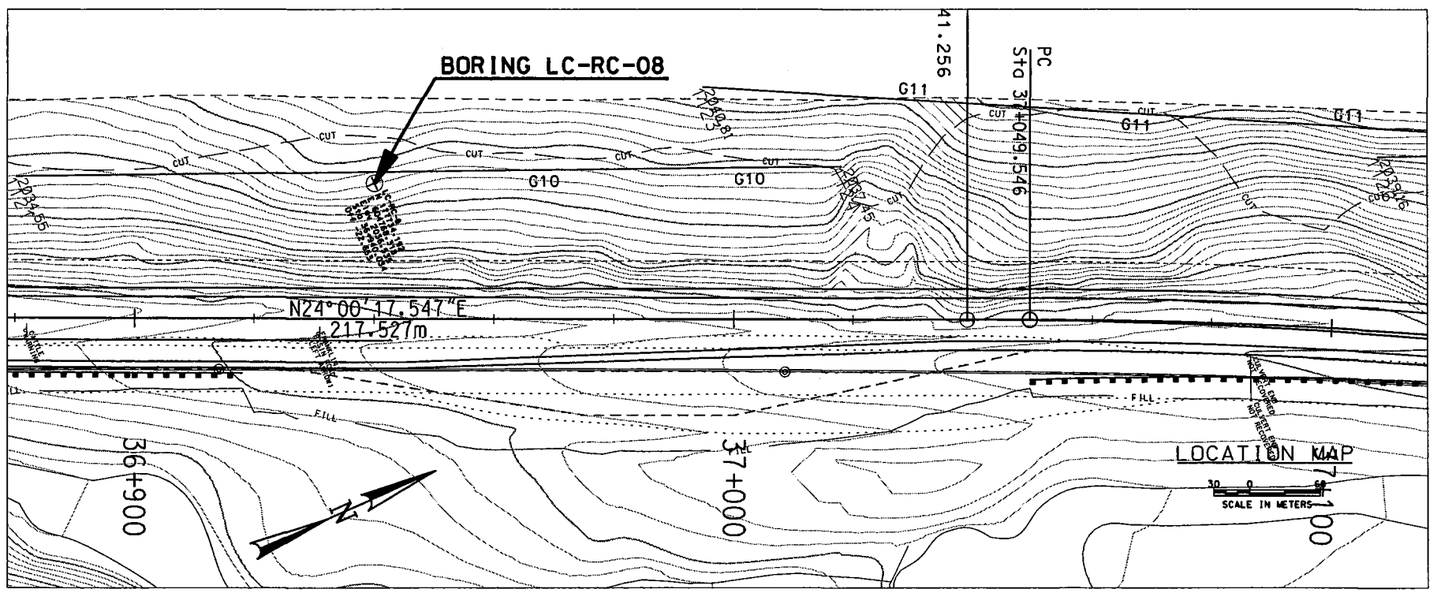
SHT. 11 OF 17

Filename:s:\common\greg\remet\584.97\soil data sheets\soil data sheet files\lc-s-3.dgn
Date:24 OCT 100 Time:16:05:16 Username:$$username$$
SOIL_DATA_SHEET2 LOGCAN.CFG LOGCAN.CGT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-08
ELEVATION: 2036.6
Sheet 1 of 1

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)	Description
0	0		S	>100	>100	TOPSOIL: Silty clay (CL), with trace sand, moist, low to medium plasticity, dark brown, with organics
						SILTY CLAY (CL), with gravel, moist, low to medium plasticity, brown, gravel is fine grained (A-7-6)
5			C			BOULDERS IN A CLAY MATRIX WITH SAND AND GRAVEL: very dense, moist to wet, moderately to highly plastic, brown to brownish yellow
			C			
10						
	5/20/199		S	4-5-6	11	CLAY (CH): with trace sand and occasional fine-grained gravel, stiff, wet, high plasticity, brownish yellow, with trace organics (A-7-6) note: grades without organics
15			C			
	5					note: grades medium stiff with trace gravel/boulder fragments
20			C			
						note: grades without gravel/boulder fragments
			S	2-3-4	7	
25			C			
						note: grades soft to medium stiff
			S	1-2-2	4	
30			C			
	10					LIMESTONE BEDROCK: moderately strong, slightly weathered, slightly fractured, thinly bedded, with calcite- and clay-filled fractures, bedding angle is approximately 10 degrees note: recovered sample (9.0-9.5m) contains 1 fracture at an angle of 60 degrees or more note: relatively slow drilling through bedrock, recovered sample (9.5-11.0m) contains 2 fractures at an angle of 60 degrees or more note: grades with a 10cm void, recovered sample (11.0-12.5m) contains 1 fracture at an angle of 60 degrees or more note: grades with a 15cm void
35			C			
40			C			
45			C			
50	15					Boring completed at 14.0m below existing grade.
55						
60						
	19					

SOIL_DATA_SHEET2 LOGAN.DPJ LOGAN.GDT 5/9/00



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GEOTECHNICAL ENGINEER

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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 12 OF 17

Filename: ss\common\greg\vernet\584_97\soil data sheets\soil data sheet files\lc-rc-8.dgn
Date: 24 OCT 100 Time: 16:00:35 Username: $$username$$

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-09
ELEVATION: 2051.4
Sheet 1 of 2

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
0					
5			C		
10			C		
15	5		C		
20		5/26/1999	C		
25			C		
30	10		C		
35			C		
40			C		
45	15		C		
50			C		
55			C		
60	19		C		

TOPSOIL: Silty clay (CL), with sand, low to medium plasticity, dark brown, with organics

DOLOMITE BEDROCK: strong, highly weathered, slightly fractured, with clay- and calcite-filled fractures, bedding angle ranges from approximately 8 to 20 degrees

note: grades slightly weathered, less fractured, recovered sample (0.3-1.8m) contains 1 fracture at an angle of 60 degrees or more

note: grades massive, recovered sample (1.8-3.4m) contains 2 fractures at angles of 60 degrees or more

note: recovered sample (3.4-4.9m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (4.9-6.4m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (6.4-7.9m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (7.9-9.5m) contains small clay nodule

note: recovered sample (9.5-11.0m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (11.0-12.5m) contains 1 fracture at an angle of 60 degrees or more

note: grades with voids, clay-filled fractures, and/or weathered zones from 11.6-17.1m; loss of water into formation at approximately 11.6m

note: recovered sample (12.5-14.0m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (14.0-15.6m) contains 1 fracture at an angle of 60 degrees or more

note: drill stem dropped during drilling, recovered sample (15.6-17.1m) contains 1 fracture at an angle of 60 degrees or more

note: grades with zone of highly weathered dolomite bedrock with sand and silt from approximately 17.1m to 18.6m; recovered sample (17.1-18.6m) contains at least 2 fractures at angles of 60 degrees or more

SOIL_DATA_SHEET2 LOGCAN.CPJ LOGCAN.GDT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-09
Sheet 2 of 2

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
65	19		C		
70	20		C		
75			C		
80			C		
85	25		C		
90			C		
95					
100	30				
105					
110					
115	35				
120	38				

note: recovered sample (18.6-20.1m) contains at least 1 fracture at an angle of 60 degrees or more

note: grades with occasional thin layers of sand and friable bedrock zones from approximately 20.7-23.2m; recovered sample (20.1-21.7m) contains 4 fractures at angles of 60 degrees or more

note: recovered sample (21.7-23.2m) contains 3 fractures at angles of 60 degrees or more

LIMESTONE BEDROCK: strong, slightly weathered, slightly fractured, massive, with calcite-filled fractures, bedding angle ranges from approximately 15 to 20 degrees

note: recovered sample (23.2-24.7m) contains 3 fractures at angles of 60 degrees or more

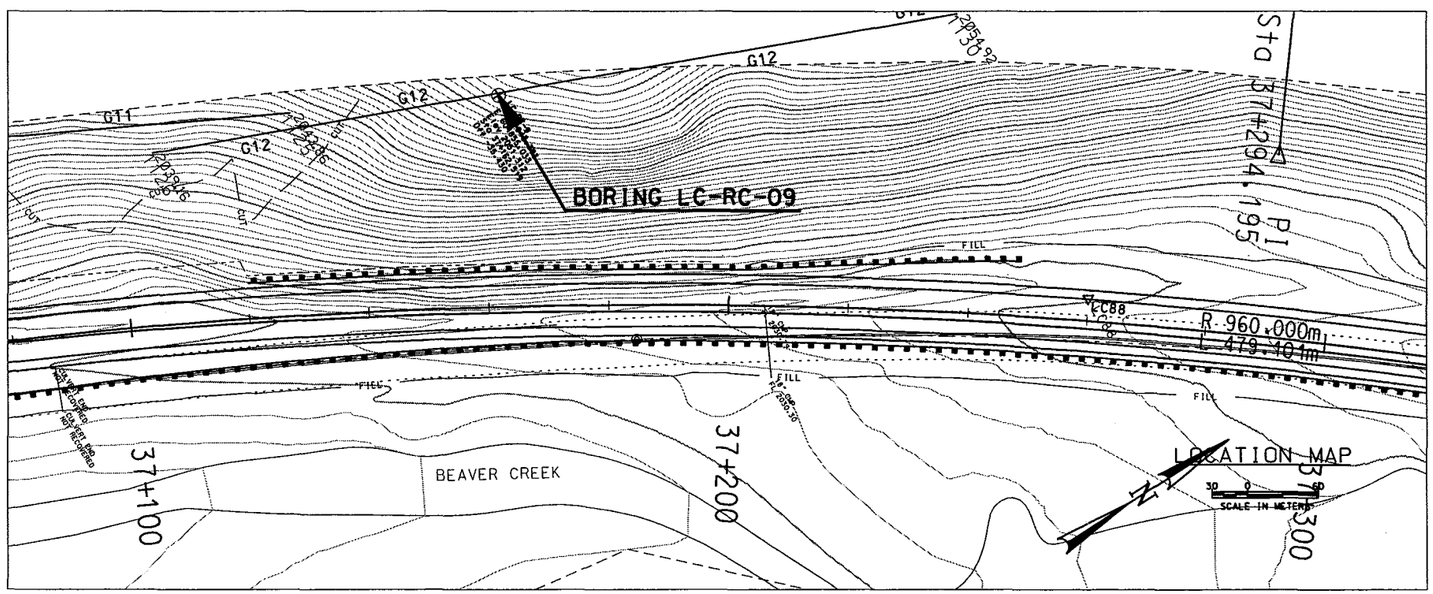
note: recovered sample (24.7-26.2m) contains 1 fracture at an angle of 60 degrees or more

note: recovered sample (26.2-27.7m) contains 2 fractures at angles of 60 degrees or more

note: grades with thin layer of sand to bottom of hole

Boring completed at 27.7m below existing grade.

SOIL_DATA_SHEET2 LOGCAN.CPJ LOGCAN.GDT 5/9/00



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LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 13 OF 17

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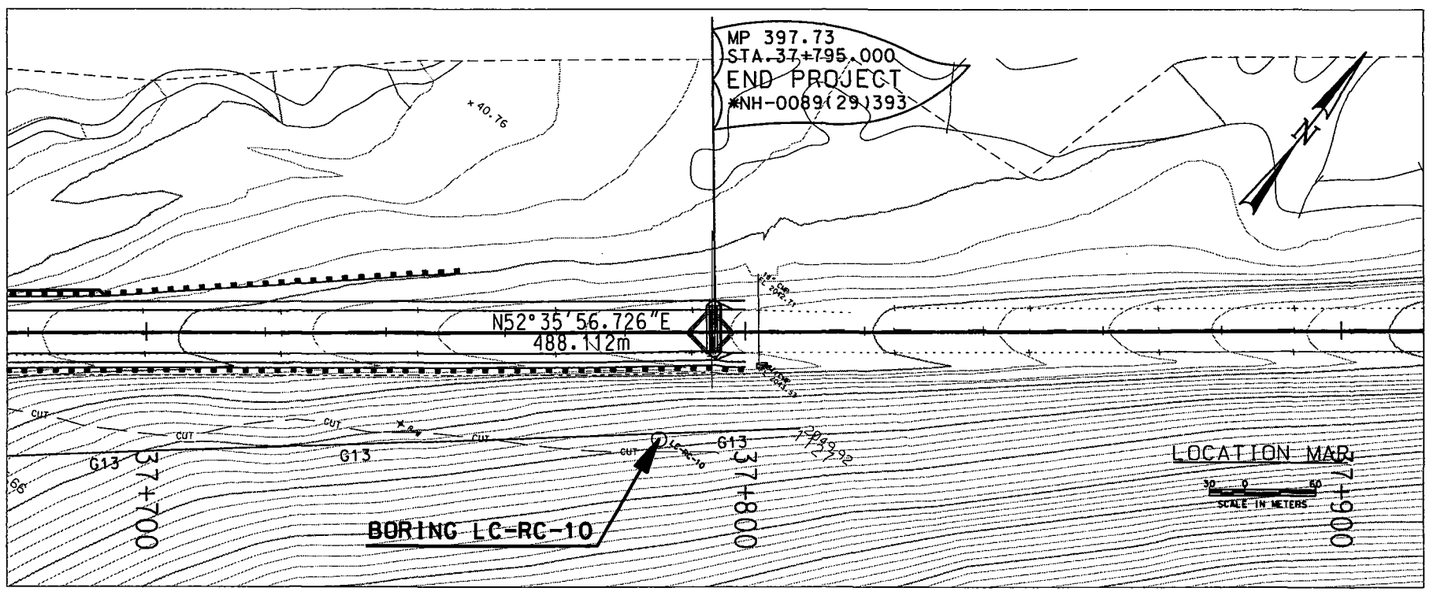
UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-10
ELEVATION: 2049.5
Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
TOPSOIL: Silty clay (CL), with trace sand, low to medium plasticity, dark brown, with organics	0	0	S	1-1-1	2
SILTY CLAY (CL): with some sand and trace gravel, moist to wet, medium plasticity, brown to yellowish brown	5		C		
			S	NR	NR
CONGLOMERATE: consists of dolomitic fragments, sand, and clay, moderately weak, weathered	10		C		
DOLOMITE BEDROCK: moderately strong, highly weathered, fractured, thinly bedded, with shale- and calcite-filled fractures, bedding angle ranges from approximately 20 to 35 degrees note: recovered sample (3.4-4.9m) contains 3 fractures at angles of 60 degrees or more note: recovered sample (4.9-6.4m) contains at least 1 fracture at an angle of 60 degrees or more	15	5	C		
	20		C		
SHALE: average hardness, slightly weathered to weathered, thinly bedded, bedding angle is approximately 10 degrees note: recovered sample (6.4-7.9m) contains 2 fractures at angles of 60 degrees or more	25		C		
	30		C		
Boring completed at 9.1m below existing grade. Groundwater not measured.	35	10			
	40				
	45				
	50	15			
	55				
	60	19			



GENERAL NOTES

1. THE SUBSURFACE EXPLORATIONS SHOWN WERE CONDUCTED BETWEEN 5-11-99 AND 6-8-99 BY DAMES & MOORE.
2. THESE BORING LOGS REPRESENT A SYNOPSIS OF THE SOIL DEPOSITS ENCOUNTERED WITHIN EACH 74 mm DIAMETER BORING AND ARE BASED ON SOUND GEOLOGICAL AND ENGINEERING JUDGEMENT. BECAUSE SOIL IS A COMPLEX MEDIUM, THESE BORING LOGS MAY OR MAY NOT REPRESENT THE SOIL CONDITIONS AT THIS SITE. THIS SUBSURFACE INTERPRETATION IS PRESENTED IN GOOD FAITH AND IS NOT INTENDED AS A SUBSTITUTE FOR PERSONAL INVESTIGATION AND JUDGEMENT OF THE CONTRACTOR.
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4. THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.
5. COBBLE - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION BETWEEN 76 mm AND 305 mm
6. BOULDER - A ROCK FRAGMENT WITH AN AVERAGE DIMENSION OF 305 mm

NOTE:

RIG USED: SD 1500 TRACK RIG

GEOTECHNICAL ENGINEER

KEY TO BORING LOG

WHEN APPLICABLE
RELATIVE DENSITY
(NON-PLASTIC SAND & SILT)

VERY LOOSE - N LESS THAN 4
LOOSE - N 4 TO 10
MEDIUM - N 10 TO 30
DENSE - N 30 TO 50
VERY DENSE - N MORE THAN 50

CONSISTENCY
(PLASTIC - SILT & CLAY)

VERY SOFT - N LESS THAN 2
SOFT - N 2 TO 4
MEDIUM - N 4 TO 8
STIFF - N 8 TO 15
VERY STIFF - N 15 TO 30
HARD - N MORE THAN 30

GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

BOULDERS, CLAYEY BOULDERS, BOULDERS AND COBBLES IN A CALY MATRIX, GRAVELS, COBBLES AND BOULDERS

CONGLOMERATE
CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT

LIMESTONE

DOLOMITE

QUARTZITE

SHALE

ABBREVIATIONS

C - HX CORE BARREL, 61 mm ID & 74 mm OD
>100 - N VALUE GREATER THAN 100 BLOWS PER 0.3 M
NR - NOT RECORDED
AASHTO - SOIL CLASSIFICATION SYSTEM SYMBOL
USCS - UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL

NO.	DATE	BY	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____ *PIN#
C.I.D.
APPROVAL RECOMM. DATE CHIEF GEOTECHNICAL ENGR.
RECEIVED DATE CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET
PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

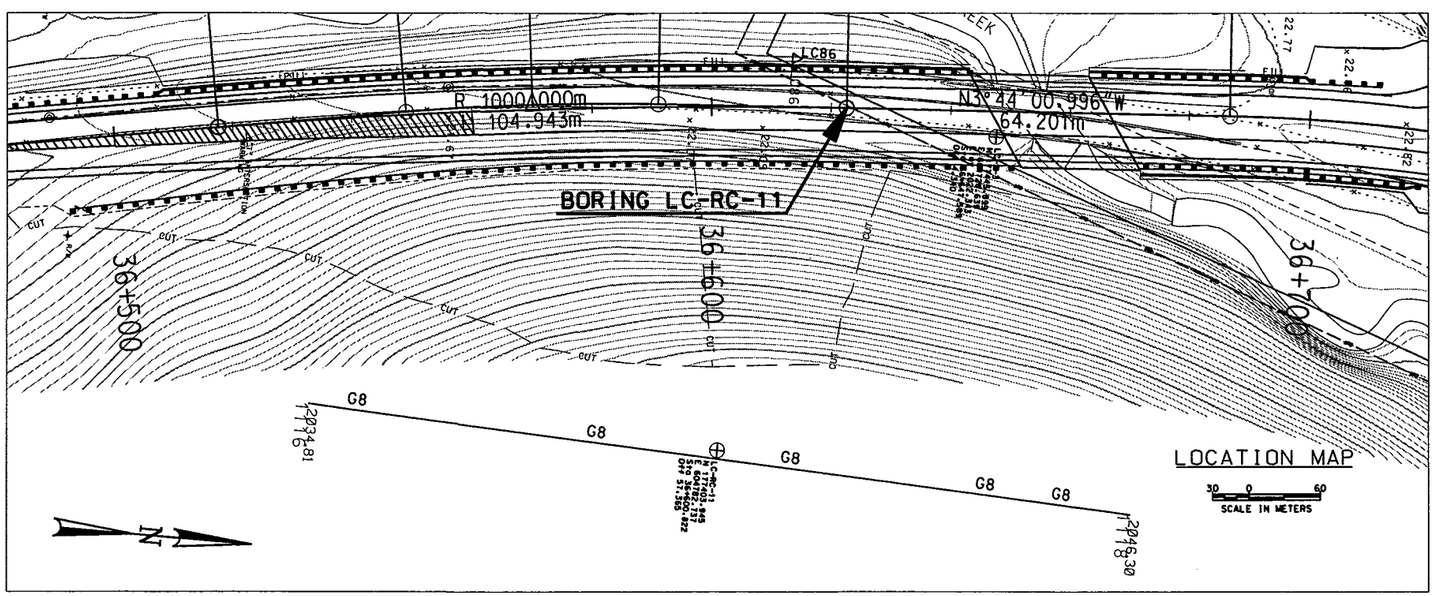
SHT. 14 OF 17

Filename:s:\common\greg\remest\584.97\soildata sheets\soildata sheet files\lc-rc-10.dgn
Date:24 OCT 100 Time:16:46:31 Username:$$$$username$$$$
SOIL_DATA_SHEET2 LOGCAN.DFJ LOGCAN.CDT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-11
ELEVATION: 2046.1
Sheet 1 of 1

Description	Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
LIMESTONE BEDROCK: moderately strong to strong, slightly weathered to moderately weathered, slightly fractured, with clay-filled fractures, occasionally thinly bedded, bedding angle generally ranges from 15 to 20 degrees		0		C		
note: recovered sample (0-1.5m) contains 3 fractures at angles of 60 degrees or more	5			C		
note: recovered sample (1.5-1.8m) contains 2 fractures at angles of 60 degrees or more				C		
note: recovered sample (1.8-2.7m) contains 2 fractures at angles of 60 degrees or more	10			C		
note: loss of water into formation at approximately 2.4m				C		
note: grades very thinly bedded with numerous clay-filled fractures from 2.7 to 3.7m, recovered sample (2.7-3.7m) contains at least 1 fracture at an angle of 60 degrees or more	15	5		C		
note: recovered sample (3.7-4.9m) contains 4 fractures at angles of 60 degrees or more				C		
note: recovered sample (4.9-6.4m) contains 2 fractures at angles of 60 degrees or more	20					
note: recovered sample (6.4-7.9m) contains at least 1 fracture at an angle of 60 degrees or more				C		
note: grades with calcite- and clay-filled fractures, recovered sample (7.9-9.0m) contains 2 fractures at angles of 60 degrees or more	25			C		
note: recovered sample (9.0-10.5m) contains 6 fractures at angles of 60 degrees or more	30	10		C		
note: grades fractured to highly fractured from 10.5-12.5m, recovered sample (10.5-11.0m) contains numerous fractures at angles of 60 degrees or more	35			C		
note: recovered sample (11.0-12.5m) contains numerous fractures at angles of 60 degrees or more				C		
note: recovered sample (12.5-13.4m) contains 3 fractures at angles of 60 degrees or more	40			C		
note: recovered sample (13.4-14.0m) contains numerous fractures at angles of 60 degrees or more	45			C		
note: recovered sample (14.0-14.6m) contains numerous fractures at angles of 60 degrees or more				C		
note: grades with increasing calcite-filled fractures, recovered sample (14.6-15.1m) contains 2 fractures at angles of 60 degrees or more	50	15		C		
note: recovered sample (15.1-15.9m) contains 2 fractures at angles of 60 degrees or more				C		
note: grades with calcite-filled fractures, recovered sample (15.9-17.4m) contains 3 fractures at angles of 60 degrees or more	55			C		
Boring completed at 17.4m below existing grade. Groundwater not measured.	60	19				

SOIL_DATA_SHEET2 LOGCAN.DPJ LOGCAN.GDT 5/5/00



LOCATION MAP
30 0 60
SCALE IN METERS

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SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

DRAWN ____ GEOLOGIST ____
C.I.D. ____ PIN# ____
APPROVAL RECOMM. ____ DATE ____ CHIEF GEOTECHNICAL ENGR.
RECEIVED ____ DATE ____ CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET
PROJECT NUMBER *NH-0089(29)393

SUMMIT
COUNTY

DRG. NO.

SHT. 15 OF 17

Filename: s:\common\greg\remet\584_97\soil data sheets\soil data sheet files\lc-rc-11.dgn
Date: 24 OCT 100 Time: 15:17:14 Username: $$username$$

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-12
ELEVATION: 1985.7

Sheet 1 of 2

Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
0	0		C		
5	5		C		
10	10		C		
15	5		C		
20	20		C		
25	25		C		
30	30		C		
35	10		C		
40	35		C		
45	40		C		
50	45		C		
55	50		C		
60	55		C		
	60		C		
	19				

CLAYEY GRAVEL (GC): with sand, low to medium plasticity, yellowish red, gravel consists of limestone and quartzite fragments (A-2-7)
note: no recovery of clay (0.3-1.8m)

note: poor recovery of clay (1.8-3.4m)

note: grades with occasional cobbles

BOULDERS IN A CLAY MATRIX WITH SAND: dense, consist predominantly of quartzite, slightly to moderately plastic, yellowish red

SILTY CLAY (CL): low to medium plasticity, yellowish red

BOULDERS IN A CLAY MATRIX WITH SAND, GRAVELS, AND COBBLES: glacial deposit, morraine: very dense, slightly to moderately plastic, yellowish red

note: loss of water into formation at approximately 16.2m

CLAY (CH): with sand, medium to high plasticity, yellowish red, sand is predominantly fine grained

CLAYEY SAND (SC): fine grained, strongly

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-12

Sheet 2 of 2

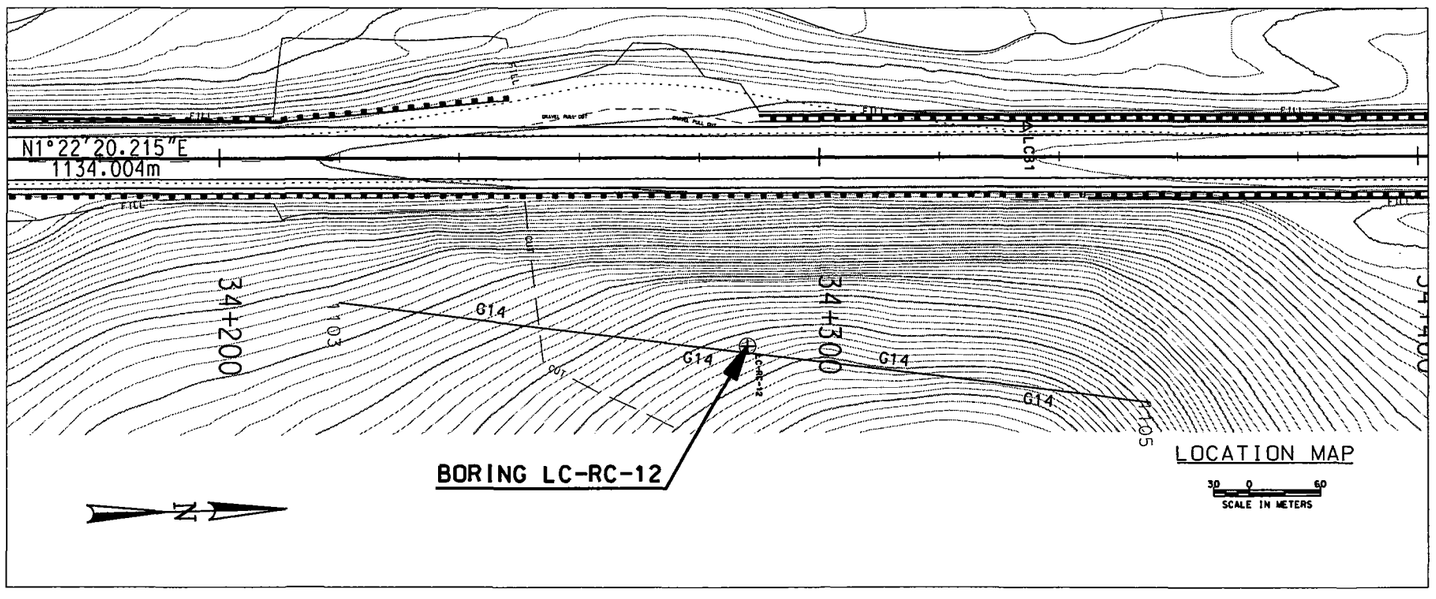
Depth (ft)	Depth (m)	Graphic Log	Sample Type	Blows/ 0.15m	Pen. Resist. (Blows/ 0.305m)
65	19		C		
70	20		C		
75					
80	25				
85					
90	30				
95					
100					
105					
110	35				
115					
120	38				

cemented, no to low plasticity, red/gray/brown, with imbedded layers (10 to 30cm thick) of fine grained sand

note: grades weakly cemented

Boring completed at 21.6m below existing grade.
Groundwater not measured.

SOIL_DATA_SHEET2 LOGCAN.GPJ LOGCAN.GDT 5/9/00



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SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST | DRAWN
C.I.D. | *PIN#

APPROVAL RECOMM. DATE CHIEF GEOTECHNICAL ENGR.
RECEIVED DATE CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(291)393

SUMMIT
COUNTY

DRG. NO.

SHT. 16 OF 17

Filename: s:\common\greg\remet\584_97\soil data sheets\soil data sheet files\lc-rc-12.dgn
Date: 24 OCT 100 Time: 15:56:48 Username: s:\username:s:\

UDOT SR-89 LOGAN CANYON
TONY GROVE TO FRANKLIN BASIN
Boring: LC-RC-13
ELEVATION: 1977.5
Sheet 1 of 1

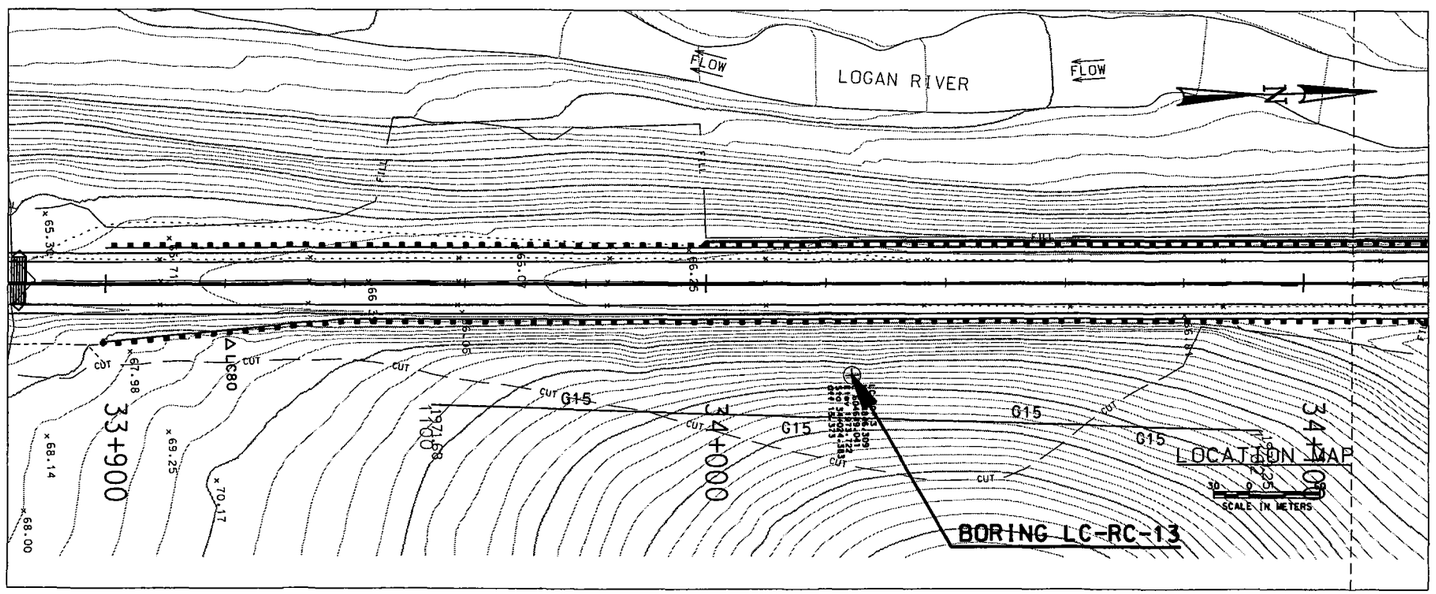
Depth (ft)	Depth (m)	Graphic Log	Description
0–10	0–3.0		CLAYEY SAND (SC): moist to wet, with zones of cementation, medium to high plasticity, yellowish red note: recovered sample contained a 10cm-layer of fine grained sand, gray
10	3.0		note: loss of water into formation at approximately 2.7 to 3.0m
10–15	3.0–4.6		CONGLOMERATE: consists of gravel in a clay matrix, average hardness: clay is very stiff, yellowish red: gravel is predominantly limestone fragments
15–40	4.6–12.2		CLAY (CH): with sand and trace gravel, very stiff, high plasticity, yellowish red to brown (A-7-6)
40–45	12.2–13.7		CLAYEY SAND (SC): with gravel, dense to very dense, medium to high plasticity, yellowish red
45–50	13.7–15.2		BOULDERS IN A CLAY MATRIX: dense, consist predominantly of quartzite, slightly to moderately plastic, yellowish red
50–60	15.2–19		Boring completed at 12.2m below existing grade. Groundwater not measured.

Sample Type: C

Blows/0.15m

Pen. Resist. (Blows/0.305m)

SOIL_DATA_SHEET2 LOGAN.GPJ LOGAN.GDT 5/9/00



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SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

BOULDERS, CLAYEY BOULDERS, BOULDERS AND COBBLES IN A CALY MATRIX, GRAVELS, COBBLES AND BOULDERS

CONGLOMERATE
CONSISTS OF CEMENTED GRAVEL, SAND, CLAY, AND/OR SILT

LIMESTONE

DOLOMITE

QUARTZITE

SHALE

ABBREVIATIONS

C - HX CORE BARREL, 61 mm ID & 74 mm OD

>100 - N VALUE GREATER THAN 100 BLOWS PER 0.3 M

NR - NOT RECORDED

AASHTO - SOIL CLASSIFICATION SYSTEM SYMBOL

USCS - UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL

NO.	DATE	BY	REMARKS

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
GEOTECHNICAL DIVISION

GEOLOGIST ____ DRAWN ____ C.I.D. ____ PIN# ____

APPROVAL RECOMM. ____ DATE ____ CHIEF GEOTECHNICAL ENGR.
RECEIVED ____ DATE ____ CHIEF STRUCTURAL ENGR.

LOGAN CANYON HIGHWAY, US89
RECONSTRUCTION
SOIL DATA SHEET

PROJECT NUMBER *NH-0089(291)393

SUMMIT
COUNTY

DRG. NO.

SHT. 17 OF 17

Filename: s:\common\pr-eg\remet\584.97\soil data sheets\soil data sheet files\lc-rc-13.dgn
Date: 24 OCT 100 Time: 15:57:08 Username: $$$$usernames$$$$

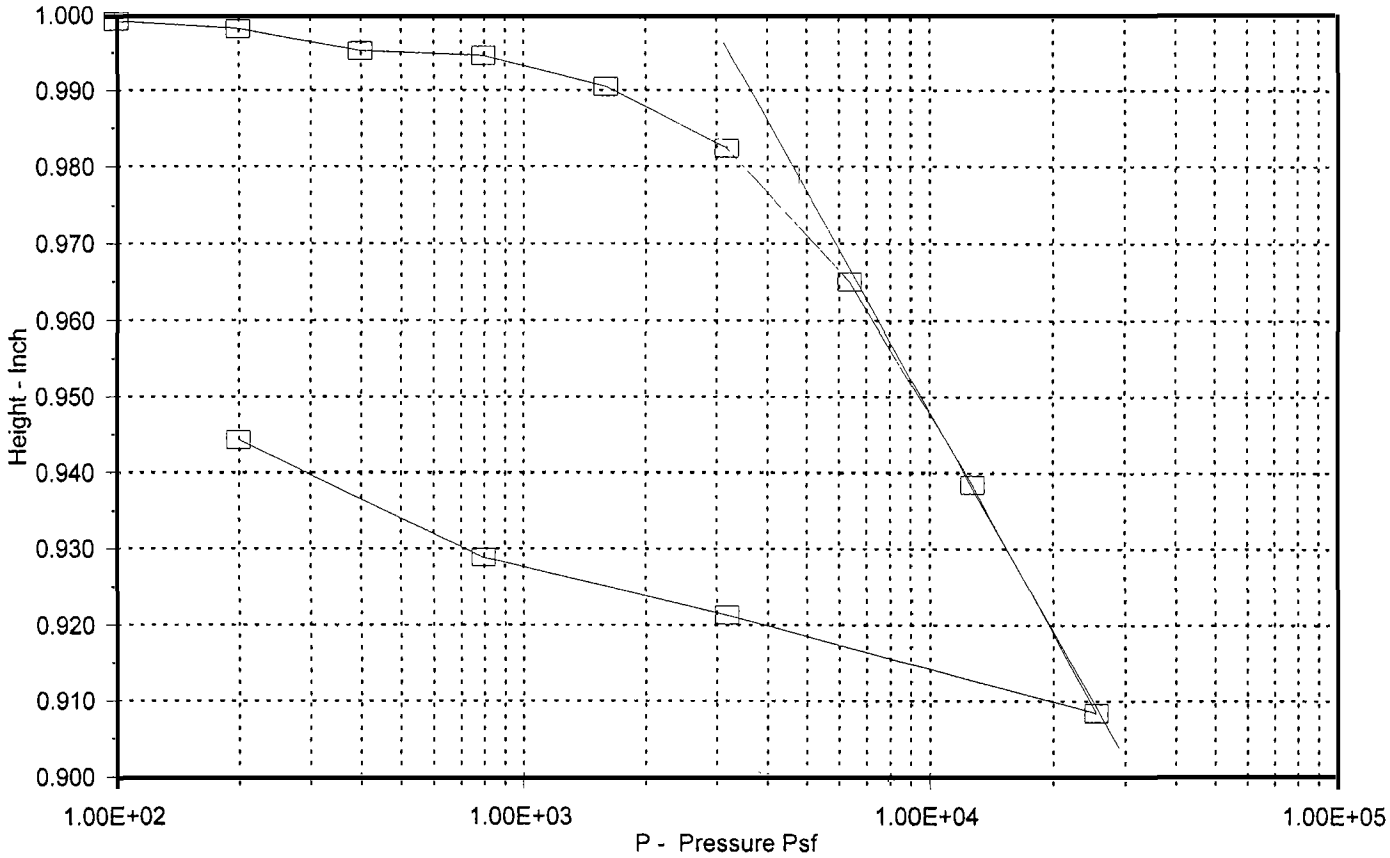
APPENDIX D

Appendix D

Consolidation Test Data Curves

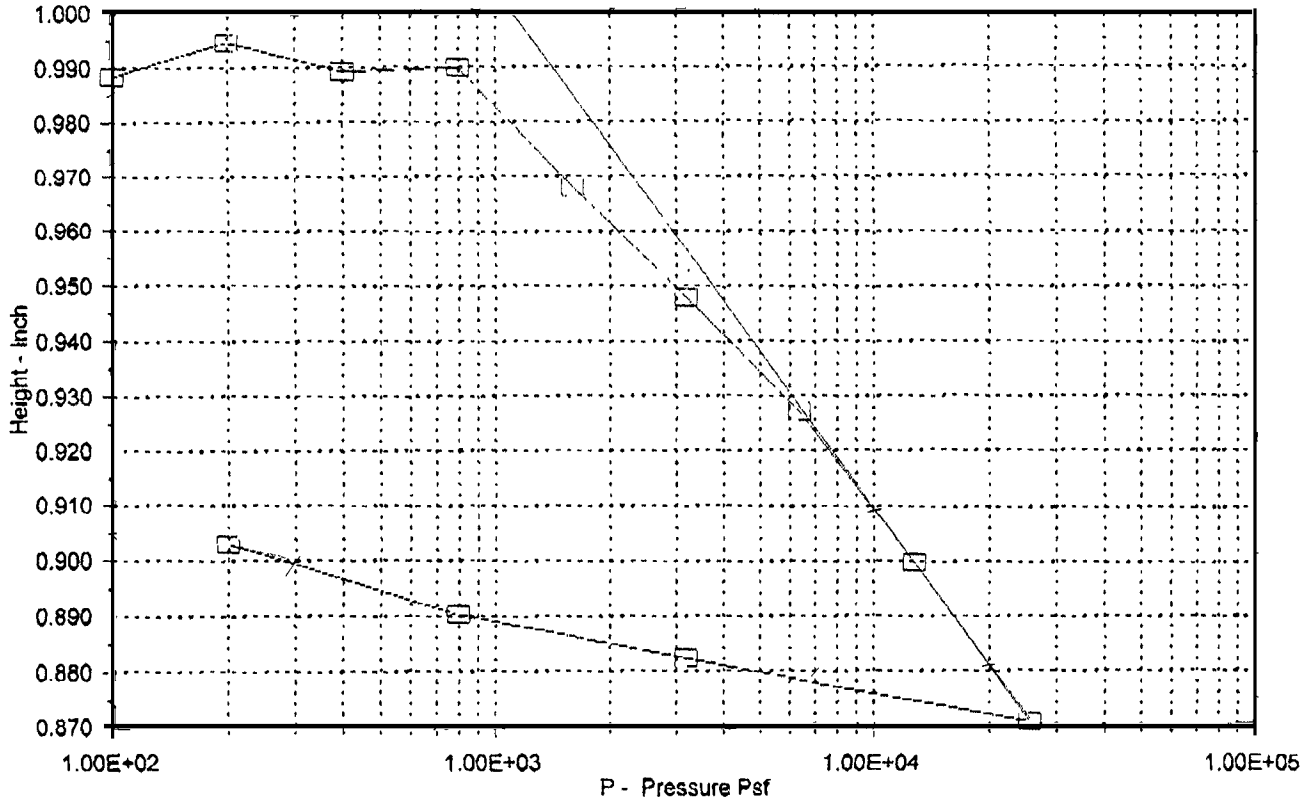
Consolidation

Boring LCRR-1, sample 3 at 3-4.5feet



Consolidation

Boring LCRR-2, sample 2 at 3-4.5 feet

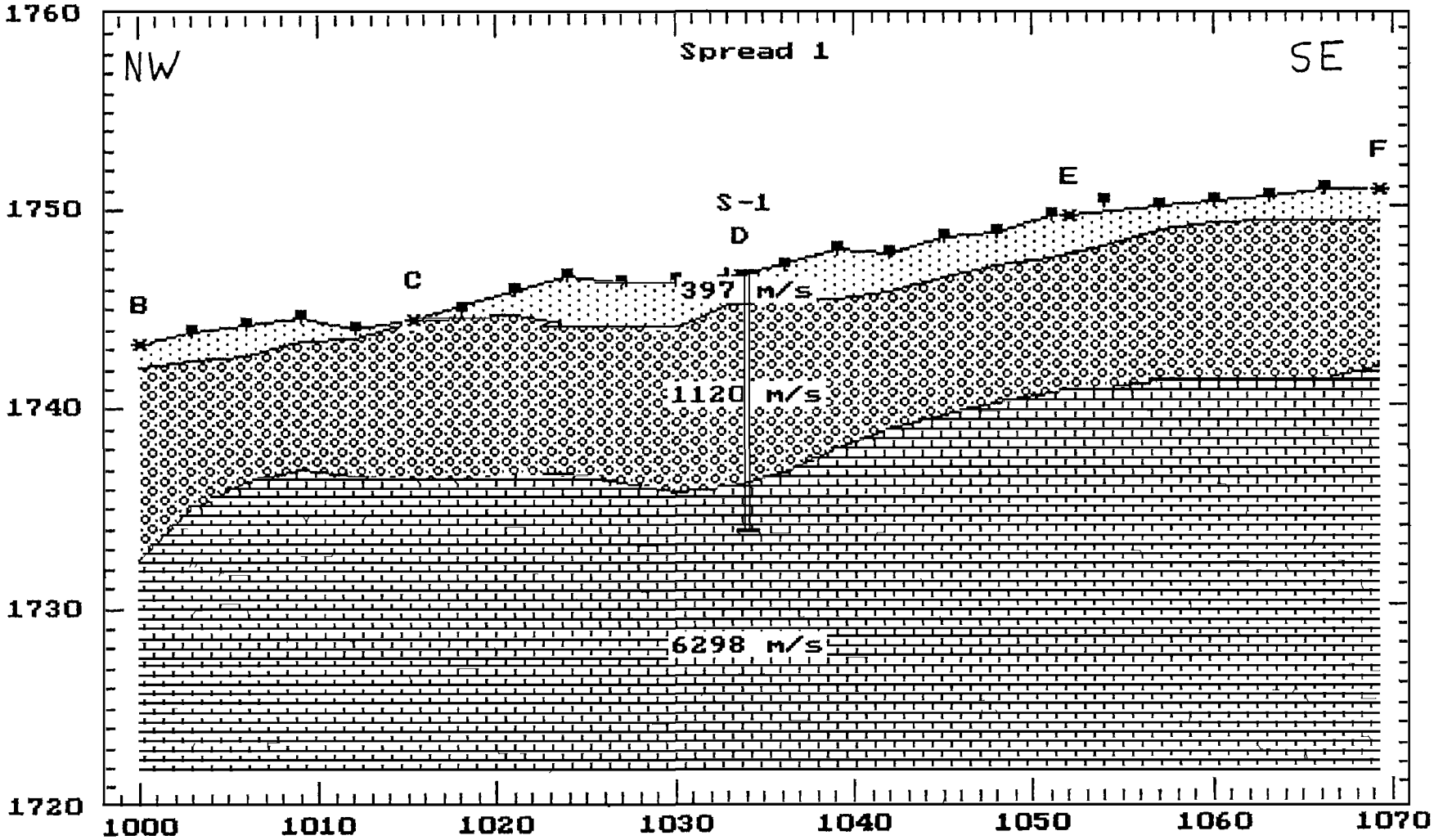


Appendix E

Depth Model Cross Sections

Logan Canyon - UDOT, Dames & Moore Line G1, Shot May 26, 1999

Station 23+026.282

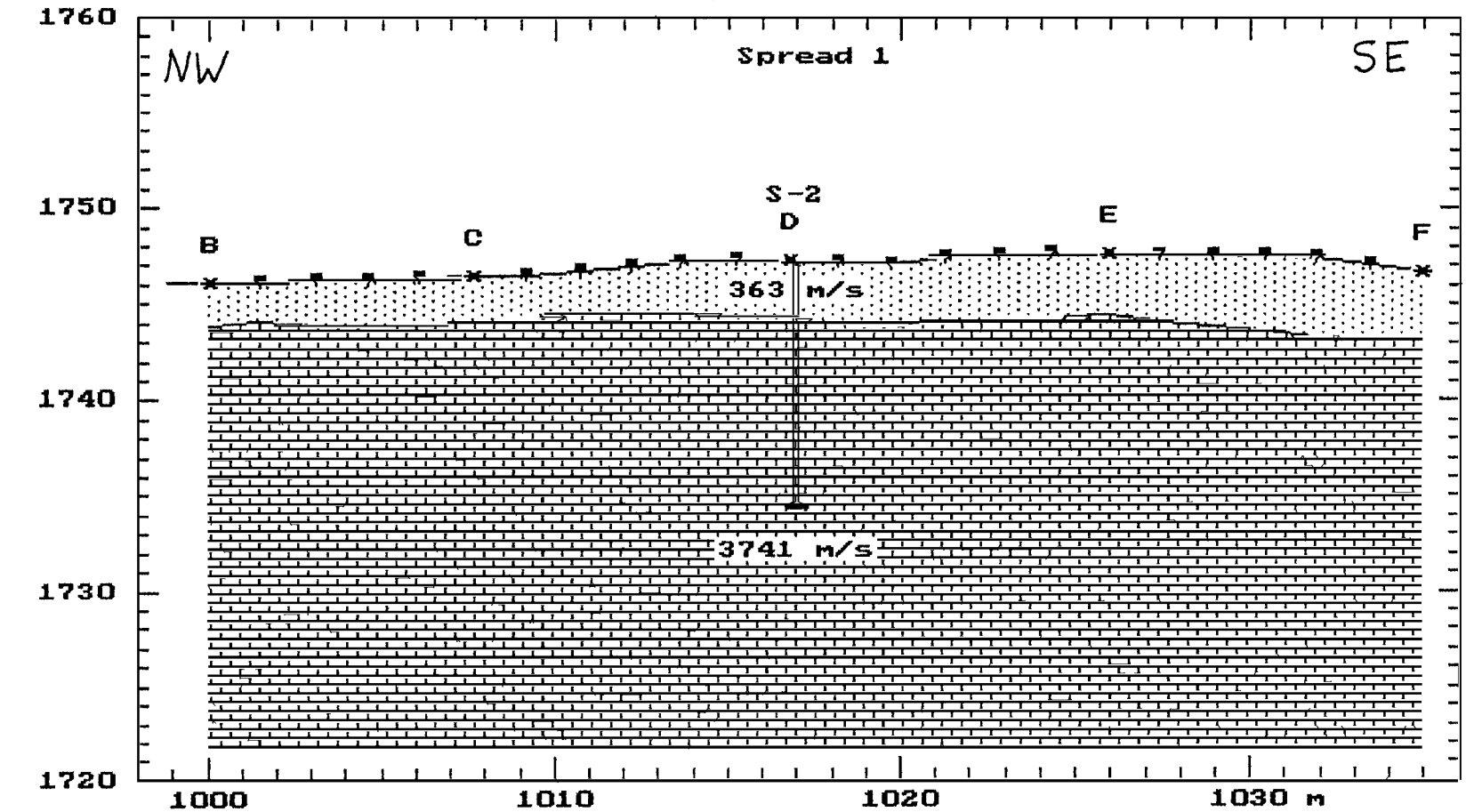


Colluvium Till/WeatheredSH Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G2, Shot May 27, 1999

Station 23+066.944



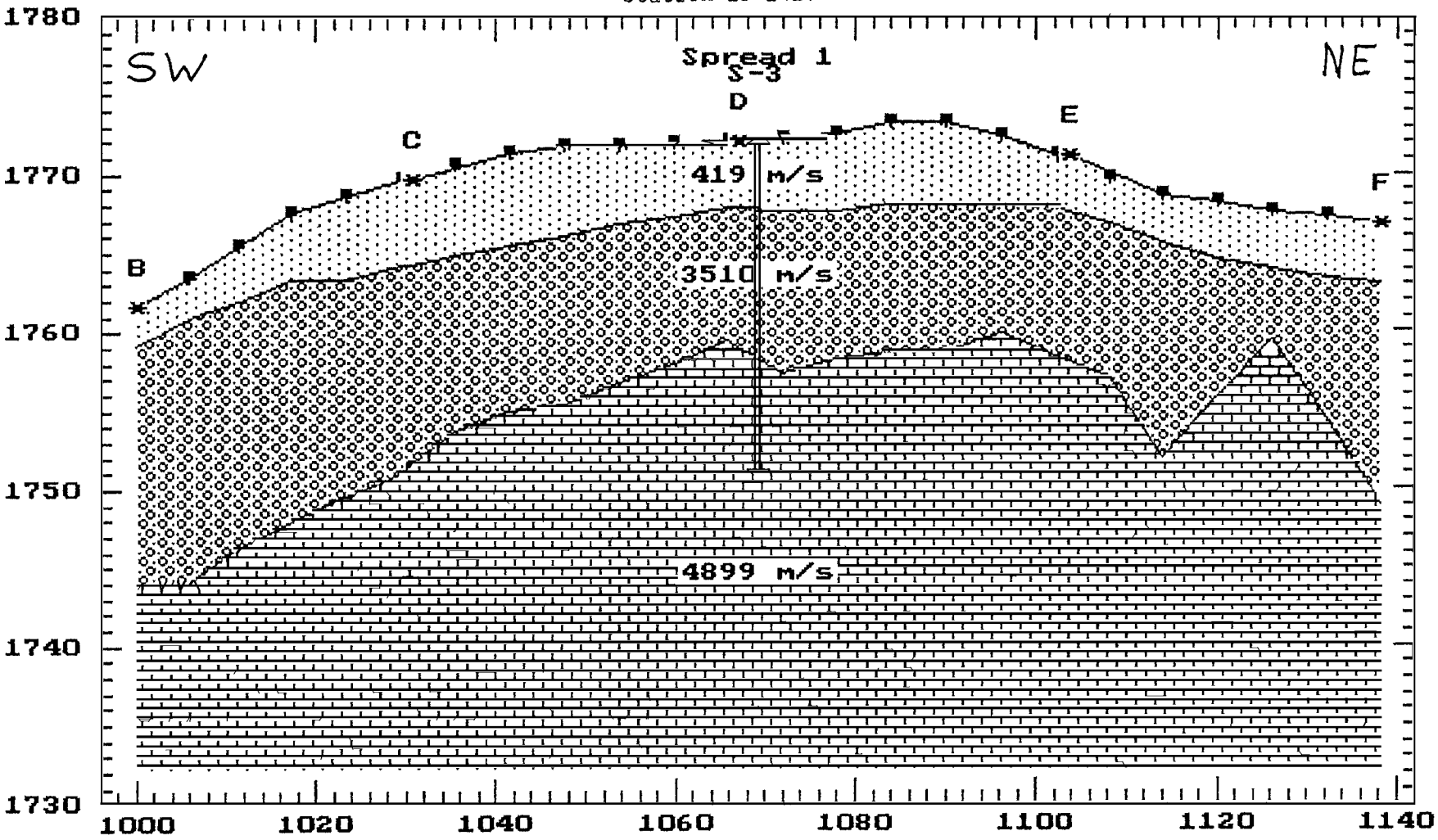
Colluvium

Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

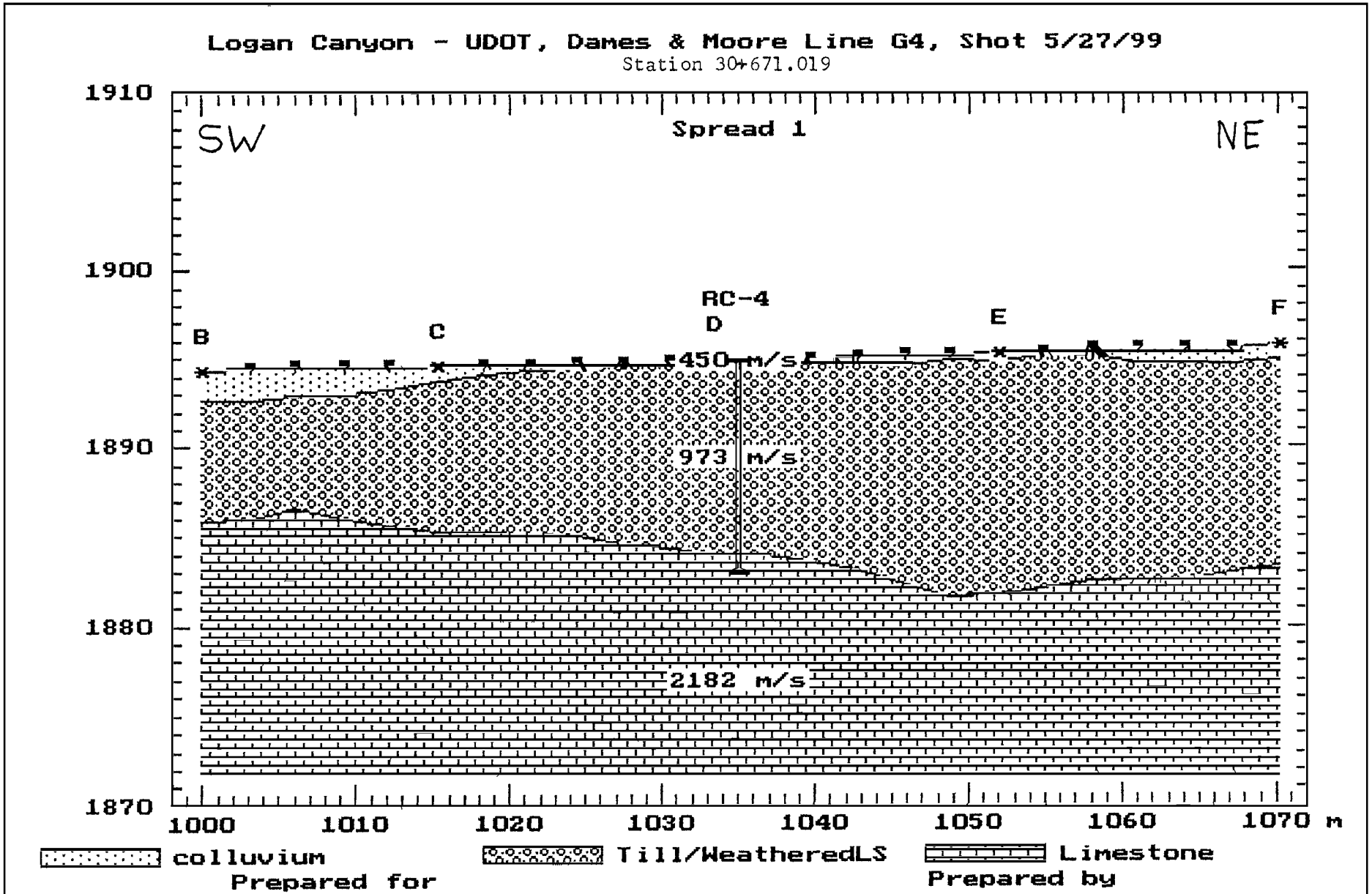
Logan Canyon - UDOT, Dames & Moore Line G3, Shot June 1, 1999

Station 23+242.378

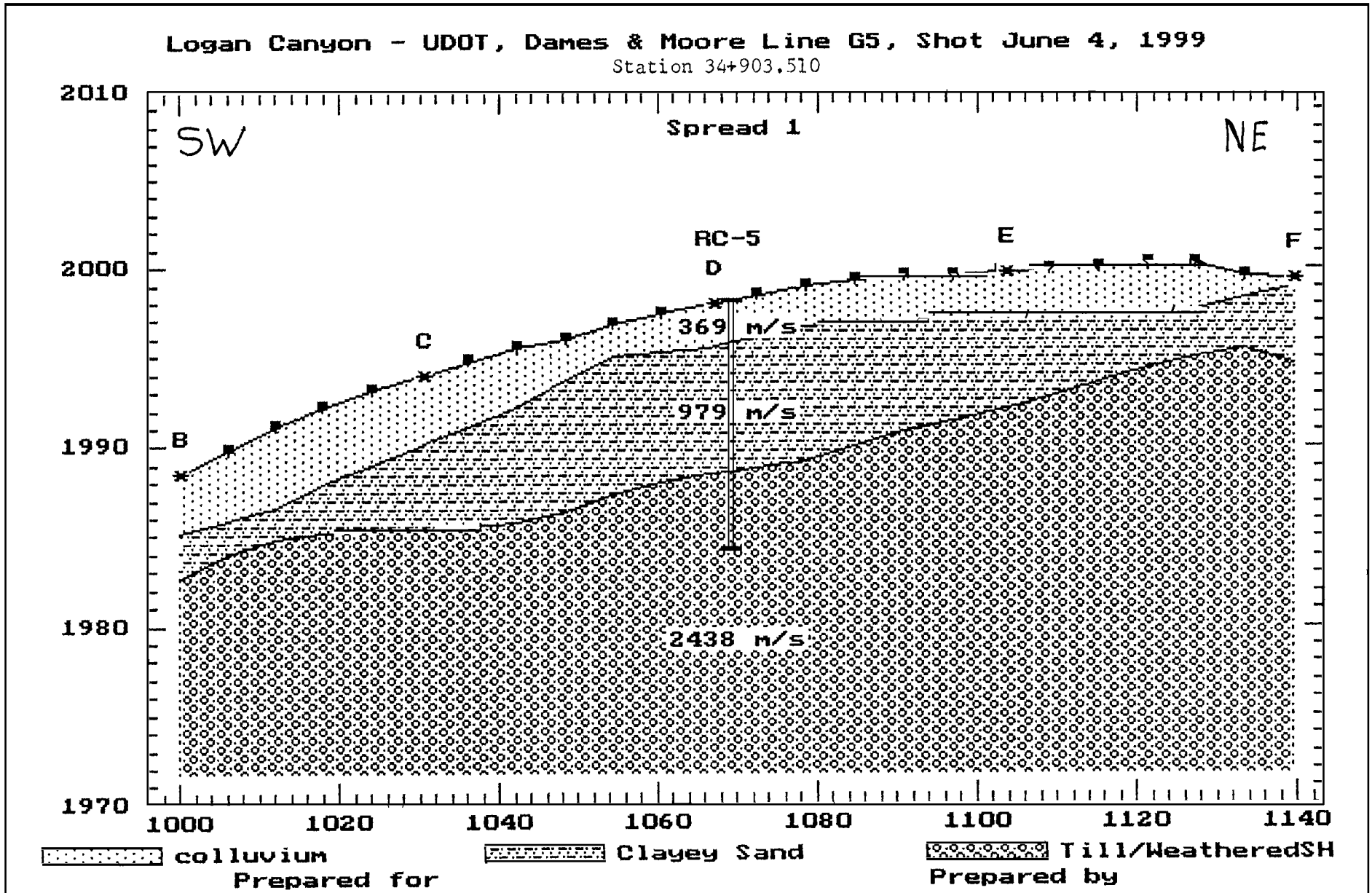


colluvium Till/WeatheredLS Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99



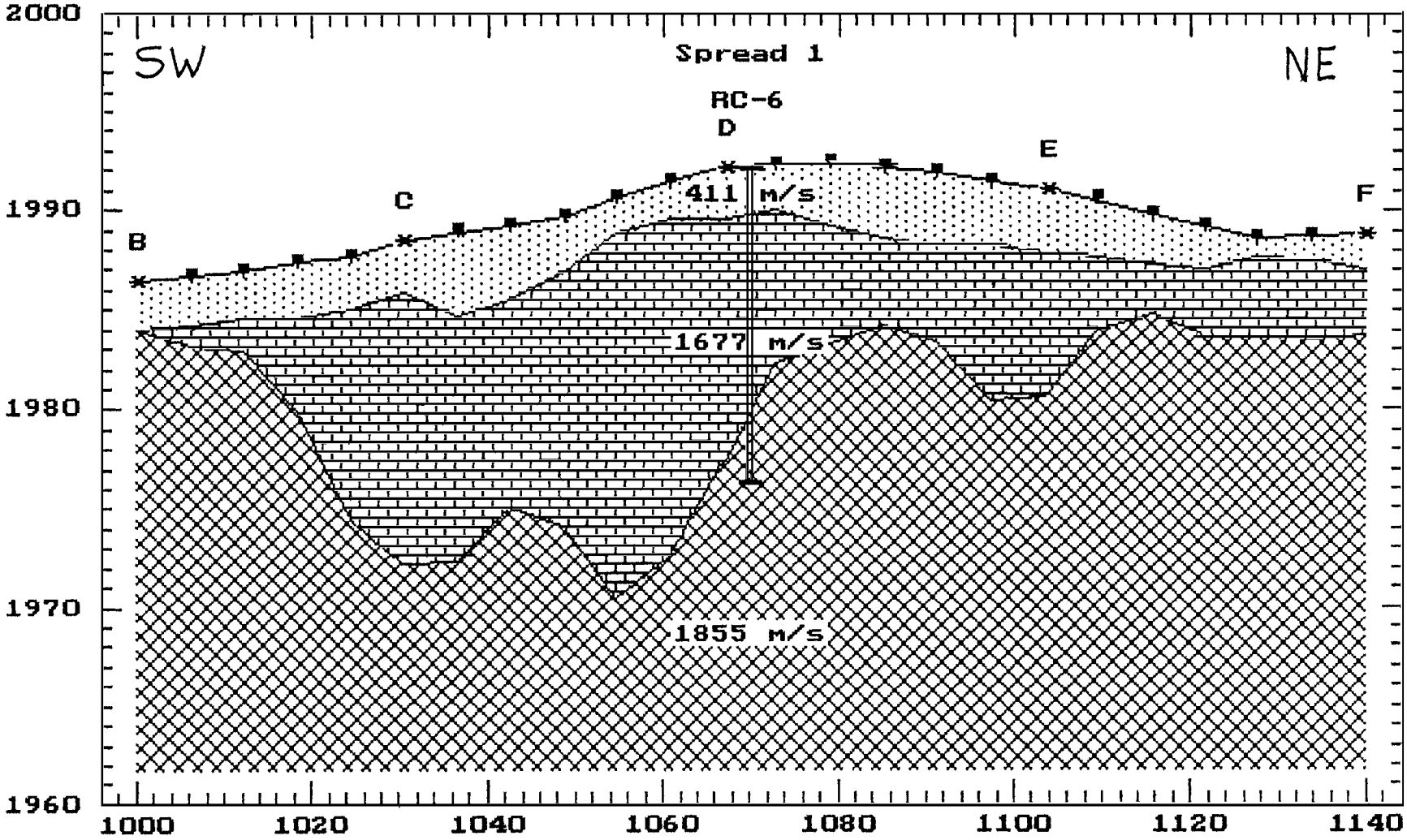
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99



Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G6, Shot June 1, 1999

Station 35+095.117

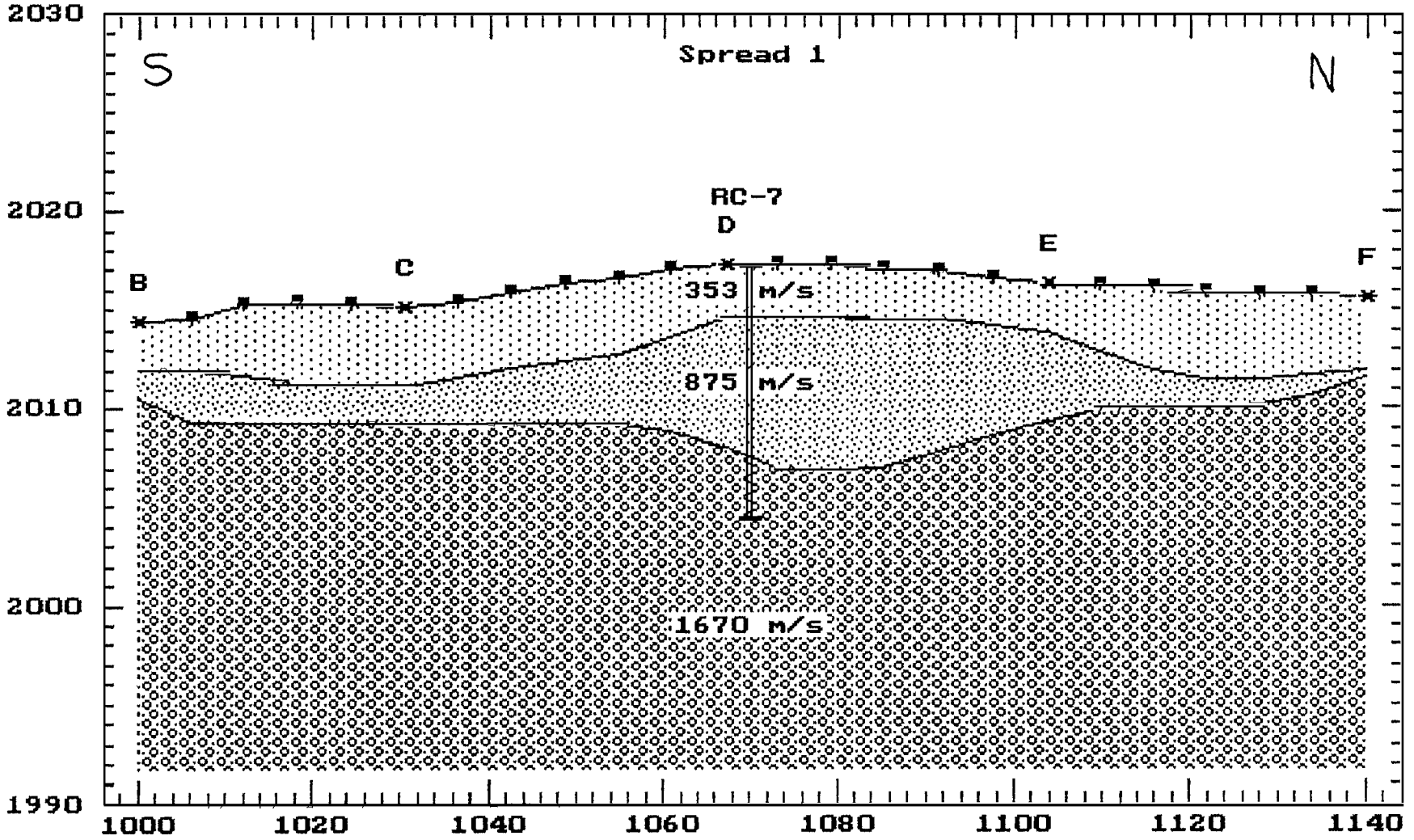


colluvium Limestone Quartzite

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G7, Shot June 4, 1999

Station 36+068.349

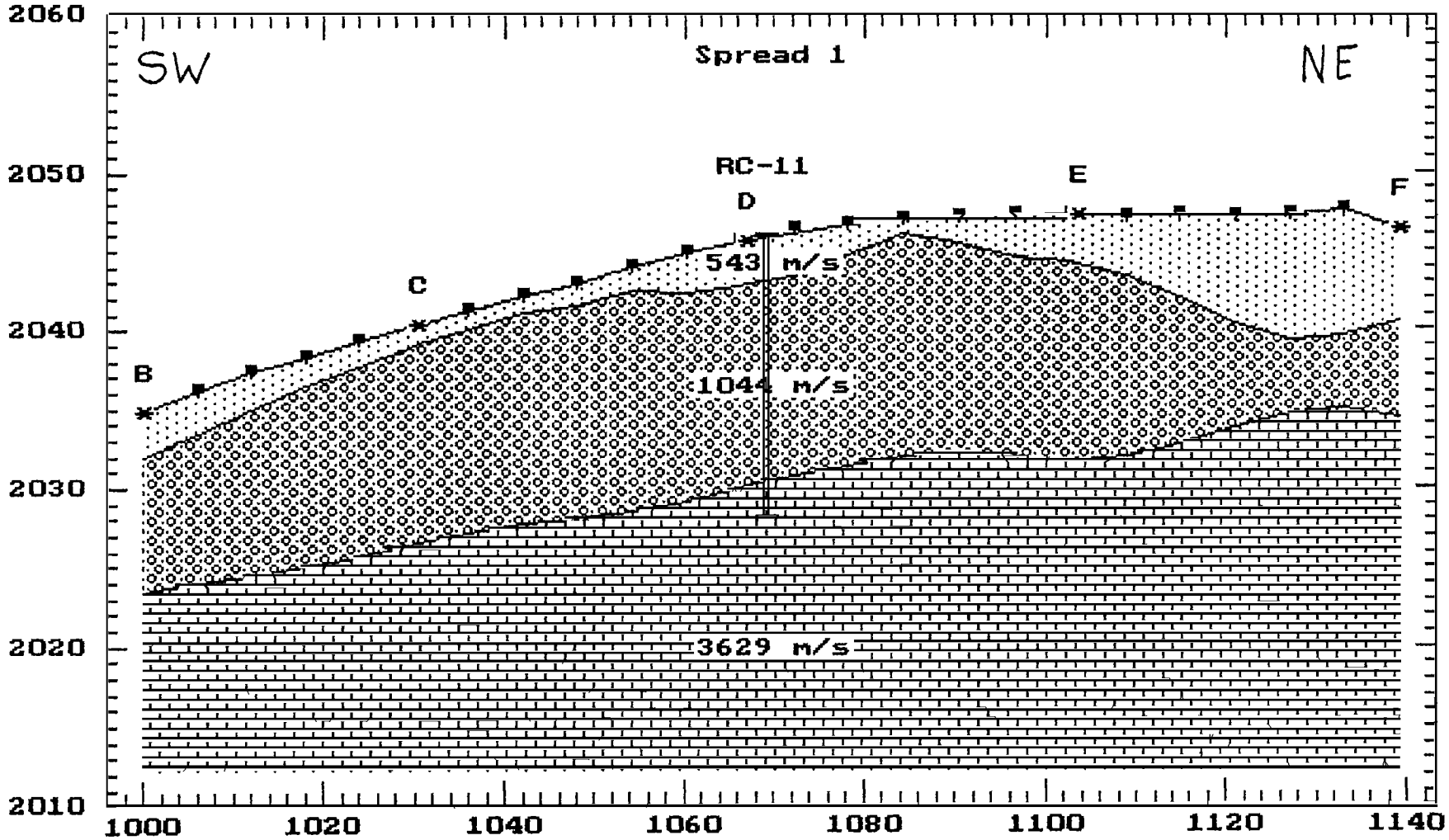


Colluvium Sandy Clay Till/WeatheredSH

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G8, Shot June 3, 1999

Station 26+600



Colluvium Weathered LS Limestone

Prepared for

Utah Department of Transportation

Logan Canyon, Hwy 89, Cache County, UT

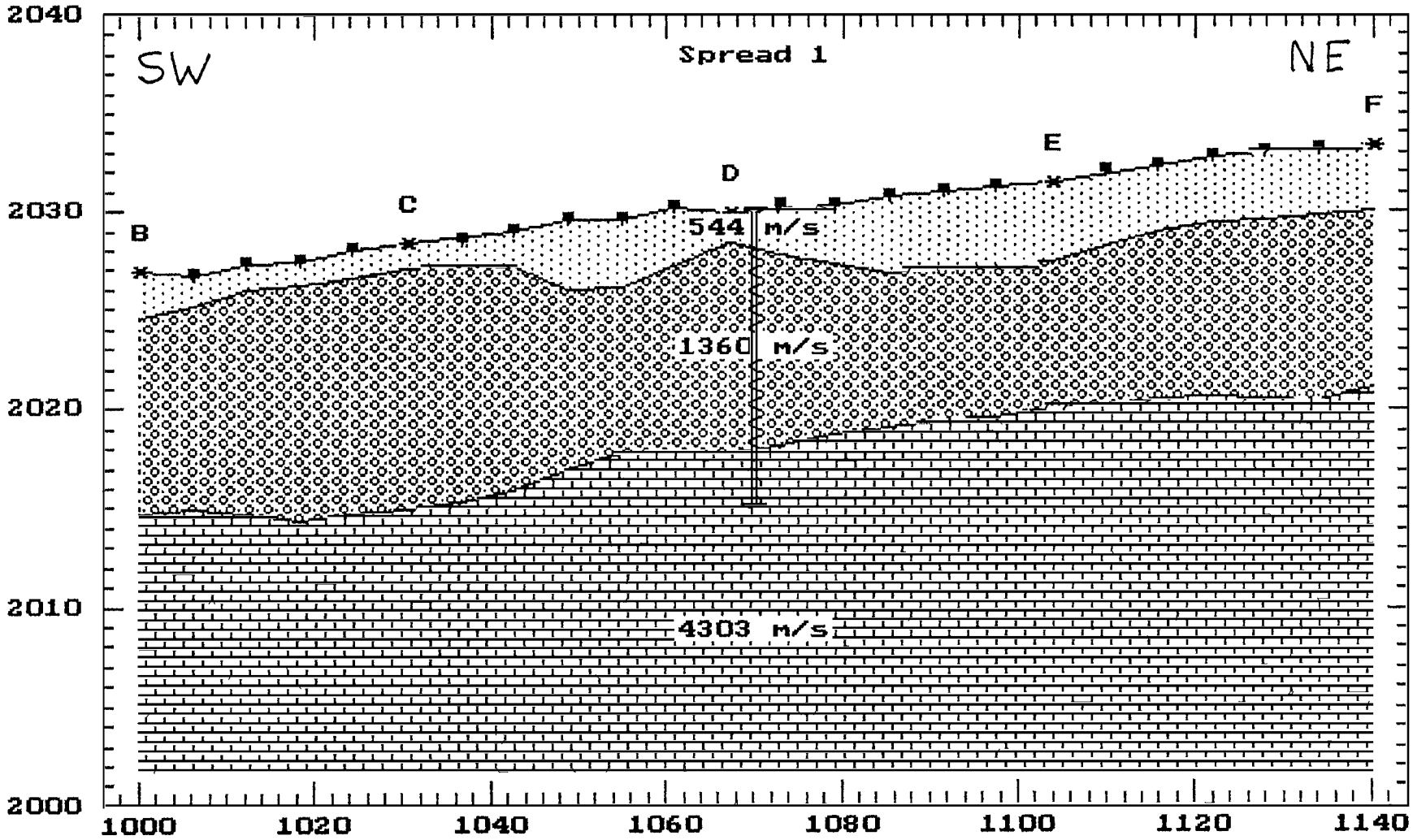
Prepared by

Dames & Moore

Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G9, Shot May 28, 1999

Station 36+760.852

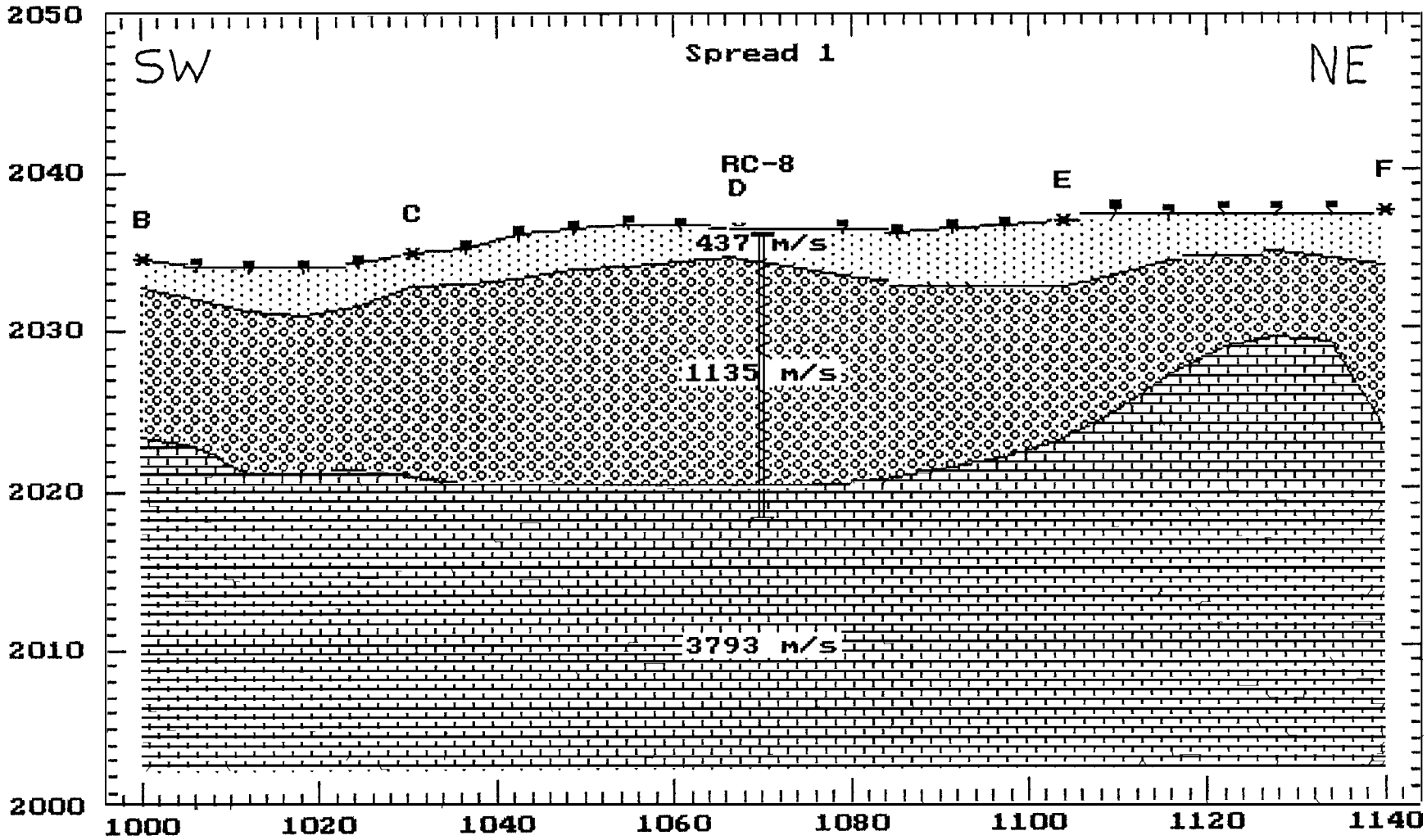


Colluvium Till/WeatheredLS Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G10, Shot May 28, 1999

Station 36+940.034

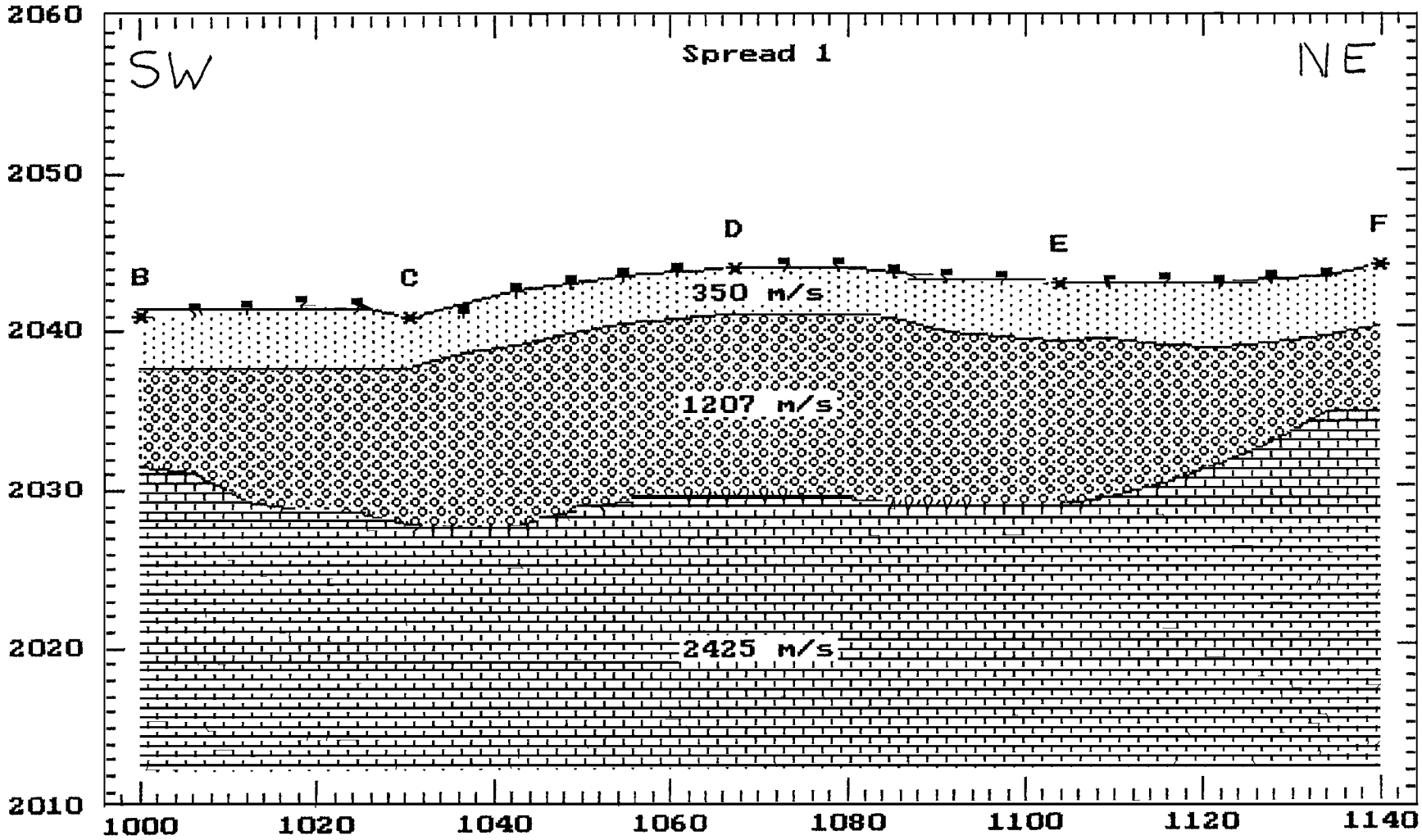


Colluvium Till/WeatheredLS Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G11, Shot June 2, 1999

Station 37+049.546

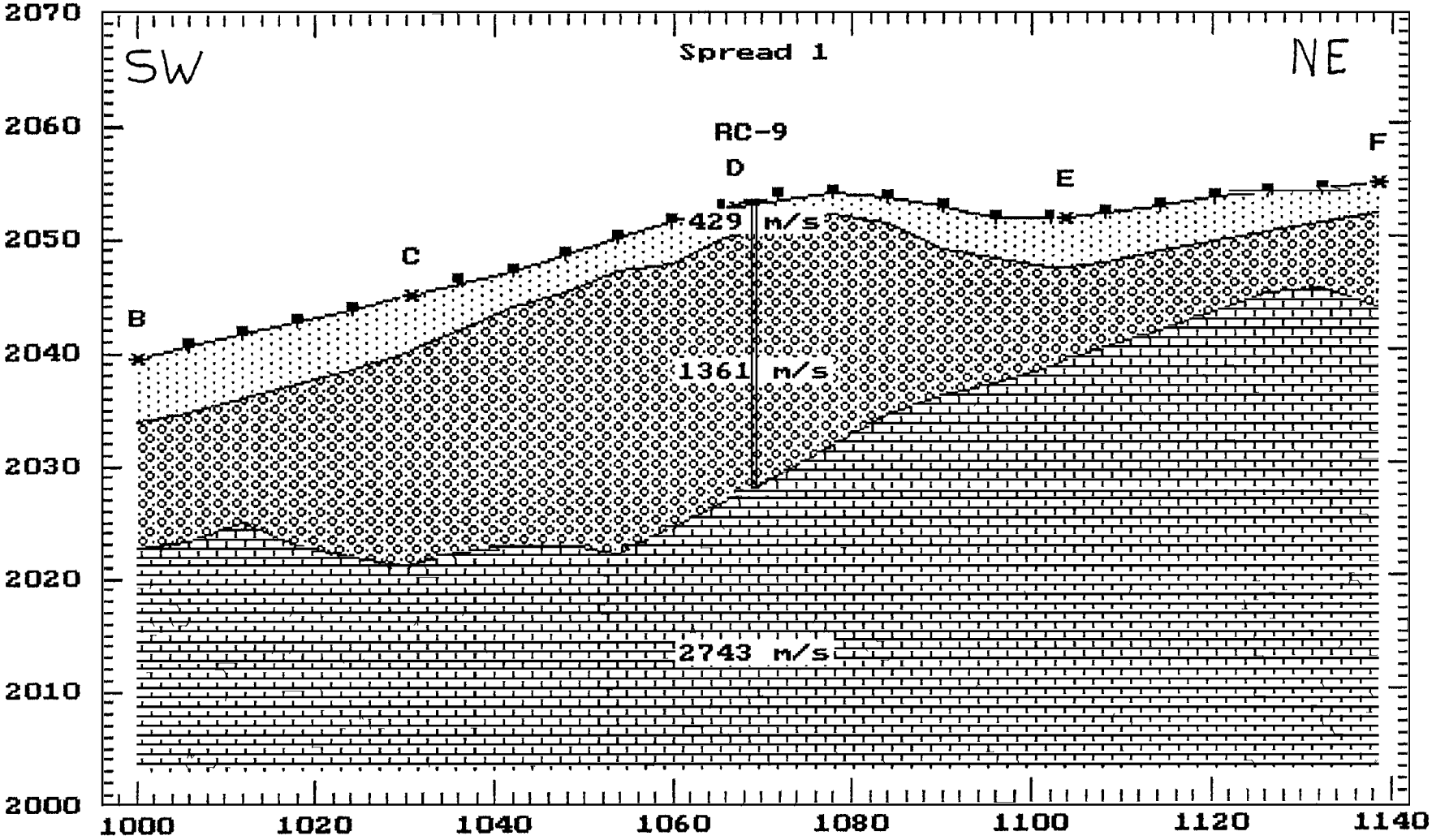


Colluvium Till/WeatheredLS Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G12, Shot June 3, 1999

Station 37+162.519

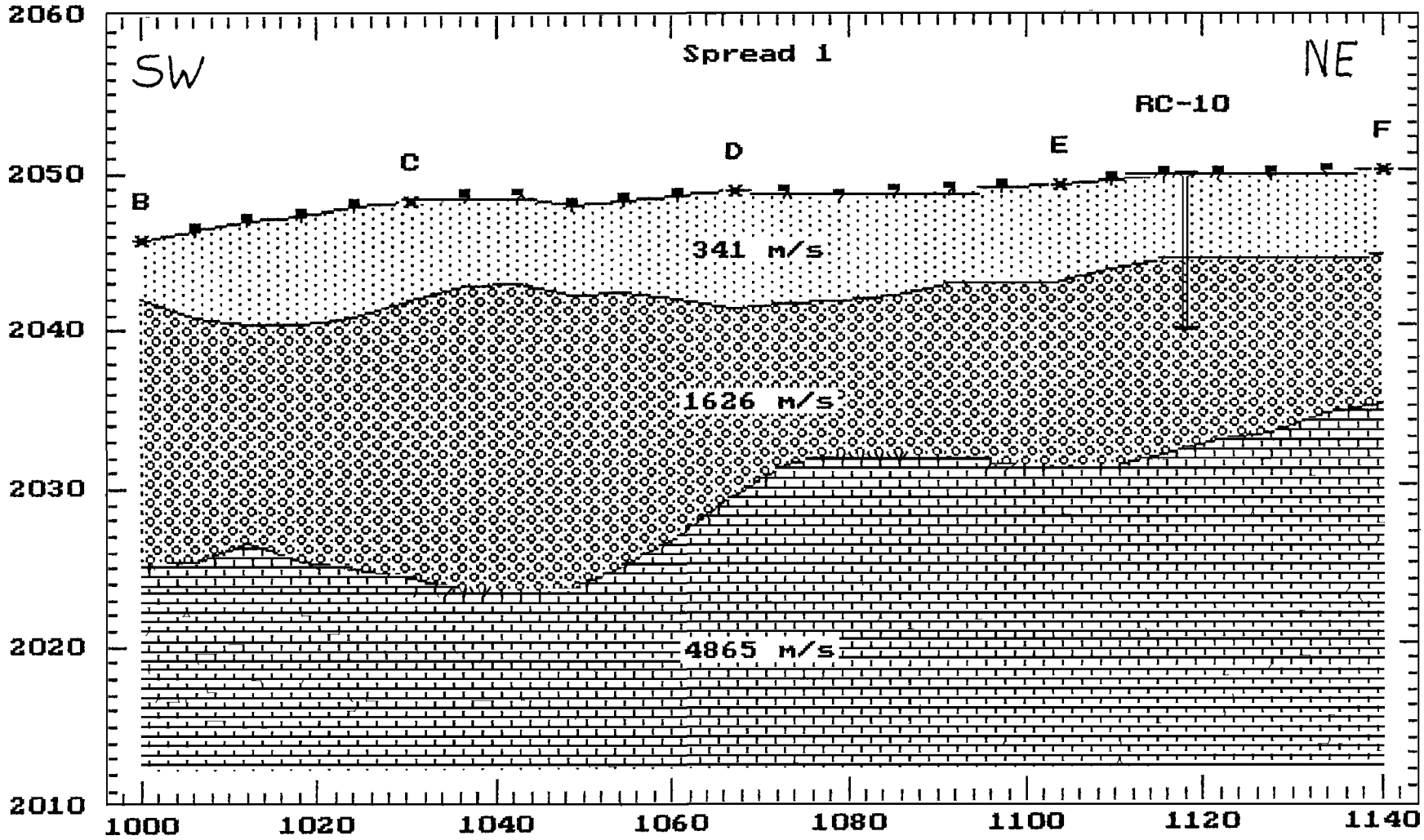


Colluvium Till/WeatheredLS Limestone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G13, Shot June 3, 1999

Station 37+782.???

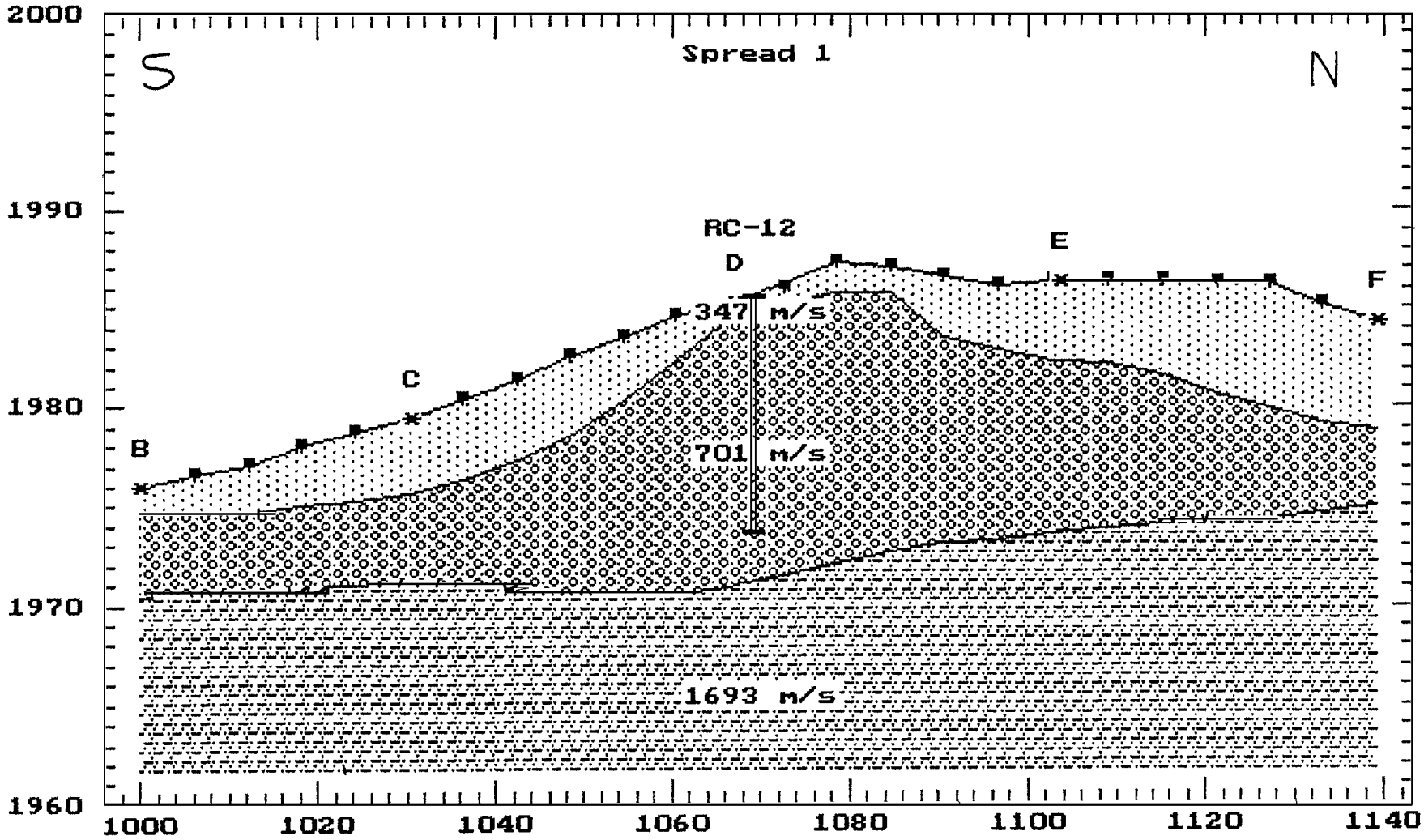


Colluvium Weathered LS Dolostone

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G14, Shot June 10, 1999

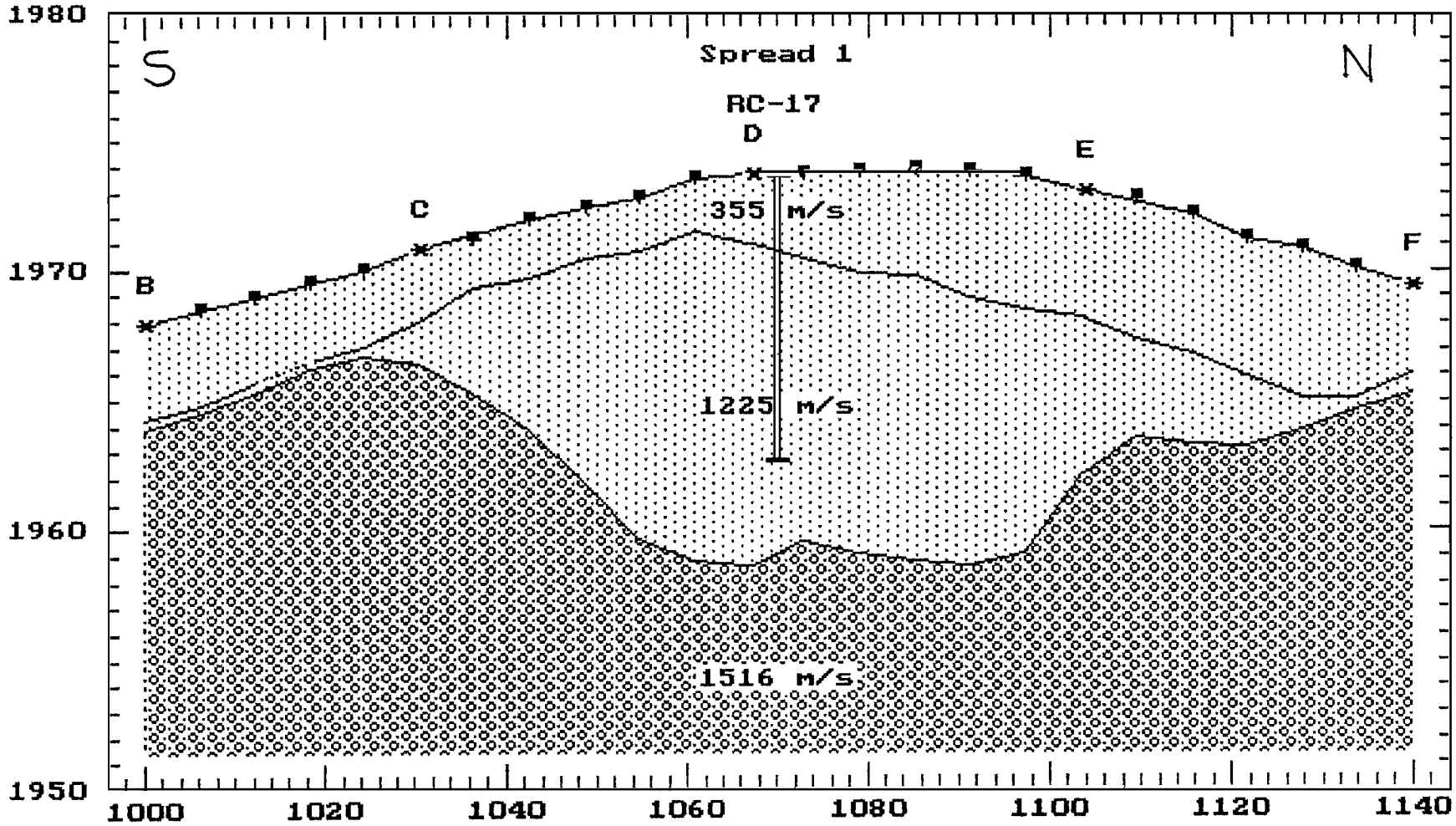
Station 34+283.???



Colluvium Till Clay/Sandy Clay

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

Logan Canyon - UDOT, Dames & Moore Line G15, Shot June 10, 1999
Station 34+024.383



Clayey Sand Till Till/WeatheredLS

Prepared for	Prepared by
Utah Department of Transportation	Dames & Moore
Logan Canyon, Hwy 89, Cache County, UT	Salt Lake City, UT Date: 11/3/99

APPENDIX F

Appendix F

Supplemental Geophysical Data

INPUT DATA FILE for LINEG1.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG1.SIP

Logan Canyon - UDOT, Dames & Moore Line G1, Shot May 26, 1999

PROGRAM CONTROL DATA

Sprds	Extr	Layrs	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OfSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1743.6	987.8	0.0	0.0	0.0	0.0	0
B	1743.2	1000.0	0.0	0.0	0.0	0.0	1
C	1744.4	1015.3	0.0	0.0	0.0	0.0	0
D	1746.6	1033.6	0.0	0.0	0.0	0.0	0
E	1749.5	1051.9	0.0	0.0	0.0	0.0	0
F	1750.9	1070.2	0.0	0.0	0.0	0.0	2
G	1751.6	1082.4	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	1743.2	1000.0	0.0	9.375	2	0.000	0	15.500	2	25.500	3	30.250	3	35.750	3	45.62	0
2	1743.8	1003.1	0.0	17.250	2	12.120	1	11.750	2	19.870	3	28.120	3	30.120	3	45.75	0
3	1744.2	1006.1	0.0	17.370	2	14.000	2	11.620	2	20.620	3	28.000	3	30.620	3	40.37	0
4	1744.5	1009.2	0.0	18.620	2	15.000	2	8.625	2	20.750	3	28.620	3	28.750	3	42.37	0
5	1744.0	1012.2	0.0	18.500	2	17.370	2	5.750	1	15.120	3	29.870	3	31.870	3	47.62	0
6	1744.4	1015.3	0.0	20.120	2	17.370	2	0.000	0	19.620	3	28.370	3	30.500	3	33.37	0
7	1744.9	1018.3	0.0	21.250	2	18.750	2	6.875	1	19.500	3	27.500	3	26.000	3	28.12	3
8	1745.9	1021.4	0.0	23.370	2	22.500	2	11.500	2	21.370	3	26.500	3	30.000	3	30.62	3
9	1746.6	1024.4	0.0	30.250	3	26.000	2	15.120	2	28.000	3	26.500	3	32.120	3	29.00	3
10	1746.2	1027.5	0.0	29.370	3	28.250	2	19.370	2	19.120	2	29.250	3	33.750	3	28.87	3
11	1746.3	1030.5	0.0	24.750	3	30.870	2	23.750	3	10.870	1	28.370	3	32.000	3	35.62	3
12	1746.6	1033.6	0.0	27.870	3	31.870	3	23.370	3	0.000	0	28.620	3	31.000	3	32.75	3
13	1747.1	1036.6	0.0	26.250	3	31.000	3	18.500	3	7.875	1	22.500	2	25.000	3	39.12	3
14	1747.9	1039.7	0.0	28.500	3	29.870	3	20.370	3	15.500	2	21.120	2	23.120	3	29.62	3
15	1747.7	1042.7	0.0	28.120	3	27.250	3	19.120	3	19.620	3	16.750	2	21.500	3	29.75	3
16	1748.5	1045.8	0.0	26.870	3	28.620	3	20.620	3	19.750	3	15.000	2	21.750	3	29.75	3
17	1748.7	1048.8	0.0	30.120	3	30.870	3	20.620	3	24.870	3	7.750	1	24.000	3	31.50	3
18	1749.5	1051.9	0.0	28.000	3	31.250	3	23.000	3	23.370	3	0.000	0	21.620	3	31.12	3
19	1750.2	1054.9	0.0	32.500	3	31.870	3	23.250	3	24.120	3	5.625	1	22.120	3	30.00	3
20	1750.0	1058.0	0.0	29.370	3	30.000	3	22.250	3	22.750	3	15.000	2	18.620	2	23.25	3
21	1750.3	1061.0	0.0	29.620	3	31.620	3	25.370	3	22.250	3	15.620	2	17.500	2	25.50	3
22	1750.5	1064.1	0.0	30.120	3	33.000	3	24.750	3	21.250	3	17.750	2	16.120	2	23.75	3
23	1750.9	1067.1	0.0	33.870	3	35.250	3	26.870	3	23.620	3	21.500	3	7.875	1	24.87	2
24	1750.9	1070.2	0.0	36.120	3	36.870	3	26.870	3	23.750	3	22.120	3	0.000	0	15.50	2

INPUT DATA FILE for LINEG2.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG2.SIP

Logan Canyon - UDOT, Dames & Moore Line G2, Shot May 27, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Layrs	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OfSP	LDip
1	6	2	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1746.3	993.9	0.0	0.0	0.0	0.0	0
B	1746.1	1000.0	0.0	0.0	0.0	0.0	1
C	1746.4	1007.6	0.0	0.0	0.0	0.0	0
D	1747.3	1016.8	0.0	0.0	0.0	0.0	0
E	1747.6	1025.9	0.0	0.0	0.0	0.0	0
F	1746.7	1035.1	0.0	0.0	0.0	0.0	2
G	1746.4	1041.2	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	SP B	SP C	SP D	SP E	SP F	SP G
1	1746.1	1000.0	0.0	11.75 2	0.000	013.500	218.120	220.120	223.750 2	25.00 2
2	1746.1	1001.5	0.0	11.87 2	3.375	111.370	215.750	217.250	223.250 2	21.87 2
3	1746.2	1003.1	0.0	12.87 2	8.250	111.620	217.120	218.620	223.620 2	24.00 2
4	1746.2	1004.6	0.0	13.62	212.250 2	8.125	118.750	217.750	223.750 2	23.87 2
5	1746.3	1006.1	0.0	12.25	213.120 2	3.750	116.500	217.870	222.750 2	23.00 2
6	1746.4	1007.6	0.0	14.12	214.750 2	0.000	016.620	218.000	222.370 2	23.12 2
7	1746.5	1009.2	0.0	14.12	214.750 2	4.750	115.370	217.500	222.000 2	22.62 2
8	1746.7	1010.7	0.0	13.62	214.250 2	7.125	114.370	217.500	220.870 2	22.37 2
9	1746.9	1012.2	0.0	13.87	214.750	210.620	113.000	116.620	220.250 2	21.62 2
10	1747.2	1013.7	0.0	15.50	216.370	212.000 2	8.375	116.370	223.250 2	20.75 2
11	1747.3	1015.3	0.0	17.12	218.120	214.250 2	3.875	118.120	222.250 2	22.37 2
12	1747.3	1016.8	0.0	16.75	217.620	214.870 2	0.000	018.000	221.750 2	22.37 2
13	1747.2	1018.3	0.0	18.25	219.000	216.250 2	5.250	116.500	221.870 2	22.37 2
14	1747.1	1019.8	0.0	18.37	218.870	217.000	210.000	117.500	221.870 2	21.62 2
15	1747.4	1021.4	0.0	19.12	220.250	217.250	213.750	112.870	121.250 2	20.62 2
16	1747.5	1022.9	0.0	19.12	220.000	216.500	218.620 2	7.125	121.000 2	19.62 2
17	1747.7	1024.4	0.0	22.12	222.370	218.750	219.120 2	3.875	121.750 2	20.25 2
18	1747.6	1025.9	0.0	18.87	221.500	216.120	217.500 2	0.000	019.620 2	21.37 2
19	1747.5	1027.5	0.0	20.37	220.870	219.000	218.370 2	4.750	121.870 1	21.12 2
20	1747.5	1029.0	0.0	21.50	222.620	220.500	218.870 2	9.375	118.120 1	25.37 2
21	1747.5	1030.5	0.0	21.50	223.000	221.750	218.000	213.750	113.500 1	22.12 2
22	1747.4	1032.0	0.0	22.75	222.620	222.120	220.250	217.870 1	9.000 1	18.75 2
23	1747.0	1033.6	0.0	23.75	223.370	222.620	220.750	223.500 2	4.000 1	17.37 2
24	1746.7	1035.1	0.0	24.75	224.120	221.620	223.120	226.000 2	0.000 0	16.62 2

INPUT DATA FILE for LINEG3.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG3.SIP

Logan Canyon - UDOT, Dames & Moore Line G3, Shot June 1, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Lays	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1752.0	969.5	0.0	0.0	0.0	0.0	0
B	1761.7	1000.0	0.0	0.0	0.0	0.0	1
C	1769.7	1030.5	0.0	0.0	0.0	0.0	0
D	1772.0	1067.1	0.0	0.0	0.0	0.0	0
E	1771.1	1103.7	0.0	0.0	0.0	0.0	0
F	1766.8	1140.2	0.0	0.0	0.0	0.0	2
G	1764.0	1170.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	1761.7	1000.0	0.0	23.50	2	0.000		026.370		030.500		048.870		057.120	0	50.75	3
2	1763.5	1006.1	0.0	22.75		211.250		125.120		032.000		046.250		052.370	0	51.12	3
3	1765.5	1012.2	0.0	26.37		216.750		228.250		031.750		043.750		047.620	0	51.50	3
4	1767.5	1018.3	0.0	28.12		219.000		229.750		232.250		041.620		045.000	0	50.87	3
5	1768.6	1024.4	0.0	35.25		222.500		215.500		133.750		037.870		046.120	0	49.37	3
6	1769.7	1030.5	0.0	38.12		225.500	2	0.000		032.500		037.620		047.120	0	50.75	3
7	1770.6	1036.6	0.0	38.25		325.620		014.500		132.120		035.870		044.500	0	50.25	3
8	1771.3	1042.7	0.0	40.62		324.870		023.000		230.120		235.870		042.750	0	50.50	3
9	1771.8	1048.8	0.0	41.00		329.370		030.870		027.250		233.750		041.750	0	49.37	3
10	1771.8	1054.9	0.0	42.25		331.250		032.620		022.620		230.370		040.620	0	50.62	3
11	1771.9	1061.0	0.0	34.87		031.620		032.250		016.370		131.370		038.620	0	44.87	3
12	1772.0	1067.1	0.0	44.75		330.870		032.870		0 0.000		030.000		036.250	0	44.37	3
13	1772.2	1073.2	0.0	44.00		331.370		030.870		017.870		127.750		035.500	0	40.12	3
14	1772.5	1079.3	0.0	43.62		331.250		033.750		024.750		225.000		236.620	0	38.87	3
15	1773.2	1085.4	0.0	51.62		033.750		033.870		027.370		222.120		234.620	0	36.75	3
16	1773.2	1091.5	0.0	45.00		332.500		028.870		028.250		020.370		233.620	0	37.00	3
17	1772.3	1097.6	0.0	46.00		334.620		038.000		030.370		014.250		132.250	0	35.75	3
18	1771.1	1103.7	0.0	44.62		333.120		039.000		029.500		0 0.000		028.620	0	32.87	3
19	1769.6	1109.8	0.0	47.00		334.870		038.870		030.370		015.750		127.120	0	32.50	3
20	1768.6	1115.9	0.0	46.37		334.120		042.120		032.000		018.000		224.750	0	29.25	3
21	1768.2	1122.0	0.0	44.75		338.120		043.500		032.870		021.250		223.500	2	27.25	3
22	1767.6	1128.0	0.0	47.00		338.750		043.120		033.500		023.250		021.370	2	27.00	3
23	1767.3	1134.1	0.0	47.87		338.120		044.500		035.120		025.750		013.370	1	27.00	3
24	1766.8	1140.2	0.0	50.37		340.000		045.870		038.000		027.000		0 0.000	0	24.62	3

INPUT DATA FILE for LINEG4.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG4.SIP

Logan Canyon - UDOT, Dames & Moore Line G4, Shot 5/27/99

PROGRAM CONTROL DATA

Spreads	Exit	Layers	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
2	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1893.1	969.5	0.0	0.0	0.0	0.0	0
B	1894.3	1000.0	0.0	0.0	0.0	0.0	1
C	1894.5	1015.2	0.0	0.0	0.0	0.0	0
D	1894.9	1033.5	0.0	0.0	0.0	0.0	0
E	1895.3	1051.9	0.0	0.0	0.0	0.0	0
F	1895.7	1070.2	0.0	0.0	0.0	0.0	2
G	1895.3	1100.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	1894.3	1000.0	0.0	29.25	2	0.000	0	19.870	2	33.250	3	43.870	3	51.120	3	60.75	3
2	1894.4	1003.1	0.0	32.62	3	10.500	1	15.870	2	31.500	3	44.620	3	51.370	3	60.00	3
3	1894.5	1006.1	0.0	31.00	3	14.750	2	13.500	2	30.620	3	44.000	3	52.120	3	60.87	3
4	1894.5	1009.2	0.0	33.12	3	16.870	2	11.370	2	28.500	3	43.250	3	49.500	3	61.50	3
5	1894.5	1012.2	0.0	33.62	3	18.500	2	6.500	1	25.120	2	41.870	3	49.250	3	59.12	3
6	1894.5	1015.3	0.0	36.00	3	22.370	2	0.000	0	17.620	2	39.250	3	48.870	3	58.62	3
7	1894.6	1018.3	0.0	36.00	3	24.120	2	6.250	2	14.870	2	38.370	3	46.370	3	51.87	3
8	1894.6	1021.4	0.0	35.62	3	24.870	2	7.000	2	10.870	2	34.500	3	44.370	3	51.62	3
9	1894.7	1024.4	0.0	38.87	3	28.870	2	11.620	2	10.250	2	27.370	3	46.120	3	50.62	3
10	1894.7	1027.5	0.0	40.50	3	29.870	2	11.750	2	6.375	2	21.750	3	42.750	3	53.00	3
11	1894.8	1030.5	0.0	39.25	3	32.620	3	15.620	2	4.250	1	20.000	2	42.250	3	51.87	3
12	1894.9	1033.6	0.0	43.12	3	34.500	3	18.250	2	0.000	0	17.500	2	39.000	3	50.37	3
13	1894.9	1036.6	0.0	43.75	3	37.500	3	22.870	2	5.125	1	16.370	2	37.870	3	50.12	3
14	1894.9	1039.7	0.0	44.25	3	36.500	3	28.750	3	6.750	2	13.120	2	38.250	3	47.50	3
15	1895.0	1042.7	0.0	46.00	3	39.250	3	30.370	3	9.250	2	11.500	2	31.120	2	48.00	3
16	1895.1	1045.8	0.0	51.00	3	41.620	3	31.870	3	12.500	2	9.750	2	28.620	2	48.50	3
17	1895.2	1048.8	0.0	50.62	3	44.000	3	33.500	3	13.250	2	5.750	1	24.870	2	45.37	3
18	1895.3	1051.9	0.0	52.37	3	47.000	3	38.370	3	17.620	2	0.000	0	20.870	2	45.87	3

19	1895.3	1054.9	0.0	54.00	346.120	339.000	318.870	2	5.375	117.500	2	42.50	3
20	1895.5	1058.0	0.0	58.50	351.120	343.620	323.370		211.000	215.250	2	40.00	3
21	1895.5	1061.0	0.0	56.12	349.500	342.370	335.250		211.750	211.000	2	39.50	3
22	1895.5	1064.1	0.0	58.50	352.120	343.870	338.500		314.250	2 9.625	2	37.25	3
23	1895.5	1067.1	0.0	60.37	352.620	344.000	340.120		317.620	2 6.375	1	36.00	3
24	1895.7	1070.2	0.0	59.75	353.750	345.870	341.250		319.620	2 0.000	0	33.37	3

SHOTPOINT AND GEOPHONE DATA

Spread 2, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1894.7	1024.4	0.0	0.0	0.0	0.0	0
B	1895.3	1054.9	0.0	0.0	0.0	0.0	1
C	1895.7	1070.2	0.0	0.0	0.0	0.0	0
D	1895.6	1088.4	0.0	0.0	0.0	0.0	0
E	1895.2	1106.8	0.0	0.0	0.0	0.0	0
F	1894.6	1125.0	0.0	0.0	0.0	0.0	0
G	1893.6	1155.6	0.0	0.0	0.0	0.0	2

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A		SP B		SP C		SP D		SP E		SP F		SP G	
					L		L		L		L		L		L		L
1	1895.3	1054.9	0.0	27.87	2	0.000		019.250		239.370		347.750		356.750	3	65.37	3
2	1895.5	1058.0	0.0	33.75	2	9.000		116.500		239.750		345.000		358.000	3	64.25	3
3	1895.5	1061.0	0.0	39.00	2	9.875		211.750		234.870		344.500		351.870	3	62.37	3
4	1895.5	1064.1	0.0	41.87		212.250		210.870		234.370		344.250		352.250	3	61.87	3
5	1895.5	1067.1	0.0	42.75		315.500	2	6.875		127.620		241.370		352.000	3	61.62	3
6	1895.7	1070.2	0.0	44.00		319.870	2	0.000		023.870		239.870		349.120	3	57.12	3
7	1895.8	1073.2	0.0	45.62		322.120	2	7.000		119.870		238.370		347.620	3	57.00	3
8	1895.7	1076.3	0.0	47.75		328.750	2	8.375		217.250		234.500		343.500	3	53.87	3
9	1895.7	1079.3	0.0	46.62		332.750		211.870		212.620		231.750		341.250	3	52.00	3
10	1895.7	1082.4	0.0	48.50		334.250		216.500		211.250		231.250		341.870	3	49.50	3
11	1895.6	1085.4	0.0	50.87		338.250		220.500	2	8.250		128.120		238.620	3	47.87	3
12	1895.6	1088.5	0.0	49.75		340.620		323.620	2	0.000		024.870		236.870	3	48.00	3
13	1895.5	1091.5	0.0	49.75		342.120		326.870	2	7.750		122.000		237.120	3	46.75	3
14	1895.4	1094.6	0.0	50.25		342.370		329.870	2	9.750		216.870		234.620	3	44.00	3
15	1895.5	1097.6	0.0	50.25		345.620		333.000		311.500		213.000		231.870	3	41.62	3
16	1895.3	1100.7	0.0	53.75		346.120		333.870		316.870		210.250		231.500	3	40.50	3
17	1895.3	1103.7	0.0	56.12		346.500		336.000		319.750	2	8.625		129.750	3	38.62	3
18	1895.2	1106.8	0.0	56.50		348.500		336.620		323.370	2	0.000		028.000	3	38.50	3
19	1895.1	1109.8	0.0	56.87		350.120		340.500		328.370	3	7.625		127.750	2	38.87	3
20	1894.9	1112.9	0.0	58.50		350.620		339.750		329.250		313.000		223.870	2	36.37	3
21	1894.9	1115.9	0.0	62.00		353.120		340.750		331.370		316.250		220.000	2	33.12	3
22	1894.9	1119.0	0.0	62.37		356.000		344.250		333.500		321.370		217.120	2	34.00	3
23	1894.8	1122.0	0.0	63.00		357.500		345.120		335.250		326.120	2	8.500	1	33.37	3
24	1894.6	1125.1	0.0	63.87		358.120		348.000		336.250		327.250	3	0.000	0	33.25	3

INPUT DATA FILE for LINEG5.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG5.SIP

Logan Canyon - UDOT, Dames & Moore Line G5, Shot June 4, 1999

PROGRAM CONTROL DATA

Spreds	Exit	Layrs	Over	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffS	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1986.4	981.7	0.0	0.0	0.0	0.0	0
B	1988.5	1000.0	0.0	0.0	0.0	0.0	1
C	1994.0	1030.5	0.0	0.0	0.0	0.0	0
D	1998.0	1067.1	0.0	0.0	0.0	0.0	0
E	1999.8	1103.7	0.0	0.0	0.0	0.0	0
F	1999.4	1140.2	0.0	0.0	0.0	0.0	2
G	1998.4	1158.5	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	SP B	SP C	SP D	SP E	SP F	SP G
1	1988.5	1000.0	0.0	29.37 2	0.000	040.370	350.000	371.750	369.870 3	79.50 3
2	1989.8	1006.1	0.0	31.50	317.500	136.620	348.500	365.000	369.750 3	76.50 3
3	1991.1	1012.2	0.0	35.75	329.750	236.120	349.000	363.120	369.750 3	71.25 3
4	1992.2	1018.3	0.0	40.87	332.620	331.750	245.000	361.870	368.370 3	72.62 3
5	1993.1	1024.4	0.0	43.87	336.120	316.870	143.120	358.870	365.000 3	73.12 3
6	1994.0	1030.5	0.0	45.87	338.620	3 0.000	040.000	360.120	362.870 3	71.37 3
7	1994.8	1036.6	0.0	47.75	341.500	318.120	138.120	357.370	363.120 3	73.50 3
8	1995.5	1042.7	0.0	49.37	344.370	330.370	234.000	352.750	357.000 3	67.50 3
9	1996.0	1048.8	0.0	51.50	344.870	336.370	230.500	248.870	356.500 3	63.00 3
10	1996.8	1054.9	0.0	50.50	347.120	336.370	324.870	244.250	352.370 3	59.00 3
11	1997.4	1061.0	0.0	53.37	347.120	337.870	316.750	141.500	351.500 3	56.87 3
12	1998.0	1067.1	0.0	56.37	350.120	340.250	3 0.000	039.120	348.870 3	55.75 3
13	1998.5	1073.2	0.0	62.50	354.870	347.620	318.250	136.750	345.120 3	54.12 3
14	1999.0	1079.3	0.0	62.00	357.250	349.370	327.000	233.620	344.370 3	53.00 3
15	1999.3	1085.4	0.0	63.37	360.250	352.370	330.370	329.620	338.750 3	47.37 3
16	1999.5	1091.5	0.0	65.87	360.120	354.750	331.870	325.620	235.620 3	46.75 3
17	1999.6	1097.6	0.0	66.62	364.750	354.750	333.500	317.250	133.500 3	43.37 3
18	1999.8	1103.7	0.0	69.62	367.500	353.870	338.750	3 0.000	031.500 3	43.37 3
19	1999.9	1109.8	0.0	66.25	367.620	359.000	340.000	318.000	129.370 3	40.25 3
20	2000.0	1115.9	0.0	70.12	368.500	359.500	341.620	325.000	225.620 3	36.12 3
21	2000.2	1122.0	0.0	71.12	369.750	354.500	044.750	328.370	323.120 3	34.12 3
22	2000.2	1128.0	0.0	71.00	369.120	361.120	346.000	330.000	318.620 2	30.12 3
23	1999.6	1134.1	0.0	71.12	370.000	362.120	347.370	333.370	312.120 1	26.50 3
24	1999.4	1140.2	0.0	75.62	368.250	360.500	347.250	334.620	3 0.000 0	22.37 3

INPUT DATA FILE for LINEG6.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG6.SIP

Logan Canyon - UDOT, Dames & Moore Line G6, Shot June 1, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Lays	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OfSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0 0.0	0.0 0.0	0	0	0.5	10.0	0	0	0

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1985.2	975.6	0.0	0.0	0.0	0.0	0
B	1986.4	1000.0	0.0	0.0	0.0	0.0	1
C	1988.5	1030.5	0.0	0.0	0.0	0.0	0
D	1992.1	1067.1	0.0	0.0	0.0	0.0	0
E	1991.1	1103.7	0.0	0.0	0.0	0.0	0
F	1988.8	1140.2	0.0	0.0	0.0	0.0	2
G	1988.2	1170.8	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	1986.4	1000.0	0.0	19.12	2	0.000	0	29.750	2	50.000	3	72.620	3	82.370	3	82.37	0
2	1986.7	1006.1	0.0	21.50	2	11.500	1	25.620	2	47.750	3	68.750	3	76.750	3	81.00	0
3	1986.9	1012.2	0.0	23.12	2	15.370	2	21.370	2	44.250	3	64.250	3	73.750	3	79.37	0
4	1987.4	1018.3	0.0	28.25	2	20.750	2	20.250	2	40.120	3	62.620	3	73.370	3	73.50	0
5	1987.7	1024.4	0.0	29.62	2	26.500	2	14.870	1	43.750	3	62.000	3	74.120	3	72.75	0
6	1988.5	1030.5	0.0	30.37	2	30.000	2	0.000	0	36.250	3	62.500	3	69.870	3	71.00	0
7	1988.9	1036.6	0.0	43.00	2	37.500	2	16.750	1	37.620	2	57.870	2	73.500	3	77.75	3
8	1989.2	1042.7	0.0	49.75	3	38.750	3	18.250	2	33.370	2	54.750	2	63.620	2	72.37	3
9	1989.7	1048.8	0.0	48.00	3	37.750	3	25.250	2	25.870	2	45.120	2	58.750	2	70.87	3
10	1990.6	1054.9	0.0	48.25	3	38.370	3	24.750	3	19.370	2	41.000	2	52.870	2	72.25	3
11	1991.5	1061.0	0.0	53.37	3	42.250	3	31.620	3	15.870	1	39.120	2	49.750	2	70.62	2
12	1992.1	1067.1	0.0	52.12	3	50.620	3	36.620	3	0.000	0	39.750	2	52.000	2	66.87	2
13	1992.3	1073.2	0.0	55.50	3	54.750	3	38.250	3	19.620	1	35.370	2	41.250	2	62.37	2
14	1992.4	1079.3	0.0	56.50	3	56.500	3	48.370	3	25.870	2	33.120	2	47.370	2	59.00	2
15	1992.2	1085.4	0.0	61.12	3	62.250	3	50.120	3	29.870	2	31.250	2	44.370	2	55.00	2
16	1991.9	1091.5	0.0	75.75	3	64.000	3	56.000	3	35.500	2	26.250	2	40.500	2	53.37	2
17	1991.4	1097.6	0.0	74.00	3	68.250	3	55.120	3	37.500	2	19.500	1	38.500	2	46.00	2
18	1991.1	1103.7	0.0	72.62	3	70.000	3	56.250	3	39.750	2	0.000	0	32.500	2	45.62	2
19	1990.6	1109.8	0.0	73.37	3	71.870	3	56.870	3	45.370	3	16.120	1	29.870	2	40.12	2
20	1989.8	1115.9	0.0	79.75	3	74.500	3	64.750	3	45.120	3	22.500	2	24.250	2	37.37	2
21	1989.2	1122.0	0.0	78.50	3	75.370	3	64.620	3	46.370	3	24.500	2	19.870	2	32.87	2
22	1988.6	1128.0	0.0	81.00	3	75.120	3	62.500	3	44.620	3	22.250	2	13.250	2	26.50	2
23	1988.7	1134.1	0.0	82.87	3	80.250	3	67.750	3	52.250	3	28.000	2	10.250	1	24.25	2
24	1988.8	1140.2	0.0	89.00	3	80.870	3	73.370	3	53.750	3	33.370	2	0.000	0	22.25	2

INPUT DATA FILE for LINEG7.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG7.SIP

Logan Canyon - UDOT, Dames & Moore Line G7, Shot June 4, 1999

PROGRAM CONTROL DATA

Spreads	Exits	Layers	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2013.3	981.7	0.0	0.0	0.0	0.0	0
B	2014.4	1000.0	0.0	0.0	0.0	0.0	1
C	2015.2	1030.5	0.0	0.0	0.0	0.0	0
D	2017.3	1067.1	0.0	0.0	0.0	0.0	0
E	2016.3	1103.7	0.0	0.0	0.0	0.0	0
F	2015.6	1140.2	0.0	0.0	0.0	0.0	2
G	2014.8	1158.5	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	SP B	SP C	SP D	SP E	SP F	SP G
1	2014.4	1000.0	0.0	29.62 2	0.000	041.500	360.370	380.250	3106.20	3112.80 3
2	2014.6	1006.1	0.0	37.37	316.370	140.500	360.250	378.870	3109.20	3116.10 3
3	2015.3	1012.2	0.0	38.50	326.500	236.370	357.120	377.370	392.500	3108.00 3
4	2015.4	1018.3	0.0	47.37	333.620	237.370	256.370	378.750	391.870	3110.80 3
5	2015.3	1024.4	0.0	47.50	335.750	319.250	152.620	376.870	392.250	3108.20 3
6	2015.2	1030.5	0.0	48.00	338.750	3 0.000	048.500	372.620	391.250	3101.70 3
7	2015.4	1036.6	0.0	50.25	341.750	316.250	144.000	367.120	387.870	3 99.25 3
8	2015.9	1042.7	0.0	58.50	345.000	334.750	242.000	359.620	384.000	3 96.87 3
9	2016.3	1048.8	0.0	62.75	349.620	341.000	238.500	357.620	380.000	3 92.12 3
10	2016.6	1054.9	0.0	70.75	353.250	344.620	333.620	252.750	376.120	3 88.12 3
11	2017.0	1061.0	0.0	70.12	355.370	345.250	318.120	250.870	374.000	3 82.00 3
12	2017.3	1067.1	0.0	74.87	357.620	349.620	3 0.000	048.250	368.620	3 77.12 3
13	2017.3	1073.2	0.0	81.62	365.870	357.620	317.620	147.250	371.250	3 76.75 3
14	2017.3	1079.3	0.0	84.87	370.500	361.620	333.620	241.120	267.870	3 72.25 3
15	2017.1	1085.4	0.0	86.75	376.500	366.250	339.120	237.620	262.370	3 67.75 3
16	2016.9	1091.5	0.0	88.12	376.120	365.870	338.120	325.750	254.750	3 64.75 3
17	2016.6	1097.6	0.0	88.75	378.370	370.000	341.500	316.370	147.870	3 59.12 3
18	2016.3	1103.7	0.0	92.75	380.870	373.120	346.120	3 0.000	045.120	3 57.62 3
19	2016.2	1109.8	0.0	95.25	384.250	377.000	349.370	318.620	142.500	3 52.25 3
20	2016.1	1115.9	0.0	98.87	388.000	382.870	352.870	330.870	238.750	3 49.12 3
21	2015.9	1122.0	0.0	94.50	095.500	384.250	360.000	339.250	237.250	3 46.25 3
22	2015.7	1128.0	0.0	94.75	097.870	387.750	360.500	341.620	332.870	2 41.87 3
23	2015.7	1134.1	0.0	96.37	099.750	389.500	361.500	342.620	316.620	1 36.25 3
24	2015.6	1140.2	0.0	99.50	0103.20	395.250	366.120	348.000	3 0.000	0 33.75 3

INPUT DATA FILE for LINEG8.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG8.SIP

Logan Canyon - UDOT, Dames & Moore Line G8, Shot June 3, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Layrs	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2029.8	969.5	0.0	0.0	0.0	0.0	0
B	2034.8	1000.0	0.0	0.0	0.0	0.0	1
C	2040.3	1030.5	0.0	0.0	0.0	0.0	0
D	2045.6	1067.1	0.0	0.0	0.0	0.0	0
E	2047.2	1103.7	0.0	0.0	0.0	0.0	0
F	2046.3	1140.2	0.0	0.0	0.0	0.0	2
G	2045.1	1164.6	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	2034.8	1000.0	0.0	35.37	2	0.000		029.500		249.370		353.000		073.120	0	77.75	3
2	2036.1	1006.1	0.0	39.50		212.870		123.750		247.250		354.620		367.370	3	74.87	3
3	2037.3	1012.2	0.0	43.00		219.620		220.000		247.620		353.000		368.620	3	75.12	3
4	2038.3	1018.3	0.0	45.75		324.750		216.250		245.750		351.870		363.120	3	76.12	3
5	2039.3	1024.4	0.0	47.25		328.750		211.250		144.370		351.620		360.500	3	74.12	3
6	2040.3	1030.5	0.0	49.87		333.000	2	0.000		042.620		352.250		359.370	3	70.62	3
7	2041.3	1036.6	0.0	49.87		336.000		210.370		140.120		249.620		357.000	3	68.50	3
8	2042.1	1042.7	0.0	52.87		338.370		316.250		230.250		249.250		358.000	3	66.50	3
9	2042.9	1048.8	0.0	55.12		340.620		323.870		224.250		246.620		353.870	3	66.87	3
10	2044.0	1054.9	0.0	60.37		342.620		328.000		222.500		247.870		354.870	3	67.50	3
11	2044.8	1061.0	0.0	63.50		345.870		337.870		212.000		146.500		351.870	3	65.87	3
12	2045.6	1067.1	0.0	64.37		347.870		340.500	3	0.000		045.870		354.000	3	62.12	3
13	2046.4	1073.2	0.0	63.12		347.250		343.120		312.000		142.370		252.120	3	60.12	3
14	2046.6	1079.3	0.0	62.75		348.370		342.000		317.750		230.620		246.370	3	60.00	3
15	2047.0	1085.4	0.0	65.12		352.870		344.500		322.250		223.370		246.870	3	56.37	3
16	2047.1	1091.5	0.0	66.37		350.250		346.620		329.870		217.120		244.750	3	53.87	3
17	2047.3	1097.6	0.0	68.87		357.000		346.870		340.620		211.120		145.500	3	55.75	3
18	2047.2	1103.7	0.0	70.25		357.250		349.870		347.500	3	0.000		047.000	3	58.00	3
19	2047.1	1109.8	0.0	74.62		359.120		350.500		347.000		310.500		143.870	3	53.50	3
20	2047.2	1115.9	0.0	76.00		357.250		052.370		351.620		319.750		238.870	2	52.50	3
21	2047.1	1122.0	0.0	78.87		357.370		052.000		352.500		331.370		232.750	2	48.75	3
22	2047.2	1128.0	0.0	82.87		353.620		055.000		355.000		336.620		220.500	2	46.62	3
23	2047.6	1134.1	0.0	84.25		350.120		054.000		355.870		342.000		210.120	1	44.75	3
24	2046.3	1140.2	0.0	85.25		347.870		054.870		358.620		345.500	2	0.000	0	29.75	2

INPUT DATA FILE for LINEG9.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG9.SIP

Logan Canyon - UDOT, Dames & Moore Line G9, Shot May 28, 1999

PROGRAM CONTROL DATA

Spreads	Exits	Layers	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2026.4	969.5	0.0	0.0	0.0	0.0	0
B	2026.9	1000.0	0.0	0.0	0.0	0.0	1
C	2028.4	1030.5	0.0	0.0	0.0	0.0	0
D	2029.9	1067.1	0.0	0.0	0.0	0.0	0
E	2031.5	1103.7	0.0	0.0	0.0	0.0	0
F	2033.4	1140.3	0.0	0.0	0.0	0.0	2
G	2033.9	1170.9	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	2026.9	1000.0	0.0	31.12	2	0.000		025.500		336.370		346.370		355.370	3	59.37	3
2	2026.7	1006.1	0.0	34.87	3	9.875		124.870		236.870		344.000		356.120	3	61.87	3
3	2027.3	1012.2	0.0	36.12		315.250		220.500		235.500		342.870		352.120	3	61.37	3
4	2027.4	1018.3	0.0	38.00		319.500		216.500		234.000		344.250		351.000	3	61.12	3
5	2028.0	1024.4	0.0	39.62		322.620		210.000		132.000		341.620		350.250	3	58.62	3
6	2028.4	1030.5	0.0	40.37		326.500	2	0.000		031.750		342.120		348.620	3	55.87	3
7	2028.5	1036.6	0.0	42.62		328.370		211.120		129.120		340.250		348.620	3	54.37	3
8	2029.0	1042.7	0.0	44.62		331.370		216.250		225.500		339.120		346.250	3	52.87	3
9	2029.5	1048.8	0.0	48.50		334.620		323.500		224.000		238.120		345.250	3	53.37	3
10	2029.6	1054.9	0.0	48.87		335.000		327.500		217.120		234.500		344.620	3	47.87	3
11	2030.1	1061.0	0.0	50.62		336.870		330.370		311.250		132.500		343.000	3	47.50	3
12	2029.9	1067.1	0.0	51.75		338.120		331.750	3	0.000		032.000		339.500	3	46.75	3
13	2030.2	1073.2	0.0	55.62		339.250		334.500		312.000		130.000		337.250	3	46.25	3
14	2030.2	1079.3	0.0	53.37		340.370		334.750		317.750		230.120		235.000	3	44.62	3
15	2030.7	1085.4	0.0	55.75		342.500		338.500		324.750		227.620		236.250	3	44.25	3
16	2031.0	1091.5	0.0	58.62		346.120		339.620		330.250		321.370		136.870	3	43.37	3
17	2031.2	1097.6	0.0	58.62		345.870		338.500		329.500		311.620		133.750	3	43.37	3
18	2031.5	1103.7	0.0	61.25		347.370		340.250		332.000	3	0.000		032.620	3	40.62	3
19	2032.0	1109.8	0.0	62.00		350.620		343.000		334.620		313.370		131.250	3	38.50	3
20	2032.3	1115.9	0.0	62.50		351.250		342.870		334.370		320.120		228.750	2	37.37	3
21	2032.7	1122.0	0.0	63.12		351.750		343.370		335.250		324.370		224.620	2	36.37	3
22	2033.0	1128.0	0.0	65.25		354.250		343.750		337.500		329.000		220.500	2	36.87	3
23	2033.1	1134.1	0.0	69.50		355.250		346.250		339.750		330.620		312.250	1	35.62	3
24	2033.4	1140.2	0.0	71.12		355.500		347.870		340.620		331.620	3	0.000	0	33.87	3

INPUT DATA FILE for LINEG10.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG10.SIP

Logan Canyon - UDOT, Dames & Moore Line G10, Shot May 28, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Lays	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0 0.0	0.0 0.0	0	0	0.5	10.0	0	0	0

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2035.5	969.5	0.0	0.0	0.0	0.0	0
B	2034.5	1000.0	0.0	0.0	0.0	0.0	1
C	2034.8	1030.5	0.0	0.0	0.0	0.0	0
D	2036.3	1067.1	0.0	0.0	0.0	0.0	0
E	2036.8	1103.7	0.0	0.0	0.0	0.0	0
F	2037.4	1140.2	0.0	0.0	0.0	0.0	2
G	2038.0	1170.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	2034.5	1000.0	0.0	32.50	2	0.000		036.750		348.370		357.370		371.750	3	84.75	3
2	2034.1	1006.1	0.0	36.25		310.870		133.120		344.120		356.620		369.870	3	83.87	3
3	2034.0	1012.2	0.0	35.87		319.370		228.620		240.750		354.500		366.750	3	80.00	3
4	2034.0	1018.3	0.0	37.37		325.750		222.000		238.750		351.250		366.000	3	79.62	3
5	2034.3	1024.4	0.0	39.50		332.750		214.000		135.370		351.120		363.620	3	78.25	3
6	2034.8	1030.5	0.0	41.25		335.370	3	0.000		035.500		350.870		364.370	3	76.87	3
7	2035.1	1036.6	0.0	43.50		336.870		313.250		137.120		350.750		361.370	3	76.12	3
8	2036.1	1042.7	0.0	45.87		340.120		319.750		231.120		248.620		360.870	3	75.25	3
9	2036.4	1048.8	0.0	45.62		342.000		324.870		223.370		245.750		358.500	3	72.87	3
10	2036.7	1054.9	0.0	50.12		342.620		331.750		218.250		245.500		357.500	3	71.50	3
11	2036.5	1061.0	0.0	52.50		345.370		339.250		011.370		141.620		355.120	3	67.87	3
12	2036.3	1067.1	0.0	57.00		347.870		339.620		0 0.000		038.620		354.120	3	67.37	3
13	2035.9	1073.2	0.0	54.75		350.000		339.870		015.370		140.500		353.870	3	66.00	3
14	2036.3	1079.3	0.0	57.87		350.250		348.750		024.120		237.500		249.750	3	63.50	3
15	2036.0	1085.4	0.0	58.25		350.370		346.120		030.000		231.500		248.370	3	61.50	3
16	2036.3	1091.5	0.0	61.62		354.120		345.620		035.750		329.000		249.000	3	62.37	3
17	2036.5	1097.6	0.0	65.50		357.250		348.750		037.250		318.250		146.000	3	60.00	3
18	2036.8	1103.7	0.0	64.12		356.250		349.750		040.250		3 0.000		041.000	3	55.87	3
19	2037.5	1109.8	0.0	64.12		356.750		358.500		042.870		316.620		140.250	3	55.75	3
20	2037.2	1115.9	0.0	56.75		352.370		353.000		043.000		326.500		235.500	2	52.50	3
21	2037.4	1122.0	0.0	53.75		352.370		357.620		042.250		330.250		231.750	2	50.25	3
22	2037.4	1128.0	0.0	57.75		351.620		363.250		043.750		333.250		226.500	2	47.87	3
23	2037.4	1134.1	0.0	61.37		351.870		366.000		046.500		339.250		315.250	1	49.00	3
24	2037.4	1140.2	0.0	65.37		355.000		366.250		049.120		339.620		3 0.000	0	41.62	2

INPUT DATA FILE for LINEG11.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG11.SIP

Logan Canyon - UDOT, Dames & Moore Line G11, Shot June 2, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Layrs	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OfSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2040.1	969.5	0.0	0.0	0.0	0.0	0
B	2040.9	1000.0	0.0	0.0	0.0	0.0	1
C	2040.8	1030.5	0.0	0.0	0.0	0.0	0
D	2043.8	1067.1	0.0	0.0	0.0	0.0	0
E	2042.7	1103.7	0.0	0.0	0.0	0.0	0
F	2044.0	1140.2	0.0	0.0	0.0	0.0	2
G	2046.1	1170.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	L	SP B	L	SP C	L	SP D	L	SP E	L	SP F	L	SP G	L
1	2040.9	1000.0	0.0	38.00	3	0.000	0	40.750	3	56.750	3	76.000	3	106.80	0	99.62	0
2	2041.2	1006.1	0.0	41.25	3	17.120	1	38.500	3	57.000	3	76.870	3	95.250	3	93.50	0
3	2041.4	1012.2	0.0	44.25	3	28.620	2	32.870	3	52.500	3	72.000	3	94.500	3	91.12	0
4	2041.7	1018.3	0.0	47.50	3	32.000	2	32.750	2	51.750	3	70.500	3	87.750	3	90.50	0
5	2041.5	1024.4	0.0	50.12	3	38.370	2	17.870	1	52.000	3	71.120	3	82.870	3	84.62	0
6	2040.8	1030.5	0.0	50.87	3	40.120	3	0.000	0	46.370	3	64.250	3	82.250	3	83.75	0
7	2041.1	1036.6	0.0	51.00	3	42.370	3	16.620	1	39.500	2	61.370	3	79.000	3	85.75	0
8	2042.4	1042.7	0.0	60.62	3	46.870	3	30.250	2	38.000	2	62.870	3	74.000	3	84.62	3
9	2042.9	1048.8	0.0	59.00	3	48.000	3	33.250	2	32.000	2	58.620	3	71.750	3	77.62	3
10	2043.3	1054.9	0.0	60.87	3	51.000	3	37.250	2	27.620	2	54.620	3	70.000	3	76.37	3
11	2043.6	1061.0	0.0	65.00	3	57.120	3	42.620	2	17.870	1	53.750	3	68.750	3	77.12	3
12	2043.8	1067.1	0.0	67.37	3	57.500	3	46.120	3	0.000	0	49.000	3	68.620	3	75.87	3
13	2043.9	1073.2	0.0	66.87	3	56.500	3	46.870	3	16.750	1	45.000	3	69.370	3	73.12	3
14	2043.9	1079.3	0.0	70.12	3	61.870	3	54.370	3	26.250	2	41.500	3	64.120	3	72.00	3
15	2043.5	1085.4	0.0	69.25	3	62.000	3	53.000	3	29.750	2	33.250	3	56.120	3	67.25	3
16	2043.2	1091.5	0.0	77.37	3	72.120	3	56.120	3	36.250	2	32.870	3	57.250	3	68.75	3
17	2043.1	1097.6	0.0	81.12	3	75.750	3	62.370	3	43.370	3	16.750	1	54.370	3	66.25	3
18	2042.7	1103.7	0.0	77.37	3	73.870	3	63.750	3	48.000	3	0.000	0	50.500	2	65.50	3
19	2042.8	1109.8	0.0	81.00	3	78.500	3	65.370	3	50.500	3	19.000	1	46.370	2	66.25	3
20	2042.9	1115.9	0.0	85.25	3	80.500	3	72.620	3	52.500	3	35.000	2	41.500	2	61.75	3
21	2042.7	1122.0	0.0	84.25	3	81.500	3	75.250	3	55.000	3	39.000	2	38.500	2	60.37	2
22	2043.1	1128.0	0.0	83.00	3	77.870	3	74.500	3	57.370	3	41.250	2	31.370	2	53.12	2
23	2043.2	1134.1	0.0	82.62	3	77.120	3	74.620	3	60.750	3	43.870	2	17.750	1	46.87	2
24	2044.0	1140.2	0.0	90.25	3	82.000	3	77.500	3	62.870	3	50.250	3	0.000	0	42.12	2

INPUT DATA FILE for LINEG12.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG12.SIP

Logan Canyon - UDOT, Dames & Moore Line G12, Shot June 3, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Layrs	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OffSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0 0.0	0.0 0.0	0	0	0.5	10.0	0	0	0

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2039.3	963.4	0.0	0.0	0.0	0.0	0
B	2039.5	1000.0	0.0	0.0	0.0	0.0	1
C	2044.9	1030.5	0.0	0.0	0.0	0.0	0
D	2052.7	1067.1	0.0	0.0	0.0	0.0	0
E	2051.6	1103.7	0.0	0.0	0.0	0.0	0
F	2054.8	1140.2	0.0	0.0	0.0	0.0	2
G	2056.3	1170.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	SP B	SP C	SP D	SP E	SP F	SP G
1	2039.5	1000.0	0.0	48.75 2	0.000	045.250	256.250	371.120	078.000 0	97.25 3
2	2040.5	1006.1	0.0	52.00	216.120	141.870	256.120	378.370	378.120 0	99.62 3
3	2041.5	1012.2	0.0	54.62	232.370	238.500	255.370	379.250	378.250 0	100.20 3
4	2042.6	1018.3	0.0	57.50	236.250	234.250	254.750	376.370	376.000 0	101.00 3
5	2043.6	1024.4	0.0	62.37	240.750	218.120	151.500	376.750	376.750 0	97.37 3
6	2044.9	1030.5	0.0	64.75	245.000	2 0.000	050.120	373.870	382.250 3	100.10 3
7	2046.1	1036.6	0.0	68.25	348.250	218.120	140.120	268.120	374.870 3	93.37 3
8	2046.9	1042.7	0.0	69.00	351.750	230.370	228.250	262.500	372.370 3	88.75 3
9	2048.5	1048.8	0.0	68.62	356.620	236.870	226.000	260.620	372.870 3	84.75 3
10	2050.0	1054.9	0.0	67.25	358.750	341.750	213.870	253.000	365.620 3	79.12 3
11	2051.3	1061.0	0.0	68.87	361.370	345.620	2 8.875	148.000	355.370 3	77.50 3
12	2052.7	1067.1	0.0	70.50	363.250	349.750	2 0.000	045.370	354.250 3	73.87 3
13	2053.6	1073.2	0.0	73.87	366.750	360.250	312.620	142.250	349.750 3	67.62 3
14	2053.9	1079.3	0.0	70.50	365.250	358.120	315.250	239.750	341.120 3	70.00 3
15	2053.5	1085.4	0.0	74.75	365.870	358.870	320.370	236.120	342.120 3	66.75 3
16	2052.7	1091.5	0.0	75.50	366.370	363.000	328.370	237.370	242.500 3	65.50 3
17	2051.5	1097.6	0.0	84.50	378.250	372.000	341.620	319.120	147.620 3	55.00 3
18	2051.6	1103.7	0.0	80.12	378.250	374.620	343.250	3 0.000	041.250 2	51.75 3
19	2052.0	1109.8	0.0	78.00	376.000	367.620	341.120	316.120	134.000 2	53.25 3
20	2052.6	1115.9	0.0	87.00	378.500	372.250	346.750	325.620	230.370 2	44.37 2
21	2053.5	1122.0	0.0	87.87	379.500	371.750	348.000	330.000	224.620 2	40.87 2
22	2053.8	1128.0	0.0	81.75	378.000	369.370	341.750	328.370	317.750 2	36.25 2
23	2054.0	1134.1	0.0	85.12	381.620	374.870	346.500	334.620	312.620 1	32.37 2
24	2054.8	1140.2	0.0	91.00	385.870	376.870	353.750	339.370	3 0.000 0	30.00 2

INPUT DATA FILE for LINEG13.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG13.SIP

Logan Canyon - UDOT, Dames & Moore Line G13, Shot June 3, 1999

PROGRAM CONTROL DATA

Spreads	Exits	Layers	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OfSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	2043.2	969.5	0.0	0.0	0.0	0.0	0
B	2045.7	1000.0	0.0	0.0	0.0	0.0	1
C	2048.2	1030.5	0.0	0.0	0.0	0.0	0
D	2048.8	1067.1	0.0	0.0	0.0	0.0	0
E	2049.1	1103.7	0.0	0.0	0.0	0.0	0
F	2049.9	1140.2	0.0	0.0	0.0	0.0	2
G	2050.7	1170.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A		SP B		SP C		SP D		SP E		SP F		SP G	
1	2045.7	1000.0	0.0	37.75	2	0.000	049.750	357.250	373.620	369.370	3	84.50	3				
2	2046.3	1006.1	0.0	52.25	219.250	151.870	364.500	373.620	377.500	3	81.25	3					
3	2046.9	1012.2	0.0	56.00	236.370	250.870	366.000	371.000	375.620	3	82.62	3					
4	2047.2	1018.3	0.0	56.12	342.750	236.870	165.120	376.870	372.750	3	79.87	3					
5	2047.8	1024.4	0.0	66.00	348.120	218.750	164.250	376.120	376.250	3	80.75	3					
6	2048.2	1030.5	0.0	65.12	350.500	3	0.000	060.620	273.000	372.120	3	73.62	3				
7	2048.4	1036.6	0.0	63.75	353.000	316.870	156.750	265.000	370.750	3	73.62	3					
8	2048.5	1042.7	0.0	69.62	355.620	334.000	154.000	264.750	368.500	3	75.00	3					
9	2047.8	1048.8	0.0	71.25	356.750	352.750	252.750	261.750	367.250	3	72.37	3					
10	2048.1	1054.9	0.0	73.37	358.870	352.500	237.120	164.370	364.250	3	76.00	3					
11	2048.4	1061.0	0.0	73.37	360.370	359.620	219.250	162.500	365.370	3	68.75	3					
12	2048.8	1067.1	0.0	73.50	360.870	360.000	3	0.000	060.370	363.750	3	66.62	3				
13	2048.6	1073.2	0.0	65.87	360.250	358.500	317.000	161.120	361.120	3	57.87	3					
14	2048.3	1079.3	0.0	68.75	359.000	362.250	334.500	152.500	359.250	3	62.87	3					
15	2048.6	1085.4	0.0	67.75	359.500	366.120	351.500	254.370	254.120	3	60.37	3					
16	2048.8	1091.5	0.0	65.75	370.250	367.000	354.120	236.620	151.620	3	62.37	3					
17	2048.9	1097.6	0.0	70.37	369.000	372.500	357.120	218.870	153.120	3	62.87	3					
18	2049.1	1103.7	0.0	63.12	365.620	373.870	363.500	3	0.000	053.120	3	61.12	3				
19	2049.3	1109.8	0.0	62.00	370.000	378.120	364.120	316.370	148.370	2	56.62	2					
20	2049.6	1115.9	0.0	65.12	372.370	373.000	366.500	334.370	145.120	2	53.37	2					
21	2049.6	1122.0	0.0	68.75	365.870	372.120	367.750	350.120	243.120	2	47.00	2					
22	2049.7	1128.0	0.0	74.87	362.250	372.870	365.750	349.500	334.250	1	44.25	2					
23	2049.8	1134.1	0.0	73.75	373.870	371.870	366.370	350.870	318.500	1	42.12	2					
24	2049.9	1140.2	0.0	75.12	378.500	378.120	367.000	351.500	3	0.000	0	36.87	2				

INPUT DATA FILE for LINEG14.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG14.SIP

Logan Canyon - UDOT, Dames & Moore Line G14, Shot June 10, 1999

PROGRAM CONTROL DATA

Sprds	Exit	Layrs	VOver	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	OfSP	LDip
1	6	3	0	0.0	0.0	0.0	0.0 0.0	0.0 0.0	0	0	0.5	10.0	0	0	0

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1974.7	969.5	0.0	0.0	0.0	0.0	0
B	1976.0	1000.0	0.0	0.0	0.0	0.0	1
C	1979.5	1030.5	0.0	0.0	0.0	0.0	0
D	1985.3	1067.1	0.0	0.0	0.0	0.0	0
E	1986.3	1103.7	0.0	0.0	0.0	0.0	0
F	1984.3	1140.2	0.0	0.0	0.0	0.0	2
G	1979.7	1170.7	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	SP B	SP C	SP D	SP E	SP F	SP G
1	1976.0	1000.0	0.0	39.37 3	0.000	044.870	374.500	394.750	3103.70	3115.00 3
2	1976.6	1006.1	0.0	44.00	317.500	143.870	372.500	393.750	399.620	3112.70 3
3	1977.1	1012.2	0.0	46.25	323.000	236.000	268.120	390.000	3102.70	3111.70 3
4	1978.0	1018.3	0.0	50.87	332.370	331.000	267.120	389.250	3104.80	3109.50 3
5	1978.7	1024.4	0.0	56.50	338.000	317.250	163.750	390.000	3100.00	3106.60 3
6	1979.5	1030.5	0.0	60.25	342.120	3 0.000	062.120	385.620	399.000	3104.10 3
7	1980.4	1036.6	0.0	63.50	345.750	318.120	160.750	382.750	396.370	3102.20 3
8	1981.3	1042.7	0.0	71.50	353.620	336.120	259.120	382.750	397.870	3100.10 3
9	1982.5	1048.8	0.0	75.00	358.370	346.250	251.620	281.000	394.500	3100.20 3
10	1983.5	1054.9	0.0	81.00	361.620	352.250	236.750	275.370	393.870	3 94.25 3
11	1984.6	1061.0	0.0	86.37	369.500	359.000	317.870	173.620	393.870	3 92.50 3
12	1985.3	1067.1	0.0	85.25	367.500	360.370	3 0.000	068.500	292.250	3 92.50 3
13	1986.0	1073.2	0.0	86.12	371.000	356.620	316.500	158.250	282.000	3 88.75 3
14	1987.3	1079.3	0.0	93.12	373.500	363.870	327.620	250.870	275.120	3 80.75 3
15	1987.1	1085.4	0.0	94.00	378.250	369.120	334.870	243.250	273.500	3 77.25 3
16	1986.6	1091.5	0.0	104.10	383.750	378.120	348.120	243.370	272.870	3 75.37 3
17	1986.1	1097.6	0.0	105.30	387.500	383.250	361.120	216.750	170.250	3 71.25 3
18	1986.3	1103.7	0.0	106.10	390.120	379.750	368.120	3 0.000	066.000	2 64.75 3
19	1986.3	1109.8	0.0	112.80	391.750	386.750	371.500	318.500	158.250	2 63.00 3
20	1986.3	1115.9	0.0	115.20	397.750	391.000	377.750	331.000	250.870	2 59.87 3
21	1986.2	1122.0	0.0	123.10	3100.70	391.250	386.250	340.750	246.620	2 58.37 3
22	1986.2	1128.0	0.0	126.00	3103.00	394.870	386.120	351.500	236.750	2 52.25 3
23	1985.2	1134.1	0.0	129.80	3104.00	098.250	386.620	364.120	318.370	1 49.12 3
24	1984.3	1140.2	0.0	131.30	3103.60	0103.10	390.250	365.120	3 0.000	0 44.12 2

INPUT DATA FILE for LINEG15.SIP

TITLE FOR SIPT2/SIPLUS INPUT DATA SET for LINEG15.SIP

Logan Canyon - UDOT, Dames & Moore Line G15, Shot June 10, 1999

PROGRAM CONTROL DATA

Spreds	Exit	Layers	Over	PRINTER PLOT SCALES Elev m/col	Horiz m/row	Time ms/col	DATUM CONTROL Pt 1 Elev/X	Pt 2 Elev/X	PLOT CONTROL Elevations Top	Bottom	BLim	TLim	Trace	Of SP	LDip
1	6	3	0	0.0	0.0	0.0	0.0	0.0	0	0	0.5	10.0	0	0	0
							0.0	0.0							

SHOTPOINT AND GEOPHONE DATA

Spread 1, 7 SP's, 24 Geo's, X-Shift = 0.0, X-True = 0, Units: Meters.

SP	Elev	X-Loc	Y-Loc	Depth	Uphole T	Fudge T	End SP
A	1966.7	969.5	0.0	0.0	0.0	0.0	0
B	1967.9	1000.0	0.0	0.0	0.0	0.0	1
C	1970.8	1030.5	0.0	0.0	0.0	0.0	0
D	1973.7	1067.1	0.0	0.0	0.0	0.0	0
E	1973.1	1103.7	0.0	0.0	0.0	0.0	0
F	1969.4	1140.2	0.0	0.0	0.0	0.0	2
G	1967.0	1158.5	0.0	0.0	0.0	0.0	0

ARRIVAL TIMES AND LAYERS REPRESENTED

Geo	Elev	X-Loc	Y	SP A	SP B	SP C	SP D	SP E	SP F	SP G
1	1967.9	1000.0	0.0	37.37 2	0.000	039.500	366.370	390.120	3108.60	3111.80 3
2	1968.5	1006.1	0.0	41.50	216.250	134.120	361.750	386.500	3103.00	3109.10 3
3	1968.9	1012.2	0.0	41.87	224.750	228.750	357.500	383.250	3101.80	3106.20 3
4	1969.5	1018.3	0.0	45.50	230.250	224.000	251.250	377.870	399.000	3107.60 3
5	1970.0	1024.4	0.0	51.50	234.620	217.000	147.000	376.750	399.370 3	97.12 3
6	1970.8	1030.5	0.0	57.00	240.370	2 0.000	046.370	370.750	396.750 3	96.37 3
7	1971.2	1036.6	0.0	58.25	240.750	218.370	139.250	366.870	392.250 3	97.00 3
8	1971.9	1042.7	0.0	61.00	246.500	228.000	241.750	367.000	392.870	3103.30 3
9	1972.4	1048.8	0.0	64.37	249.750	230.000	235.870	264.000	388.000 3	97.25 3
10	1972.8	1054.9	0.0	70.75	255.370	236.370	231.370	261.500	383.370 3	92.62 3
11	1973.5	1061.0	0.0	75.75	261.500	239.750	217.120	158.120	387.620 3	90.62 3
12	1973.7	1067.1	0.0	82.50	266.370	243.870	2 0.000	060.620	388.750 3	95.37 3
13	1973.7	1073.2	0.0	82.50	269.620	250.750	217.370	153.120	277.750 2	89.12 2
14	1973.8	1079.3	0.0	90.62	276.620	261.620	234.620	249.370	274.500 2	85.50 2
15	1973.9	1085.4	0.0	93.87	379.250	263.120	240.120	239.870	267.000 2	78.37 2
16	1973.8	1091.5	0.0	95.75	384.250	369.370	348.620	238.250	262.750 2	73.62 2
17	1973.6	1097.6	0.0	93.62	383.620	370.750	354.000	217.500	153.870 2	72.12 2
18	1973.1	1103.7	0.0	94.87	385.620	370.370	355.620	2 0.000	050.750 2	66.50 2
19	1972.8	1109.8	0.0	101.20	389.870	373.750	362.120	316.870	148.870 2	64.25 2
20	1972.1	1115.9	0.0	104.30	386.120	372.250	359.370	332.750	240.000 2	56.00 2
21	1971.2	1122.0	0.0	104.30	396.250	377.500	363.250	335.870	237.870 2	52.75 2
22	1970.8	1128.0	0.0	105.30	396.250	376.370	371.000	344.120	232.000 2	49.62 2
23	1970.1	1134.1	0.0	109.60	3101.00	379.000	072.000	351.250	217.000 1	37.00 2
24	1969.4	1140.2	0.0	111.80	3103.80	379.870	077.370	055.370	2 0.000 0	29.87 2

VELOCITY ANALYSIS TABLES for LINEG1.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	3.1	256	
					256
	C	5	3.3	568	
	C	7	2.8	412	
					490
	D	11	3.6	331	
	D	13	2.5	318	
					325
	E	17	3.9	509	
	E	19	2.2	384	
					447
	F	23	3.1	394	
					394

Wtd Avg Velocity computed for Layer 1 = 397

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 8	5.7	1818	1818	5.7	8
			B	3 11	7.8	1369	1369	7.8	9
1343	4.5	1 4	C	8 10	2.7	669	938	3.6	7
440	5.6	9 10	D	14 15	5.7	528	480	5.7	4
1076	7.8	13 16	E	20 22	10.9	1847	1311	9.3	7
3117	15.3	20 22	F				3117	15.3	3
366	-16.9	23 24	G				366	-16.9	2
						Avg =	1038	for	40 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 4	1248	-1.0	2.510	4.124	2	-2.607	1	-1.112	4	-0.406	3
B C	3 4	1547	4.4	0.000	0.000	3	-0.000	4				
B D	9 10	545	-28.7	0.000	-0.000	9	0.000	10				
C D	9 10	457	-11.3	0.000	-0.000	9	0.000	10				
D E	14 15	688	5.1	0.000	-0.000	15	0.000	14				
E F	20 22	2319	-0.9	0.397	-0.561	21	0.285	20	0.276	22		
		Avg = 1228	for 15 Pts									

Wtd Avg Velocity computed for Layer 2 = 1120

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	9 24	22.0	7866	7866	22.0	16
			B	12 24	24.5	7560	7560	24.5	13
			C	11 24	20.0	8176	8176	20.0	14
9687	19.2	1 8	D	16 24	22.1	13276	11305	20.6	17
327662	27.6	1 12	E	23 24	13.8	2006	13542	20.7	14
4651	19.8	1 19	F				4651	19.8	19
7342	24.2	7 22	G				7342	24.2	16
						Avg =	7640	for	109 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A F	9 19	3999	-3.0	2.431	-4.935	11	3.457	9	3.121	14	2.880	15
A G	9 22	7693	-3.6	4.400	-9.629	13	7.640	9	6.102	10	-6.047	11
B F	12 19	6198	3.7	1.291	-2.284	12	1.879	13	1.640	14	-1.149	17
B G	12 22	4845	-2.1	2.418	4.340	12	-4.136	13	2.970	14	-2.134	18
C F	11 19	5009	-3.2	1.220	-2.510	17	1.718	14	1.026	18	0.936	16
C G	11 22	4547	-7.3	3.347	-7.901	13	4.656	12	3.530	11	-3.474	17
D F	16 19	4686	1.4	0.672	0.868	17	-0.725	16	-0.581	19	0.438	18
D G	16 22	4645	-3.8	1.590	3.415	20	-1.242	18	-1.209	22	1.198	17
	Avg =	5335	for	76 Pts								

Wtd Avg Velocity computed for Layer 3 = 6298

VELOCITY ANALYSIS TABLES for LINEG2.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	1.5	444	
	B	3	3.1	376	
					410
	C	4	3.0	370	
	C	5	1.5	403	
	C	7	1.6	335	
	C	8	3.1	433	
	C	9	4.6	432	
					395
	D	9	4.7	358	
	D	10	3.2	379	
	D	11	1.6	406	
	D	13	1.4	272	
	D	14	2.9	293	
	D	15	4.5	327	
					339
	E	15	4.6	358	
	E	16	3.1	437	
	E	17	1.6	420	
	E	19	1.5	310	
	E	20	3.0	317	
	E	21	4.5	325	
	E	22	6.0	334	
					357
	F	19	7.6	346	
	F	20	6.1	335	
	F	21	4.6	340	
	F	22	3.1	344	
	F	23	1.5	375	
					348

Wtd Avg Velocity computed for Layer 1 = 363

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 24	8.8	2723	2723	8.8	24
			B	4 24	11.2	2463	2463	11.2	21
1724	9.7	1 3	C	10 24	8.8	1759	1753	9.3	18
3462	12.8	1 8	D	16 24	11.4	1700	2235	12.1	17
5906	14.1	1 14	E	23 24	6.7	428	2271	10.4	16
5379	20.4	1 18	F				5379	20.4	18
7681	18.6	1 24	G				7681	18.6	24
						Avg =	2832	for	138 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 3	2076	-0.8	0.376	0.532	2	-0.274	1	-0.257	3		
A D	1 8	4375	-3.5	0.816	1.425	2	-1.240	4	-1.045	5	0.540	7
A E	1 14	4810	-3.1	0.849	1.396	13	1.229	2	1.192	4	-1.138	1
A F	1 18	4285	-5.6	0.641	-1.756	10	1.403	17	-0.985	5	0.566	6
A G	1 24	4018	-4.3	1.880	-5.277	20	3.722	24	-2.772	21	2.746	17
B D	4 8	1974	-1.7	0.688	-0.923	4	-0.720	8	0.677	5	0.668	6
B E	4 14	4141	-1.2	0.677	1.194	13	-0.966	12	0.909	10	-0.901	8
B F	4 18	3654	-3.4	0.720	-1.453	10	1.122	6	-1.117	4	-0.901	14
B G	4 24	3832	-2.2	1.586	-4.898	20	2.364	17	2.209	24	-2.049	21
C E	10 14	2668	-2.4	0.626	1.040	13	-0.725	12	0.354	10	-0.344	11
C F	10 18	3457	-4.9	0.984	-1.987	10	-1.247	18	0.992	13	0.879	14
C G	10 24	3347	-2.8	1.884	-4.790	20	-3.324	18	2.612	23	1.663	22
D F	16 18	22772	-2.2	0.179	-0.253	17	0.127	16	0.126	18		
D G	16 24	3446	-0.9	3.097	-5.623	20	-4.111	21	3.872	24	3.401	16
E G	23 24	916	6.2	0.000	0.000	23	-0.000	24				
		Avg = 4128 for 162 Pts										

Wtd Avg Velocity computed for Layer 2 = 3741

VELOCITY ANALYSIS TABLES for LINEG3.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	542	
					542
	C	5	7.2	466	
	C	7	5.0	343	
					405
	D	11	7.4	451	
	D	13	4.8	270	
					360
	E	17	7.6	533	
	E	19	4.6	295	
					414
	F	23	6.1	456	
					456

Wtd Avg Velocity computed for Layer 1 = 419

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 6	37.7	14656	14656	37.7	6
			B	3 6	38.0	744335	744335	38.0	4
1503	1.6	8 10	D	14 15	9.9	4907	2080	5.7	5
2107	3.6	14 16	E	20 21	12.3	1345	1718	7.9	5
14477	37.7	21 22	F				14477	37.7	2
						Avg =	3749	for	22 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
D E	14 15	2196	6.5	0.000	-0.000	14	0.000	15				
Avg =		2196	for	2 Pts								

Wtd Avg Velocity computed for Layer 2 = 3510

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	7 24	14.3	4100	4100	14.3	16
4601	19.2	1 24	G				4601	19.2	24
						Avg =	4387	for	40 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A G	7 24	5539	0.2	1.316	-3.041	10	2.679	13	-1.924	23	1.368	14

Avg = 5539 for 16 Pts

Wtd Avg Velocity computed for Layer 3 = 4899

VELOCITY ANALYSIS TABLES for LINEG4.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	3.1	295	
					295
	C	5	3.0	462	
					462
	D	11	3.0	706	
	D	13	3.1	605	
					655
	E	17	3.1	542	
	E	19	3.0	555	
					549
	F	23	3.1	491	
					491

Spread 2	SP	Geo	DD	V	Avg V
	B	2	3.1	343	
					343
	C	5	3.1	455	
	C	7	3.0	424	
					440
	D	11	3.0	364	
	D	13	3.1	400	
					382
	E	17	3.1	365	
	E	19	3.0	387	
					376
	F	23	3.0	353	
					353

Wtd Avg Velocity computed for Layer 1 = 450

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			B	3 10	12.0	1391	1391	12.0	8
1056	6.6	1 4	C	7 13	3.8	1154	1116	5.2	11
877	-0.7	5 10	D	14 21	-1.6	911	896	-1.2	14
1062	1.6	8 16	E	20 24	4.4	1345	1148	3.0	14
912	-0.2	15 22	F				912	-0.2	8
						Avg =	1054	for	55 Pts

Spread 2

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 4	-18.3	660	660	-18.3	4
			B	3 11	0.1	822	822	0.1	9
995	2.0	1 4	C	8 14	-1.0	806	866	0.5	11
901	1.9	5 10	D	14 18	0.7	817	861	1.3	11
860	3.4	11 16	E	20 23	5.2	666	770	4.3	10
900	13.7	19 22	F				900	13.7	4
						Avg =	818	for	49 Pts

Avg of all regression velocities: 928 for 104 points in Layer 2.

Layer 2 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
B C	3 4	1459	3.3	0.000	-0.000	3	0.000	4				
B D	5 10	1085	4.9	1.840	-3.105	5	2.552	6	1.524	7	-1.185	10
B E	8 10	688	4.4	1.131	1.600	9	-0.813	8	-0.787	10		
C D	7 10	1296	0.8	0.294	0.492	9	-0.286	10	-0.119	8	-0.087	7
C E	8 13	947	1.2	1.813	-3.058	8	2.358	9	1.564	10	-1.148	13
D E	14 16	1337	-2.0	0.172	-0.243	15	0.124	14	0.120	16		
D F	15 21	855	-2.8	2.977	5.629	21	-3.483	20	-2.986	19	2.318	15
E F	20 22	1375	0.4	0.299	0.423	21	-0.215	20	-0.208	22		
		Avg = 1073	for 34 Pts									

Spread 2

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 4	794	-9.7	1.522	2.442	3	-1.619	4	-0.823	1	0.001	2
B C	3 4	1904	-0.2	0.000	-0.000	3	0.000	4				
B D	5 10	831	-0.6	1.442	2.389	9	-2.203	10	0.981	8	-0.812	7
C D	8 10	864	-1.5	0.555	0.785	9	-0.399	8	-0.386	10		
C E	11 14	900	-1.0	0.485	-0.713	13	0.529	14	0.351	11	-0.167	12
D E	14 16	886	-0.7	0.535	-0.757	15	0.385	14	0.372	16		
E F	20 22	806	-3.5	0.149	-0.211	21	0.107	20	0.104	22		
		Avg = 929	for 25 Pts									

Avg of all Hobson-Overton velocities: 1012 for 59 points in Layer 2.

Wtd Avg Velocity computed for Layer 2 = 973

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	2 24	15.5	2275	2275	15.5	23
			B	11 24	18.5	1917	1917	18.5	14
			C	14 24	16.5	1800	1800	16.5	11
1883	16.5	1 4	D	22 24	26.0	2550	2121	21.2	7
2796	27.1	1 7	E				2796	27.1	7
2511	25.0	1 14	F				2511	25.0	14
2484	23.0	1 24	G				2484	23.0	24
						Avg =	2244	for	100 Pts

Spread 2

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	5 24	23.4	2416	2416	23.4	20
			B	12 24	20.1	1781	1781	20.1	13
			C	15 24	14.5	1641	1641	14.5	10
1477	16.2	1 4	D	19 24	14.8	1587	1541	15.5	10
1579	15.3	1 10	E				1579	15.3	10
1799	19.4	1 18	F				1799	19.4	18
2181	22.2	1 24	G				2181	22.2	24
						Avg =	1892	for	105 Pts

Avg of all regression velocities: 2049 for 205 points in Layer 3.

Layer 3 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
A D	2 4	3459	-0.6	1.160	-1.641	3	0.834	2	0.807	4		
A E	2 7	2686	-8.2	1.273	1.825	2	1.492	6	-1.409	3	-1.200	5
A F	2 14	2594	-8.9	1.604	3.057	2	2.420	12	-2.311	11	1.868	13
A G	2 24	2355	-5.1	2.301	4.929	2	4.204	20	-3.573	11	3.535	7
B F	11 14	2206	-4.1	1.710	2.333	13	-1.857	14	-1.397	11	0.922	12
B G	11 24	1982	0.2	1.305	3.261	20	-2.434	16	-1.176	15	-1.116	19
C G	14 24	1817	-0.5	1.716	4.083	20	-2.744	16	1.849	14	-1.553	23
D G	22 24	1837	4.4	0.186	-0.262	23	0.133	22	0.129	24		

Avg = 2292 for 77 Pts

Spread 2 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A E	5 10	1817	-0.4	0.919	1.858	8	-0.855	10	-0.732	7	-0.552	6
A F	5 18	2266	-0.2	1.669	3.018	8	2.990	11	-2.372	5	-2.011	13
A G	5 24	2379	3.5	1.822	3.587	21	3.333	11	-3.164	5	2.458	17
B F	12 18	2117	4.5	1.019	2.045	15	-1.124	14	-0.947	13	-0.712	17
B G	12 24	2217	8.7	1.227	2.245	15	1.748	21	-1.676	24	-1.503	19
C F	15 18	2324	0.6	0.559	-0.931	16	0.494	15	0.368	17	0.070	18
C G	15 24	2322	4.3	0.644	1.004	17	-0.926	18	-0.918	20	0.748	21
D G	19 24	2233	1.6	1.189	2.136	21	-1.351	24	-1.153	19	0.611	22
		Avg = 2247 for 80 Pts										

Avg of all Hobson-Overton velocities: 2269 for 157 points in Layer 3.

Wtd Avg Velocity computed for Layer 3 = 2182

VELOCITY ANALYSIS TABLES for LINEG5.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	349	
					349
	C	5	6.6	392	
	C	7	5.6	309	
					350
	D	11	6.8	408	
	D	13	5.4	294	
					351
	E	17	6.9	400	
	E	19	5.3	295	
					347
	F	23	6.1	503	
					503

Wtd Avg Velocity computed for Layer 1 = 369

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			C	8 9	16.0	1030	1030	16.0	2
934	3.8	9 10	D				934	3.8	2
						Avg =	979	for	4 Pts

Layer 2 Velocity computed by Hobson-Overton method

Not enough points.

Wtd Avg Velocity computed for Layer 2 = 979

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	2 24	28.4	3177	3177	28.4	23
			B	4 24	33.1	2711	2711	33.1	21
1385	24.5	1 3	C	10 24	22.8	2343	2088	23.7	17
1632	12.8	1 8	D	15 24	13.0	1867	1755	12.9	18
1681	12.4	1 15	E	21 24	16.0	1409	1615	14.2	19
2202	20.5	1 21	F				2202	20.5	21
2546	19.4	1 24	G				2546	19.4	24
						Avg =	2231	for	143 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	2 3	2564	-4.9	0.000	0.000	3	0.000	2				
A D	2 8	2233	-0.1	1.191	-1.933	3	1.729	4	1.147	5	-0.896	7
A E	2 15	2392	-2.1	1.477	2.712	5	2.694	13	-2.100	7	1.808	4
A F	2 21	2666	4.3	2.030	-3.975	19	3.922	13	3.092	16	-2.452	11
A G	2 24	2873	2.4	2.145	-4.862	7	-3.949	19	3.848	13	2.995	15
B D	4 8	2182	1.7	0.457	-0.806	7	0.596	8	0.198	4	0.022	6
B E	4 15	2268	-0.5	1.380	2.251	5	1.903	15	-1.871	6	-1.616	11
B F	4 21	2476	6.7	1.828	-3.697	11	-2.986	12	2.806	8	2.509	15
B G	4 24	2691	4.3	1.936	-4.659	7	4.048	15	-3.541	24	3.506	17
C E	10 15	1931	4.0	1.228	-2.211	12	1.410	10	1.214	13	-0.656	11
C F	10 21	2364	10.1	2.538	4.055	16	3.700	15	-3.076	12	-3.016	18
C G	10 24	2767	7.4	2.154	4.350	15	-3.357	18	2.948	16	-2.946	12
D F	15 21	2436	6.4	0.684	-1.191	17	1.053	18	-0.574	19	0.440	15
D G	15 24	2485	3.4	0.831	1.933	15	-0.941	19	-0.853	16	-0.749	17
E G	21 24	1987	3.7	0.336	0.524	23	-0.347	22	-0.234	24	0.057	21
	Avg =	2523	for 174 Pts									

Wtd Avg Velocity computed for Layer 3 = 2438

VELOCITY ANALYSIS TABLES for LINEG6.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	530	
					530
	C	5	6.2	416	
	C	7	6.0	359	
					388
	D	11	6.4	403	
	D	13	5.8	296	
					349
	E	17	6.4	330	
	E	19	5.8	358	
					344
	F	23	6.1	595	
					595

Wtd Avg Velocity computed for Layer 1 = 411

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 7	11.7	2261	2261	11.7	7
			B	3 7	15.0	1380	1380	15.0	5
1627	15.9	1 4	C	8 9	6.9	1002	1347	11.4	6
837	-3.8	7 10	D	14 18	5.2	1304	1045	0.7	9
1570	9.5	7 16	E	20 24	15.3	1761	1629	12.4	15
2285	20.3	8 22	F				2285	20.3	15
2230	13.4	11 24	G				2230	13.4	14
						Avg =	1697	for	71 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 4	1975	-7.4	0.131	0.217	2	-0.115	1	-0.088	3	-0.014	4
B C	3 4	1876	-2.7	0.000	-0.000	4	0.000	3				
C D	8 9	841	-0.2	0.000	0.000	8	-0.000	9				
C E	8 9	733	30.4	0.000	0.000	8	-0.000	9				
C F	8 9	1026	37.5	0.000	-0.000	8	0.000	9				
D E	14 16	1478	0.6	1.122	-1.586	15	0.793	14	0.793	16		
D F	14 18	1717	7.3	1.043	1.949	16	-1.148	17	-0.450	15	-0.350	14
D G	14 18	1713	14.1	1.476	2.488	17	-2.001	18	-0.800	14	0.228	16
E F	20 22	2246	4.1	0.451	0.638	21	-0.322	22	-0.316	20		
E G	20 24	1889	7.4	0.897	-1.688	22	0.801	24	0.532	21	0.480	20
		Avg = 1655 for 33 Pts										

Wtd Avg Velocity computed for Layer 2 = 1677

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	8 24	2.8	1848	1848	2.8	17
			B	8 24	11.1	1706	1706	11.1	17
			C	10 24	8.4	1524	1524	8.4	15
1971	14.4	1 6	D	19 24	17.6	2048	2008	16.0	12
2225	27.1	1 6	E				2225	27.1	6
2821	40.2	1 7	F				2821	40.2	7
2119	13.5	7 10	G				2119	13.5	4
						Avg =	1855	for	78 Pts

Layer 3 Velocity computed by Hobson-Overton method

Not enough points.

Wtd Avg Velocity computed for Layer 3 = 1855

VELOCITY ANALYSIS TABLES for LINEG7.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	373	
					373
	C	5	6.1	319	
	C	7	6.1	373	
					346
	D	13	6.0	340	
					340
	E	17	6.2	381	
	E	19	6.0	321	
					351
	F	23	6.1	367	
					367

Wtd Avg Velocity computed for Layer 1 = 353

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			B	3 4	16.4	873	873	16.4	2
			C	8 9	25.6	1160	1160	25.6	2
370	-5.1	10 11	D	14 15	14.4	982	537	4.6	4
874	11.3	14 16	E	20 21	13.9	671	780	12.6	5
						Avg =	727	for	13 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
D E	14 15	1355	1.7	0.000	0.000	14	0.000	15				
	Avg =	1355	for	2 Pts								

Wtd Avg Velocity computed for Layer 2 = 875

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	2 20	24.3	1772	1772	24.3	19
			B	5 24	21.5	1614	1614	21.5	20
1646	28.3	1 3	C	10 24	25.8	1486	1510	27.1	18
1824	25.1	1 9	D	16 24	17.4	1481	1635	21.2	18
1618	23.6	1 13	E	22 24	29.5	1756	1642	26.6	16
1694	28.3	1 21	F				1694	28.3	21
1648	23.5	1 24	G				1648	23.5	24
						Avg =	1644	for	136 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	2 3	2311	-3.1	0.000	0.000	2	-0.000	3				
A D	2 9	1841	-4.4	1.844	-2.660	6	-2.534	7	2.220	9	2.064	4
A E	2 13	1644	-2.9	3.935	-6.800	6	-6.471	7	6.160	10	5.961	2
A F	2 20	1725	-3.0	3.435	7.845	4	-6.470	7	5.412	3	-5.374	2
A G	2 20	1661	-2.6	3.003	-6.137	7	4.130	14	3.943	12	3.722	13
B D	5 9	1774	-6.3	0.544	-0.922	8	0.701	7	0.322	9	-0.177	5
B E	5 13	1649	-6.2	1.994	3.104	10	-2.806	12	2.771	8	1.999	9
B F	5 21	1665	-5.4	1.906	3.751	5	-3.685	13	-2.999	14	2.914	17
B G	5 24	1623	-4.2	1.778	5.444	15	-2.627	8	-2.577	18	2.451	14
C E	10 13	1950	2.7	1.645	-1.992	11	1.745	10	1.498	13	-1.251	12
C F	10 21	1589	3.8	1.942	3.059	10	2.991	17	-2.842	21	-2.378	14
C G	10 24	1647	6.0	1.524	3.575	15	-2.073	11	1.844	14	1.814	20
D F	16 21	1616	-0.1	1.003	-1.380	16	1.331	17	1.153	18	-0.828	20
D G	16 24	1654	0.3	1.033	2.430	21	-1.066	16	-0.959	24	-0.702	23
E G	22 24	1682	3.3	0.297	-0.419	23	0.210	22	0.210	24		
		Avg = 1682	for 160 Pts									

Wtd Avg Velocity computed for Layer 3 = 1670

VELOCITY ANALYSIS TABLES for LINEG8.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	474	
					474
	C	5	6.6	587	
	C	7	5.6	540	
					563
	D	11	7.0	583	
	D	13	5.2	434	
					508
	E	17	7.1	636	
	E	19	5.1	488	
					562
	F	23	6.1	603	
					603

Wtd Avg Velocity computed for Layer 1 = 543

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 3	28.5	2469	2469	28.5	3
			B	3 7	22.0	1892	1892	22.0	5
1099	6.2	1 4	C	8 11	3.3	988	1041	4.8	8
930	-0.0	7 10	D	14 17	-6.6	744	826	-3.3	8
783	-4.5	13 16	E	20 24	8.8	814	800	2.1	9
736	14.7	20 22	F				736	14.7	3
						Avg =	985	for	36 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 3	1423	6.7	0.621	0.878	2	-0.439	1	-0.439	3		
B C	3 4	1373	4.4	0.000	-0.000	3	0.000	4				
C D	8 10	1251	-1.8	1.823	2.578	9	-1.289	10	-1.288	8		
D E	14 16	952	1.6	0.500	-0.707	15	0.354	16	0.354	14		
E F	20 22	686	-0.3	0.017	-0.025	21	0.012	22	0.012	20		
Avg =		1120	for 14 Pts									

Wtd Avg Velocity computed for Layer 2 = 1044

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	4 24	26.1	2850	2850	26.1	21
			B	8 19	27.8	3160	3160	27.8	12
			C	12 24	23.2	2876	2876	23.2	13
2641	25.0	1 6	D	18 24	24.1	2001	2253	24.6	13
3730	30.5	2 12	E				3730	30.5	11
3603	36.8	2 19	F				3603	36.8	18
3990	37.8	1 23	G				3990	37.8	23
						Avg =	3157	for	111 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A D	4 6	3365	0.0	0.351	-0.497	5	0.248	6	0.248	4		
A E	4 12	3644	2.2	1.238	1.978	4	1.694	11	-1.685	7	-1.660	8
A F	4 19	3990	2.9	2.122	5.587	11	-4.106	18	2.505	10	-2.079	4
A G	4 23	3553	-1.5	2.480	-6.818	18	3.691	12	3.560	22	3.393	23
B E	8 12	3911	-5.5	0.803	1.263	9	-1.097	10	-0.501	8	0.409	11
B F	8 19	4031	-4.1	1.767	2.506	11	2.446	15	-2.393	13	-2.346	18
B G	8 19	3864	-8.5	1.802	3.370	15	-3.313	18	-2.291	10	2.051	12
C F	12 19	4609	-3.3	1.537	2.613	16	-2.202	12	-1.666	18	1.653	14
C G	12 23	4405	-7.5	1.768	-3.266	18	3.136	16	2.237	22	-2.091	14
D F	18 19	4635	0.6	0.000	-0.000	19	0.000	18				
D G	18 23	2699	-1.1	0.651	-1.001	23	0.757	22	-0.648	19	0.568	21
	Avg =	3879	for 105 Pts									

Wtd Avg Velocity computed for Layer 3 = 3629

VELOCITY ANALYSIS TABLES for LINEG9.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	618	
					618
	C	5	6.2	618	
	C	7	6.0	542	
					580
	D	11	6.2	555	
	D	13	6.0	496	
					526
	E	16	12.4	580	
	E	17	6.3	541	
	E	19	5.9	442	
					521
	F	23	6.2	506	
					506

Wtd Avg Velocity computed for Layer 1 = 544

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			B	3 8	9.9	1989	1989	9.9	6
1418	7.8	2 4	C	8 10	4.9	1088	1231	6.3	6
934	3.7	9 10	D	14 15	5.4	922	928	4.5	4
2111	19.5	14 15	E	20 22	11.8	1399	1617	15.6	5
1426	11.6	20 22	F				1426	11.6	3
						Avg =	1380	for	24 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1		Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
B C	3 4	1478	-1.1	0.000	-0.000	3	0.000	4				
C D	9 10	1121	-0.3	0.000	-0.000	9	0.000	10				
D E	14 15	1283	-2.6	0.000	-0.000	14	0.000	15				
E F	20 22	1413	0.1	0.120	-0.170	21	0.086	22	0.084	20		
	Avg =	1333	for	9 Pts								

Wtd Avg Velocity computed for Layer 2 = 1360

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	2 24	25.8	3852	3852	25.8	23
			B	9 24	21.0	3921	3921	21.0	16
			C	11 24	25.2	4922	4922	25.2	14
3814	20.8	1 8	D	16 24	24.3	4522	4158	22.5	17
4483	24.3	1 13	E	23 24	26.2	6224	4657	25.3	15
4417	24.1	1 19	F				4417	24.1	19
4832	26.7	1 24	G				4832	26.7	24
						Avg =	4343	for	128 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A D	2 8	3641	4.0	1.078	-2.081	6	1.721	8	0.687	2	-0.551	7
A E	2 13	3819	4.3	1.646	-2.814	6	2.567	2	2.215	13	-1.949	8
A F	2 19	4001	4.8	1.473	4.485	13	-1.624	2	-1.605	7	1.551	9
A G	2 24	4235	4.3	1.903	3.976	10	3.715	13	3.219	11	-3.141	22
B E	9 13	3915	-1.3	0.586	1.020	11	-0.622	9	-0.337	12	-0.323	13
B F	9 19	4092	-0.7	0.965	1.614	14	-1.464	10	1.223	13	-0.954	11
B G	9 24	4588	-0.9	1.203	2.459	19	-1.845	17	-1.836	9	1.560	20
C E	11 13	3674	0.8	0.674	-0.953	12	0.477	11	0.476	13		
C F	11 19	4526	0.7	1.471	-2.497	11	2.000	13	1.807	14	1.613	15
C G	11 24	5238	-1.4	1.260	2.428	19	-2.287	17	-2.139	22	1.491	15
D F	16 19	3630	-0.3	0.418	-0.540	17	0.450	16	0.361	19	-0.271	18
D G	16 24	4717	-2.2	1.225	-2.561	17	2.259	19	-0.946	22	0.775	16
E G	23 24	4435	-3.5	0.000	-0.000	23	0.000	24				
	Avg =	4283 for 133 Pts										

Wtd Avg Velocity computed for Layer 3 = 4303

VELOCITY ANALYSIS TABLES for LINEG10.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	561	
					561
	C	5	6.1	439	
	C	7	6.1	457	
					448
	D	11	6.3	550	
	D	13	5.9	387	
					468
	E	17	6.3	345	
	E	19	5.9	355	
					350
	F	23	6.1	400	
					400

Wtd Avg Velocity computed for Layer 1 = 437

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			B	3 5	6.8	909	909	6.8	3
972	11.6	3 4	C	8 10	7.0	1076	1032	9.3	5
900	0.9	8 10	D	14 15	9.6	881	892	5.3	5
1563	21.5	14 16	E	20 22	19.8	1730	1642	20.7	6
1382	19.0	20 22	F				1382	19.0	3
						Avg =	1124	for	22 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
B C	3 4	938	-2.7	0.000	0.000	3	-0.000	4				
C D	8 10	980	1.4	0.204	0.289	9	-0.144	10	-0.144	8		
D E	14 15	1025	-1.1	0.000	-0.000	14	0.000	15				
E F	20 22	1536	-1.1	0.207	-0.293	21	0.148	22	0.145	20		
Avg =		1147 for 10 Pts										

Wtd Avg Velocity computed for Layer 2 = 1135

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	2 24	30.3	4680	4680	30.3	23
			B	6 24	32.7	5537	5537	32.7	19
2573	24.9	1 2	C				2573	24.9	2
3130	24.4	1 7	D	16 24	29.8	4055	3591	27.1	16
3604	30.0	1 13	E	23 24	36.5	8440	3902	33.2	15
3623	34.1	1 19	F				3623	34.1	19
3587	38.0	1 23	G				3587	38.0	23
						Avg =	4023	for	117 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
A D	2 7	3924	-1.2	1.230	2.221	5	-1.736	7	0.741	6	-0.579	3
A E	2 13	3475	-4.7	2.255	5.627	12	-2.503	7	-2.360	9	-2.002	13
A F	2 19	3442	-7.1	1.523	2.869	12	-2.665	13	-2.266	9	-1.920	6
A G	2 23	4030	-14.3	3.787	-7.938	21	6.147	17	5.872	18	5.391	12
B E	6 13	3114	-2.7	1.388	2.225	12	-2.081	10	-1.427	13	-1.372	7
B F	6 19	3494	-5.4	0.966	-1.728	16	1.421	18	-1.358	15	1.053	9
B G	6 23	4273	-13.0	3.084	-6.932	23	4.785	18	4.508	17	-3.505	7
D F	16 19	2190	-2.2	0.947	1.492	18	-0.940	17	-0.682	19	0.130	16
D G	16 23	3542	-9.3	1.526	2.268	18	-1.845	16	-1.754	23	1.580	19
	Avg =	3670 for 110 Pts										

Wtd Avg Velocity computed for Layer 3 = 3793

VELOCITY ANALYSIS TABLES for LINEG11.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	356	
					356
	C	5	6.2	345	
	C	7	6.0	363	
					354
	D	11	6.4	356	
	D	13	5.8	349	
					352
	E	17	6.4	381	
	E	19	5.8	306	
					344
	F	23	6.1	344	
					344

Wtd Avg Velocity computed for Layer 1 = 350

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			B	3 5	20.3	1213	1213	20.3	3
			C	8 11	25.8	1869	1869	25.8	4
1030	9.4	7 10	D	14 16	6.9	968	1003	8.1	7
1344	24.7	18 22	F				1344	24.7	5
872	6.4	21 24	G				872	6.4	4
						Avg =	1156	for	23 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
C D	8 10	1403	1.3	0.146	0.207	9	-0.103	8	-0.103	10		
	Avg =	1403	for	3 Pts								

Wtd Avg Velocity computed for Layer 2 = 1207

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 24	30.1	2796	2796	30.1	24
			B	6 24	29.9	2374	2374	29.9	19
1396	24.5	1 3	C	12 24	27.6	1879	1764	26.0	16
3582	36.2	1 6	D	17 24	29.2	2310	2725	32.7	14
1848	27.2	1 15	E	21 24	33.8	2174	1909	30.5	19
2117	30.7	2 17	F				2117	30.7	16
4851	51.7	8 20	G				4851	51.7	13
						Avg =	2373	for	121 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 3	1725	-3.3	0.737	-1.043	2	0.522	1	0.521	3		
A D	1 6	2632	-5.0	1.082	1.451	3	-1.439	5	-1.414	2	0.815	4
A E	1 15	2325	-8.4	1.439	2.618	15	-2.116	5	-1.929	7	1.859	1
A F	2 17	2411	-10.9	3.360	7.581	8	-6.821	13	-4.141	3	-3.379	14
A G	8 20	3237	-6.5	1.931	4.447	17	-3.190	19	-2.303	18	1.961	16
B E	6 15	2105	-5.7	1.660	-2.865	13	2.812	15	1.924	6	-1.826	9
B F	6 17	2291	-6.7	3.498	-8.811	13	4.178	17	3.535	8	-3.514	14
B G	8 20	2682	-4.0	2.201	4.401	17	-3.565	13	2.815	16	2.153	11
C E	12 15	1543	-3.7	1.276	-2.090	13	1.055	12	1.016	14	0.019	15
C F	12 17	1908	-5.3	2.487	-4.436	13	2.194	15	-2.190	16	1.953	12
C G	12 20	2600	-3.6	2.207	-4.233	19	2.827	20	2.399	14	2.125	17
D G	17 20	2857	-7.8	0.978	-1.536	19	0.982	18	0.697	20	-0.143	17
		Avg = 2454	for 111 Pts									

Wtd Avg Velocity computed for Layer 3 = 2425

VELOCITY ANALYSIS TABLES for LINEG12.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	378	
					378
	C	5	6.6	363	
	C	7	5.6	310	
					337
	D	11	7.4	838	
	D	13	4.8	377	
					607
	E	17	7.7	404	
	E	19	4.5	278	
					341
	F	23	6.1	483	
					483

Wtd Avg Velocity computed for Layer 1 = 429

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 6	41.6	2725	2725	41.6	6
			B	3 9	38.1	2216	2216	38.1	7
1331	29.7	1 4	C	8 12	26.1	2154	1690	27.9	9
624	-19.7	7 10	D	14 16	-18.8	640	631	-19.3	7
			E	20 21	25.9	1628	1628	25.9	2
1095	14.9	18 22	F				1095	14.9	5
1782	16.6	20 24	G				1782	16.6	5
						Avg =	1349	for	41 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1			Avg	Std Err	4 Highest Std Err at geophones							
SPs	Geos	V	TdSP	Overall	Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 4	1862	0.4	0.235	-0.391	3	0.212	4	0.146	2	0.033	1
B C	3 4	1501	-1.7	0.000	-0.000	3	0.000	4				
B D	7 9	1082	5.1	1.945	2.750	8	-1.375	7	-1.375	9		
C D	8 10	946	15.6	1.943	-2.748	9	1.375	8	1.373	10		
E F	20 21	1202	6.6	0.000	0.000	20	-0.000	21				
E G	20 21	1545	9.8	0.000	-0.000	21	0.000	20				

Avg = 1377 for 16 Pts

Wtd Avg Velocity computed for Layer 2 = 1361

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	7 24	34.9	3059	3059	34.9	18
			B	10 24	30.7	2083	2083	30.7	15
			C	13 24	34.3	2135	2135	34.3	12
2621	29.5	1 6	D	17 24	27.6	3880	3218	28.6	14
1233	13.3	2 15	E	22 24	14.1	1049	1196	13.7	17
1458	6.7	6 17	F				1458	6.7	12
1787	14.7	1 19	G				1787	14.7	19
						Avg =	1906	for	107 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A E	7 15	2540	-1.4	1.655	-3.045	14	2.603	13	-2.058	9	1.332	11
A F	7 17	2458	3.3	3.096	-5.260	9	-4.278	10	3.755	14	3.449	13
A G	7 19	2661	-2.8	4.143	9.736	17	-5.836	14	-5.353	16	4.491	13
B E	10 15	2590	5.9	1.619	2.715	13	-2.064	10	-1.347	15	-0.955	14
B F	10 17	2502	11.0	3.621	-5.925	10	5.701	14	-4.099	16	3.421	13
B G	10 19	2295	4.6	5.217	-8.989	16	8.307	17	6.259	18	-5.570	15
C E	13 15	5080	15.3	0.948	-1.341	14	0.672	15	0.669	13		
C F	13 17	3817	17.9	1.255	2.284	14	-1.111	15	-1.038	13	-0.475	16
C G	13 19	2107	12.5	6.446	8.013	18	7.920	17	-6.277	19	6.200	13
D G	17 19	19474	-9.7	2.006	2.837	18	-1.419	19	-1.418	17		
	Avg =	3340	for	75 Pts								

Wtd Avg Velocity computed for Layer 3 = 2743

VELOCITY ANALYSIS TABLES for LINEG13.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	317	
					317
	C	4	12.3	334	
	C	5	6.2	331	
	C	7	6.0	355	
	C	8	12.1	356	
					344
	D	10	12.4	334	
	D	11	6.3	326	
	D	13	5.9	348	
	D	14	12.0	348	
					339
	E	16	12.4	339	
	E	17	6.3	334	
	E	19	5.9	360	
	E	20	12.0	349	
					345
	F	22	12.2	356	
	F	23	6.1	330	
					343

Wtd Avg Velocity computed for Layer 1 = 341

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 3	3.8	784	784	3.8	3
			B	3 5	30.5	1226	1226	30.5	3
			C	9 11	41.0	2049	2049	41.0	3
3200	44.6	6 9	D	15 17	42.4	2187	2670	43.5	7
2303	35.5	19 21	F				2303	35.5	3
1616	18.6	19 24	G				1616	18.6	6
						Avg =	1626	for	25 Pts

Layer 2 Velocity computed by Hobson-Overton method

Not enough points.

Wtd Avg Velocity computed for Layer 2 = 1626

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	4 24	60.8	15250	15250	60.8	21
			B	6 24	48.2	4726	4726	48.2	19
7783	47.5	1 3	C	12 24	50.6	4237	4632	49.1	16
15916	66.5	1 5	D	18 24	59.7	10869	12523	63.1	12
3641	49.4	1 14	E	22 24	45.8	5426	3866	47.6	17
4039	43.9	1 18	F				4039	43.9	18
3942	41.1	1 18	G				3942	41.1	18
						Avg =	5209	for	121 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A D	4 5	1133	-8.9	0.000	0.000	4	-0.000	5				
A E	4 14	3986	-3.5	4.955	-10.046	13	-8.058	4	6.937	9	5.330	8
A F	4 18	6015	2.0	4.040	-8.202	18	7.128	10	-6.487	4	4.036	9
A G	4 18	6770	1.3	4.820	-9.804	4	-9.240	18	6.440	12	5.981	11
B E	6 14	4257	-6.9	2.732	-5.496	6	-3.880	13	3.444	9	2.146	8
B F	6 18	3951	-0.4	3.165	8.203	16	-4.503	14	-4.102	18	2.698	10
B G	6 18	4523	0.9	3.043	6.910	13	-4.516	10	-4.446	18	4.328	16
C E	12 14	2408	-2.7	3.447	-4.875	13	2.439	14	2.436	12		
C F	12 18	2628	9.2	1.945	2.841	15	-2.508	13	-2.332	18	1.581	16
C G	12 18	4196	11.0	1.703	2.705	13	2.017	15	-2.010	16	-1.641	12
		Avg =	4646	for	95 Pts							

Wtd Avg Velocity computed for Layer 3 = 4865

VELOCITY ANALYSIS TABLES for LINEG14.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	349	
					349
	C	5	6.3	366	
	C	7	5.9	325	
					345
	D	11	6.8	379	
	D	13	5.4	328	
					354
	E	17	7.0	419	
	E	19	5.2	280	
					350
	F	23	6.1	332	
					332

Wtd Avg Velocity computed for Layer 1 = 347

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
971	24.4	3 4	C	8 10	26.4	984	978	25.4	5
371	-8.5	9 10	D	14 17	-17.2	434	411	-12.9	6
964	17.9	12 16	E	20 22	8.6	517	728	13.2	8
1081	42.4	18 22	F				1081	42.4	5
						Avg =	679	for	24 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
C D	9 10	585	-3.9	0.000	-0.000	10	0.000	9				
D E	14 16	865	-7.0	0.410	0.581	15	-0.290	14	-0.290	16		
E F	20 22	698	-2.5	1.638	-2.317	21	1.170	22	1.147	20		
Avg =		732 for		8 Pts								

Wtd Avg Velocity computed for Layer 2 = 701

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 24	20.2	1504	1504	20.2	24
			B	4 22	29.1	1605	1605	29.1	19
4326	45.7	1 2	C	11 24	22.2	1194	1312	34.0	16
1957	39.0	1 8	D	18 24	25.4	1023	1372	32.2	15
1880	45.9	1 11	E	23 24	47.0	1238	1741	46.5	13
1974	55.8	1 17	F				1974	55.8	17
1878	30.8	1 23	G				1878	30.8	23
						Avg =	1603	for	127 Pts

Layer 3 Velocity computed by Hobson-Overton method

Spread 1

SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A C	1 2	2165	-5.4	0.000	-0.000	2	-0.000	1				
A D	1 8	1835	-14.9	0.980	-1.885	7	1.399	5	1.103	8	-0.959	4
A E	1 11	1800	-16.9	1.996	2.995	11	-2.727	5	2.613	10	2.479	1
A F	1 17	1922	-12.1	3.671	-7.735	12	6.821	2	5.341	16	4.716	14
A G	1 23	1697	2.1	3.018	-8.631	13	-6.117	12	4.032	1	3.788	2
B D	4 8	1761	-16.4	1.106	-1.725	7	1.375	5	0.850	8	-0.700	4
B E	4 11	1620	-17.0	1.191	1.986	11	1.810	4	-1.525	9	-0.884	7
B F	4 17	1794	-14.1	2.388	-7.539	12	2.576	5	2.138	14	1.757	15
B G	4 22	1710	1.0	2.165	-4.937	12	-4.767	13	4.148	11	3.070	18
C F	11 17	1416	-4.2	2.301	-4.114	13	3.542	11	-2.043	12	1.546	14
C G	11 23	1630	10.5	3.693	-9.170	13	5.396	17	4.316	11	3.564	16
D G	18 23	1649	22.0	1.748	2.644	21	-2.316	23	-1.993	19	1.396	22
	Avg =	1736	for 133 Pts									

Wtd Avg Velocity computed for Layer 3 = 1693

VELOCITY ANALYSIS TABLES for LINEG15.SIP

Layer 1 Velocity from direct arrivals

Spread 1	SP	Geo	DD	V	Avg V
	B	2	6.1	375	
					375
	C	5	6.2	367	
	C	7	6.0	324	
					346
	D	11	6.4	372	
	D	13	5.8	335	
					354
	E	17	6.4	366	
	E	19	5.8	344	
					355
	F	23	6.1	359	
					359

Wtd Avg Velocity computed for Layer 1 = 355

Layer 2 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	1 14	26.8	2060	2060	26.8	14
			B	3 15	28.2	1693	1693	28.2	13
			C	8 15	13.2	1251	1251	13.2	8
1145	10.5	9 10	D	14 18	10.9	957	1004	10.7	7
1167	18.7	13 16	E	20 24	14.5	741	884	16.6	9
1572	37.2	13 22	F				1572	37.2	10
1703	32.3	13 24	G				1703	32.3	12
						Avg =	1420	for	73 Pts

Layer 2 Velocity computed by Hobson-Overton method

Spread 1 SPs	Geos	V	Avg TdSP	Std Err Overall	4 Highest Std Err at geophones Err	Geo	Err	Geo	Err	Geo	Err	Geo
A D	9 10	1121	-25.6	0.000	-0.000	9	0.000	10				
A E	13 14	1027	-41.6	0.000	-0.000	13	0.000	14				
A F	13 14	1070	-29.6	0.000	-0.000	13	0.000	14				
A G	13 14	1036	-24.4	0.000	0.000	13	-0.000	14				
B D	9 10	1205	-11.2	0.000	0.000	9	-0.000	10				
B E	13 15	1065	-23.5	0.326	-0.461	14	0.230	13	0.230	15		
B F	13 15	1194	-13.3	0.028	0.039	14	-0.020	15	-0.020	13		
B G	13 15	1193	-9.3	0.202	0.286	14	-0.143	15	-0.143	13		
C D	9 10	1122	-5.5	0.000	0.000	10	-0.000	9				
C E	13 15	951	-14.1	0.853	1.206	14	-0.603	15	-0.603	13		
C F	13 15	1053	-3.0	1.206	1.706	14	-0.853	15	-0.853	13		
C G	13 15	1052	3.1	1.380	1.952	14	-0.976	15	-0.976	13		
D E	14 16	971	-0.8	1.151	1.628	15	-0.814	14	-0.814	16		
D F	14 18	1046	8.3	2.326	3.657	17	-3.256	18	-1.404	14	1.051	16
D G	14 18	1216	6.6	2.181	3.630	16	-2.283	18	-2.234	14	0.494	17
E F	20 22	1250	1.2	2.127	-3.008	21	1.516	22	1.492	20		
E G	20 24	943	5.6	3.071	-4.233	22	3.651	20	-2.902	21	2.584	23

Avg = 1086 for 51 Pts

Wtd Avg Velocity computed for Layer 2 = 1225

Layer 3 Velocity computed by regression of datum-corrected arrivals

Spread 1

V	Ti	Geos	<-SP->	Geos	Ti	V	Avg V	Avg Ti	Pts
			A	15 24	10.2	1552	1552	10.2	10
			B	16 24	13.5	1329	1329	13.5	9
941	14.3	1 3	C	16 22	32.6	1961	1480	23.5	10
1187	9.4	1 8	D	19 23	14.9	1138	1168	12.2	13
1463	21.6	1 12	E				1463	21.6	12
1884	48.7	1 12	F				1884	48.7	12
2085	40.9	1 12	G				2085	40.9	12

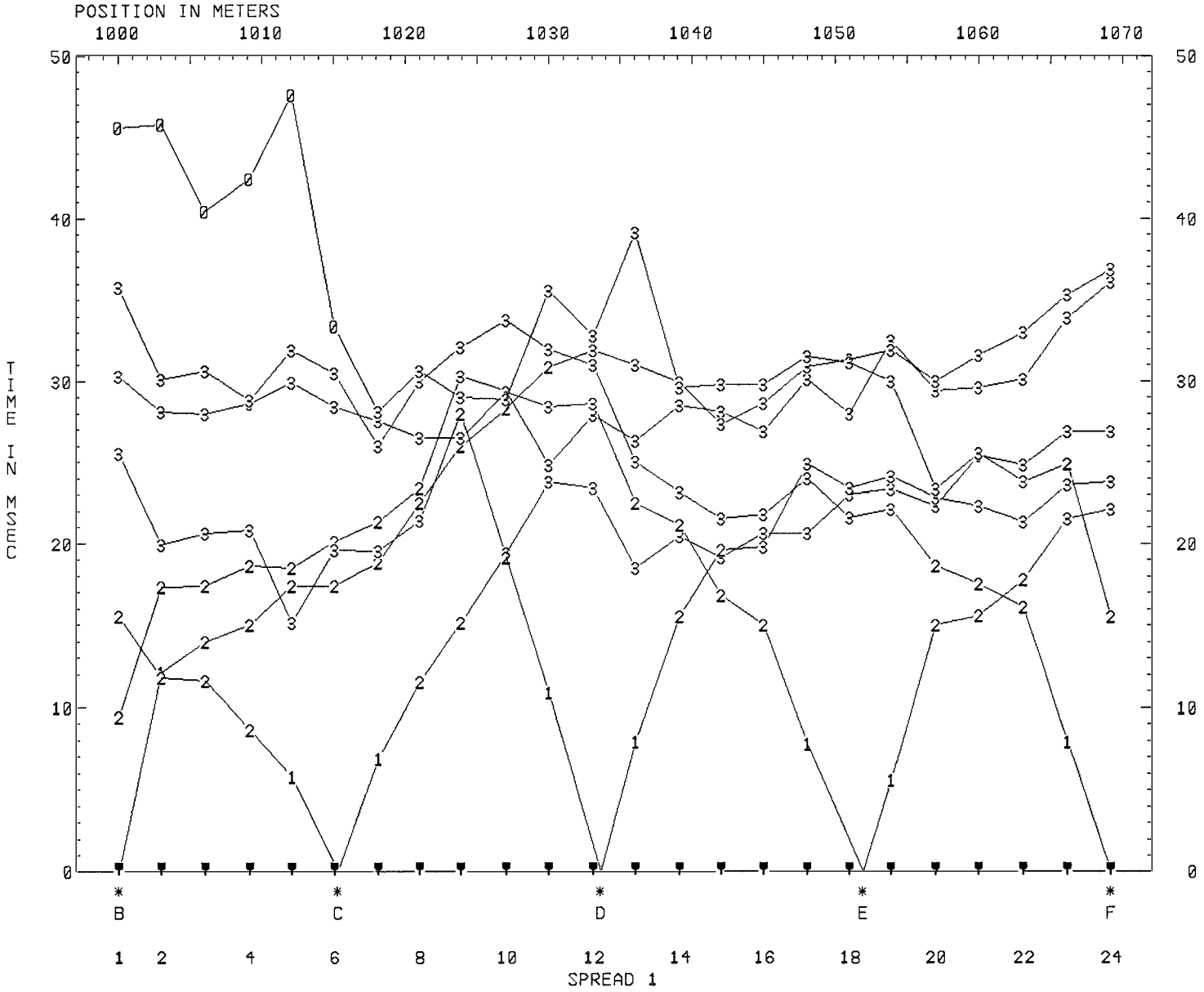
Avg = 1516 for 78 Pts

Layer 3 Velocity computed by Hobson-Overton method

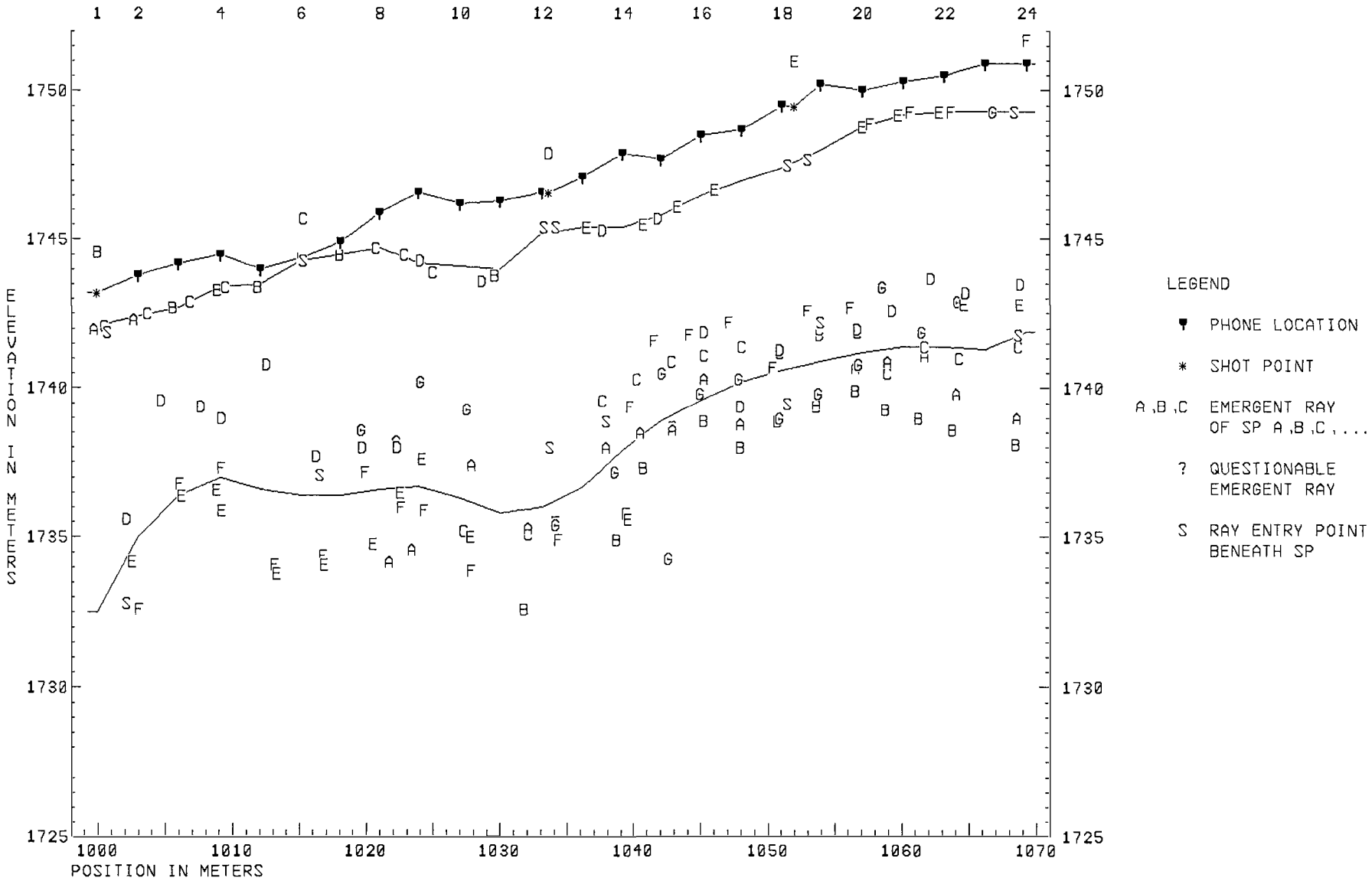
Not enough points.

Wtd Avg Velocity computed for Layer 3 = 1516

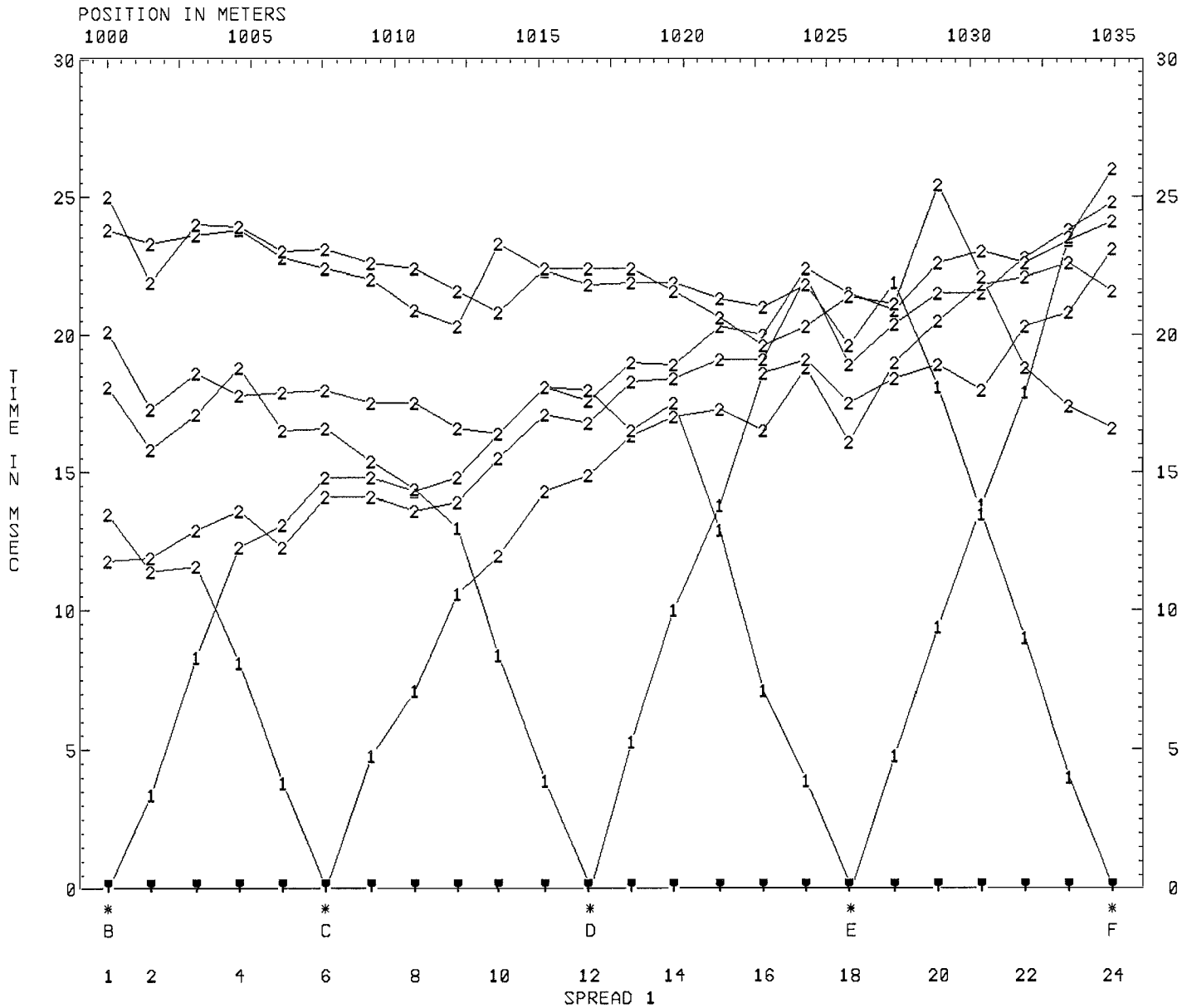
FILE LINEG1.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G1, SHOT MAY 26, 1999 - RAW ARRIVAL TIMES



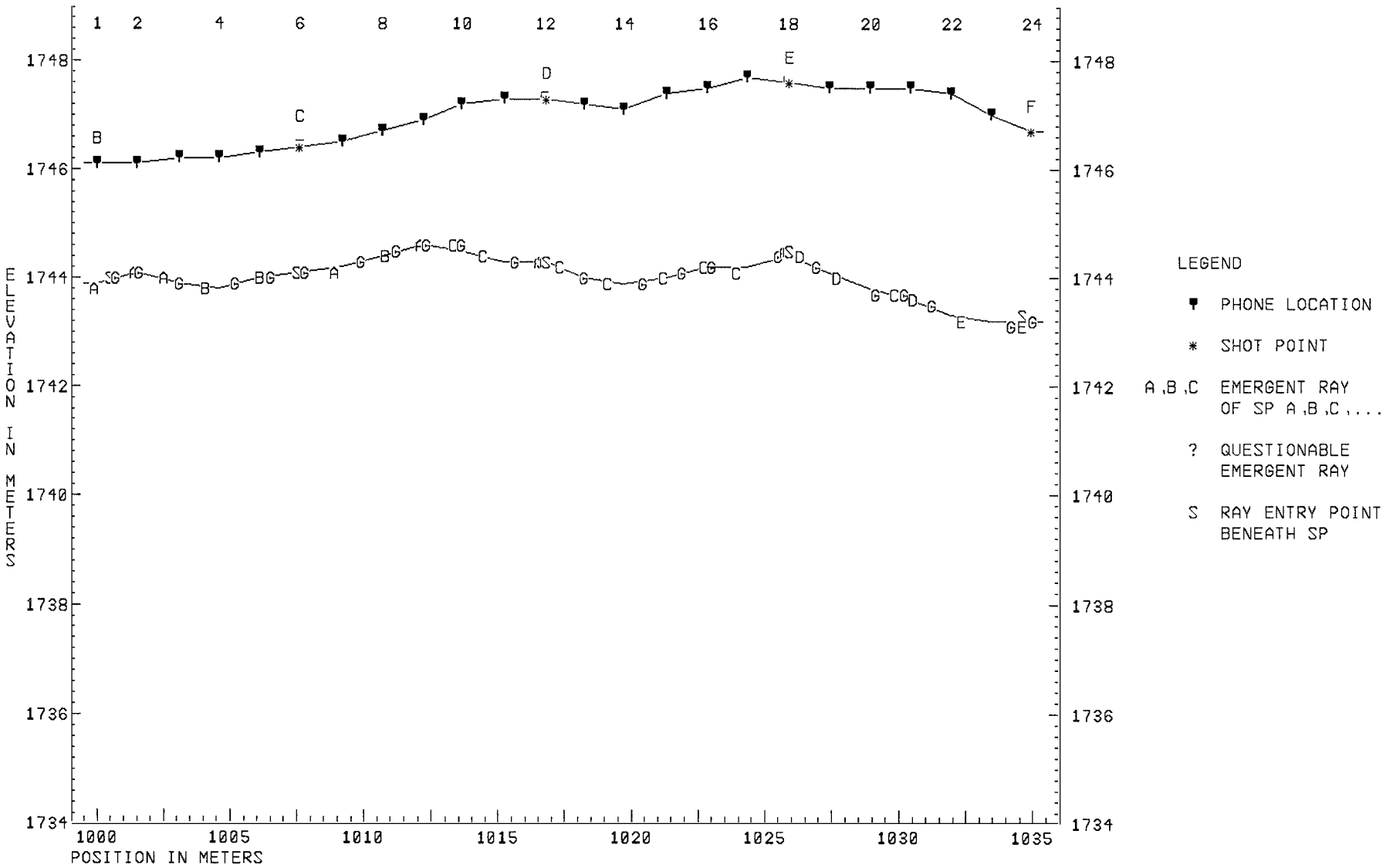
FILE LINEG1.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G1, SHOT MAY 26, 1999
SPREAD 1



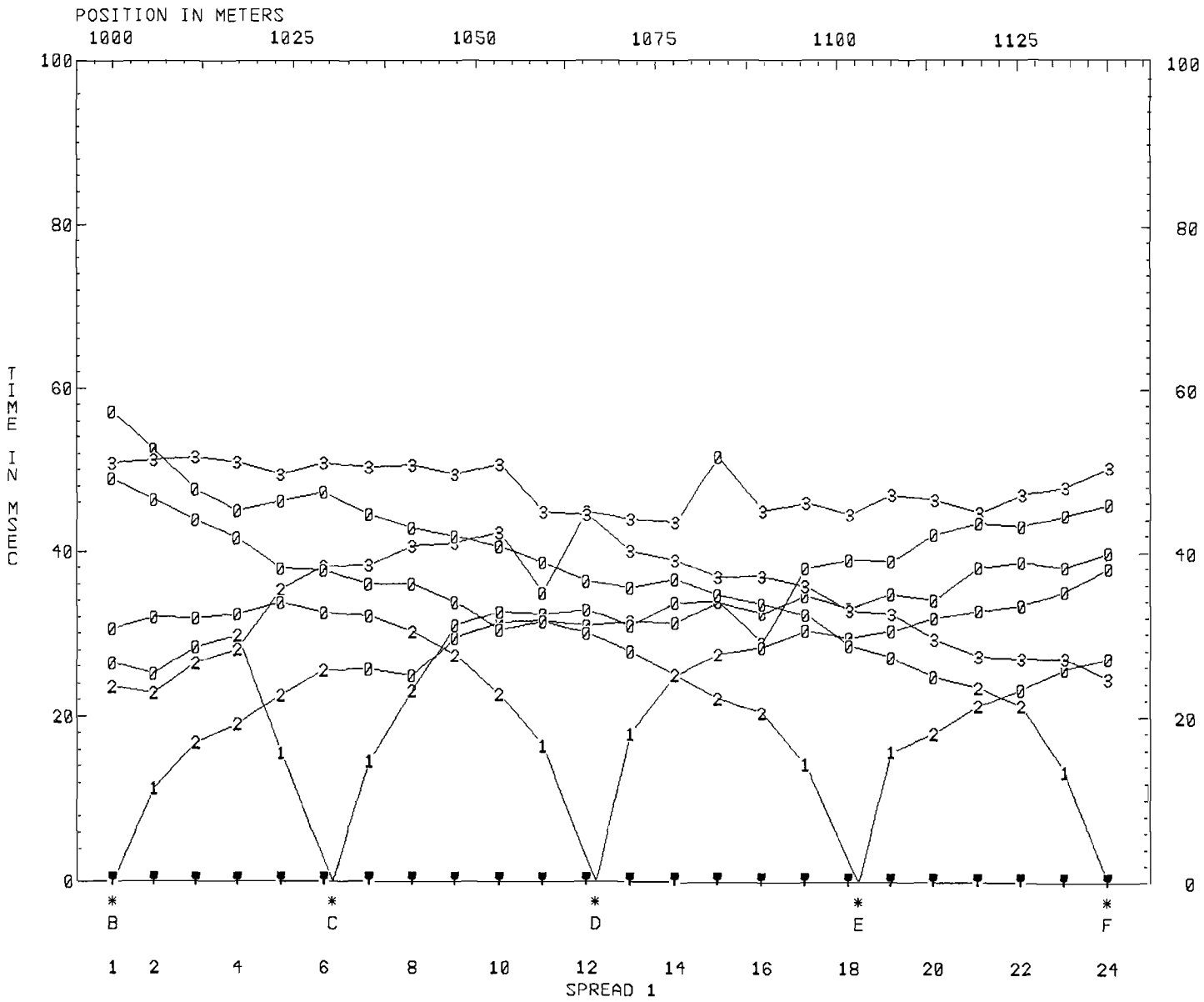
FILE LINEG2.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G2, SHOT MAY 27, 1999 - RAW ARRIVAL TIMES



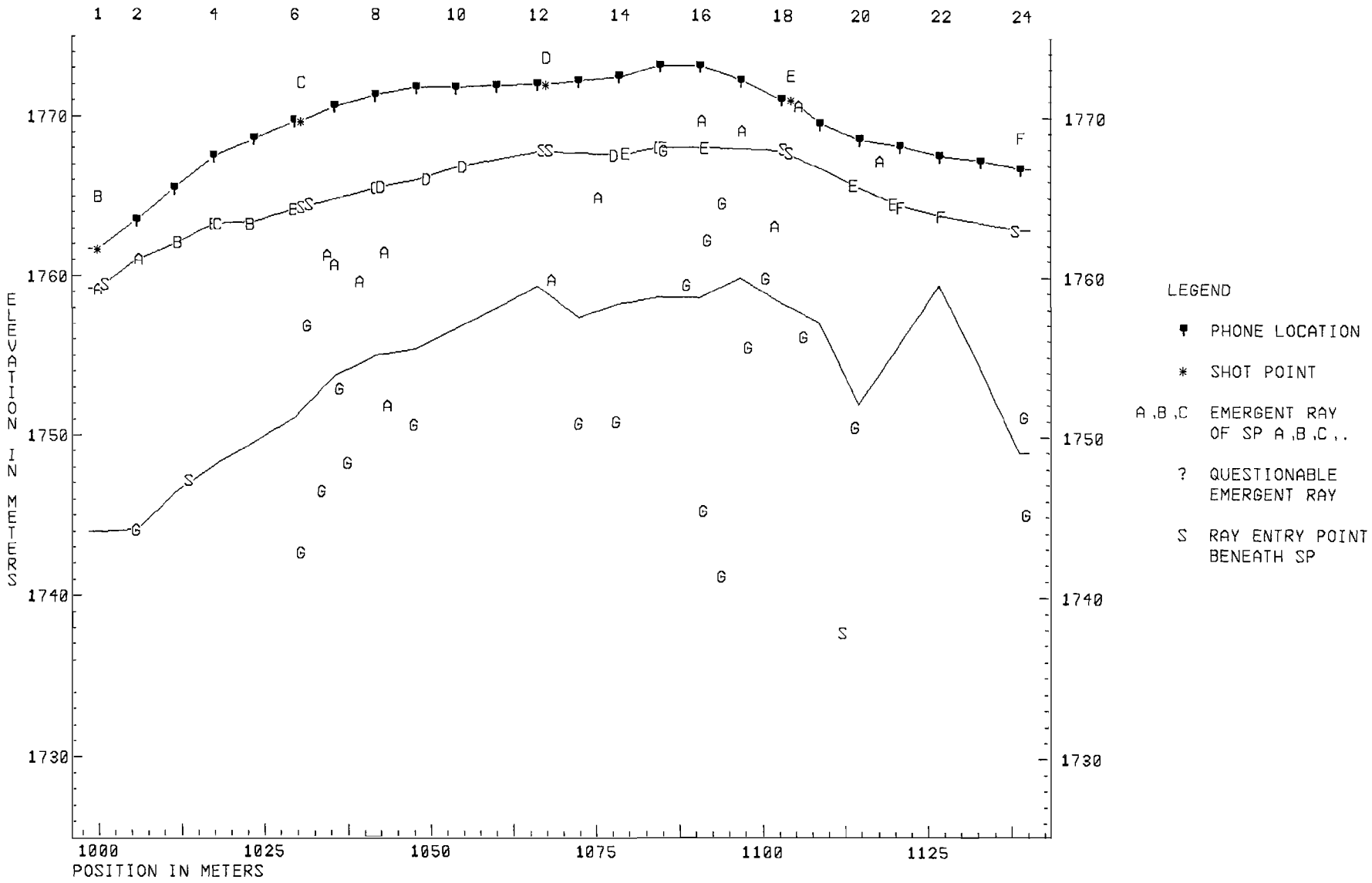
FILE LINEG2 SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G2, SHOT MAY 27, 1999
SPREAD 1



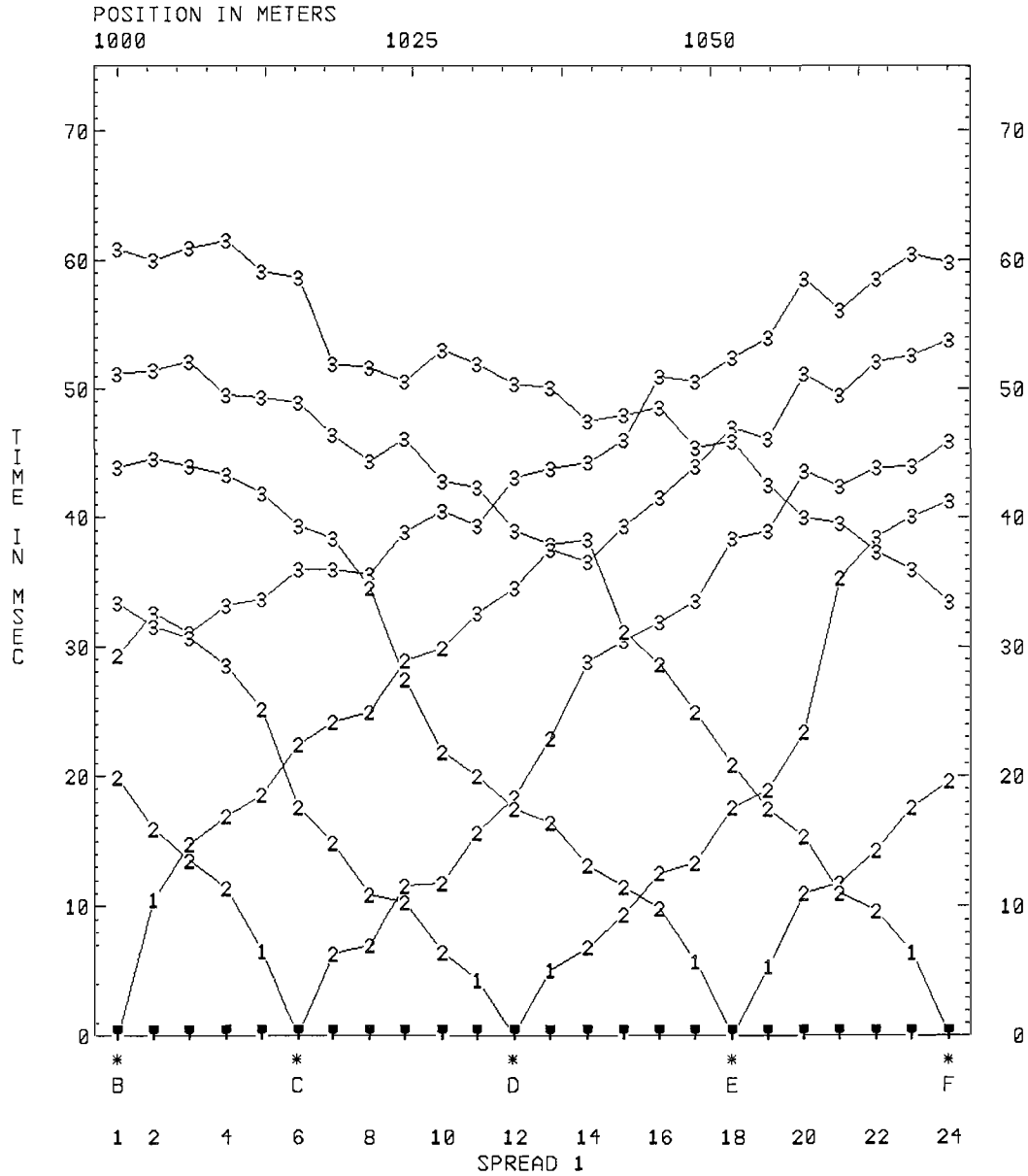
FILE LINEG3.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G3, SHOT JUNE 1, 1999 - RAW ARRIVAL TIMES



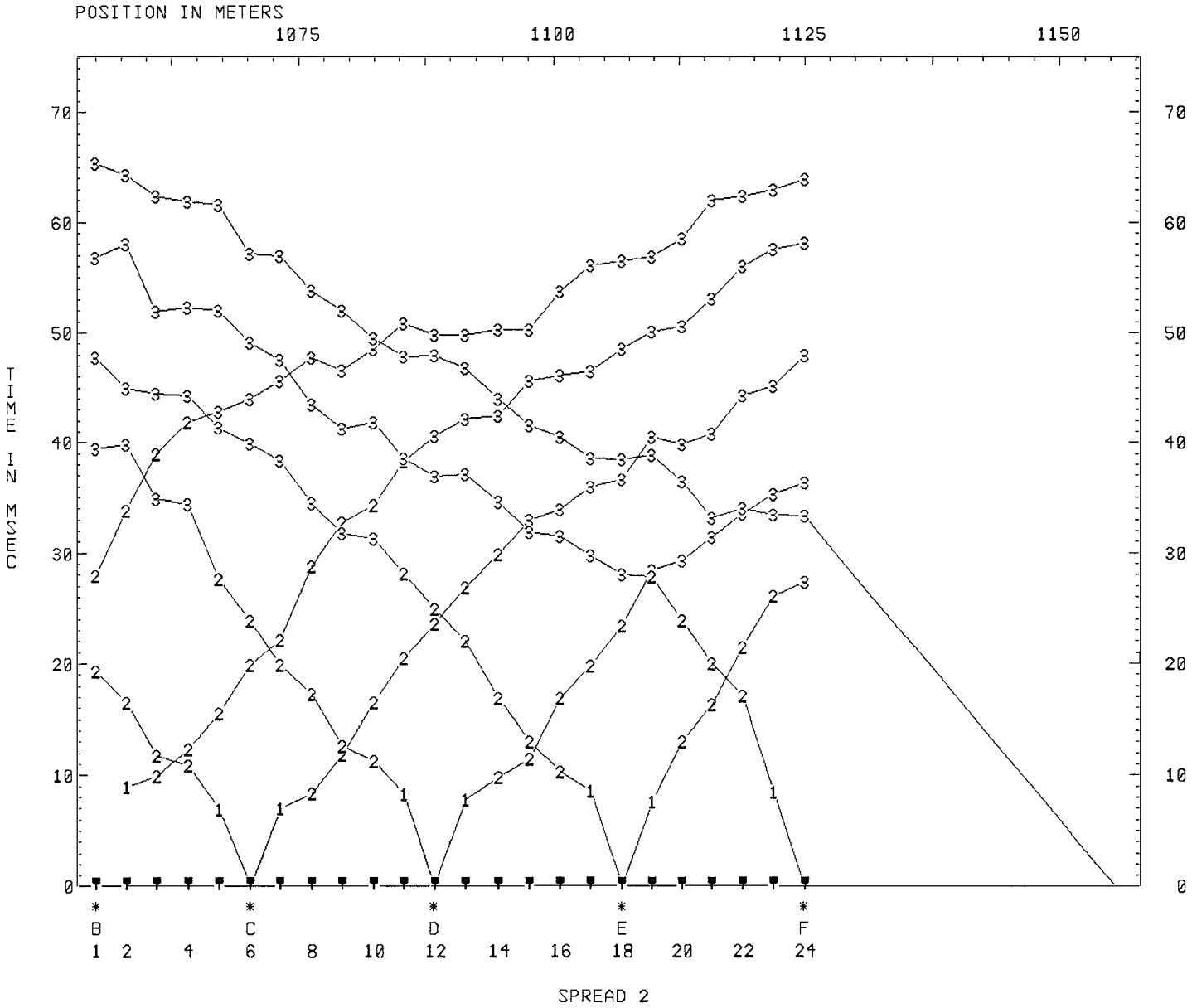
FILE LINEG3 SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G3, SHOT JUNE 1, 1999
SPREAD 1



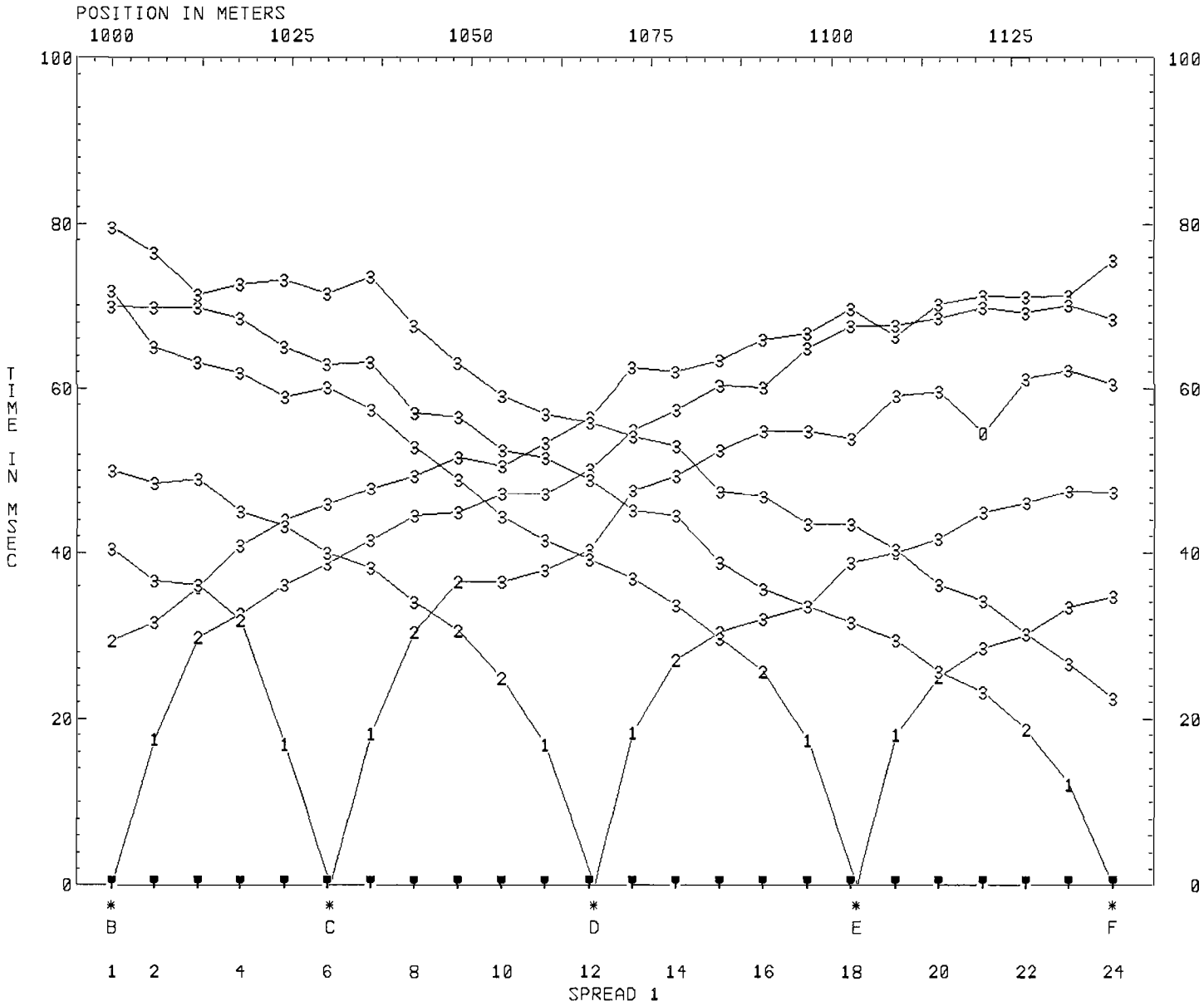
FILE LINEG4.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G4, SHOT 5/27/99 - RAW ARR



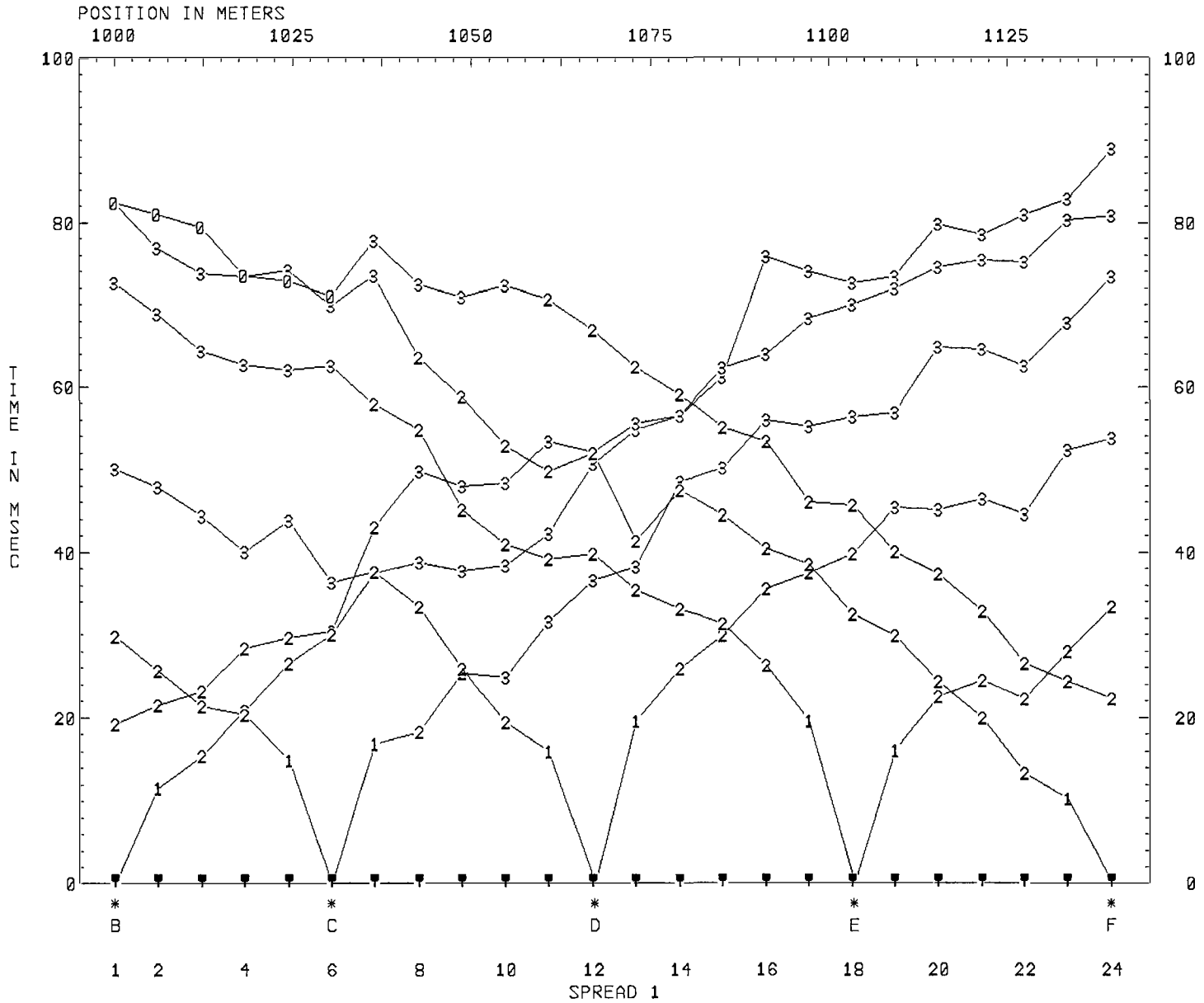
FILE LINEG4.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G4, SHOT 5/27/99 - RAW ARRIVAL TIMES



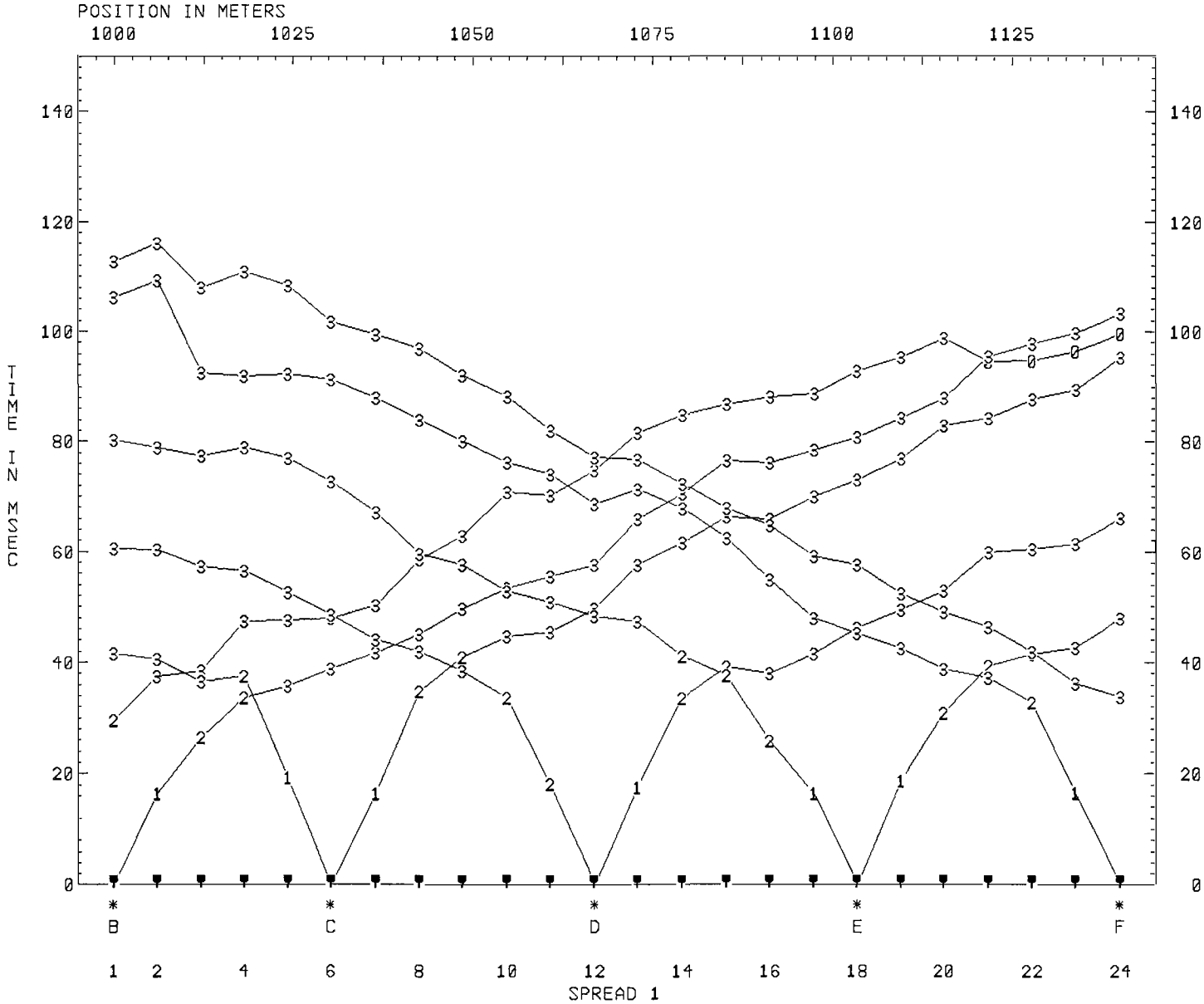
FILE LINEG5.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G5, SHOT JUNE 4, 1999 - RAW ARRIVAL TIMES



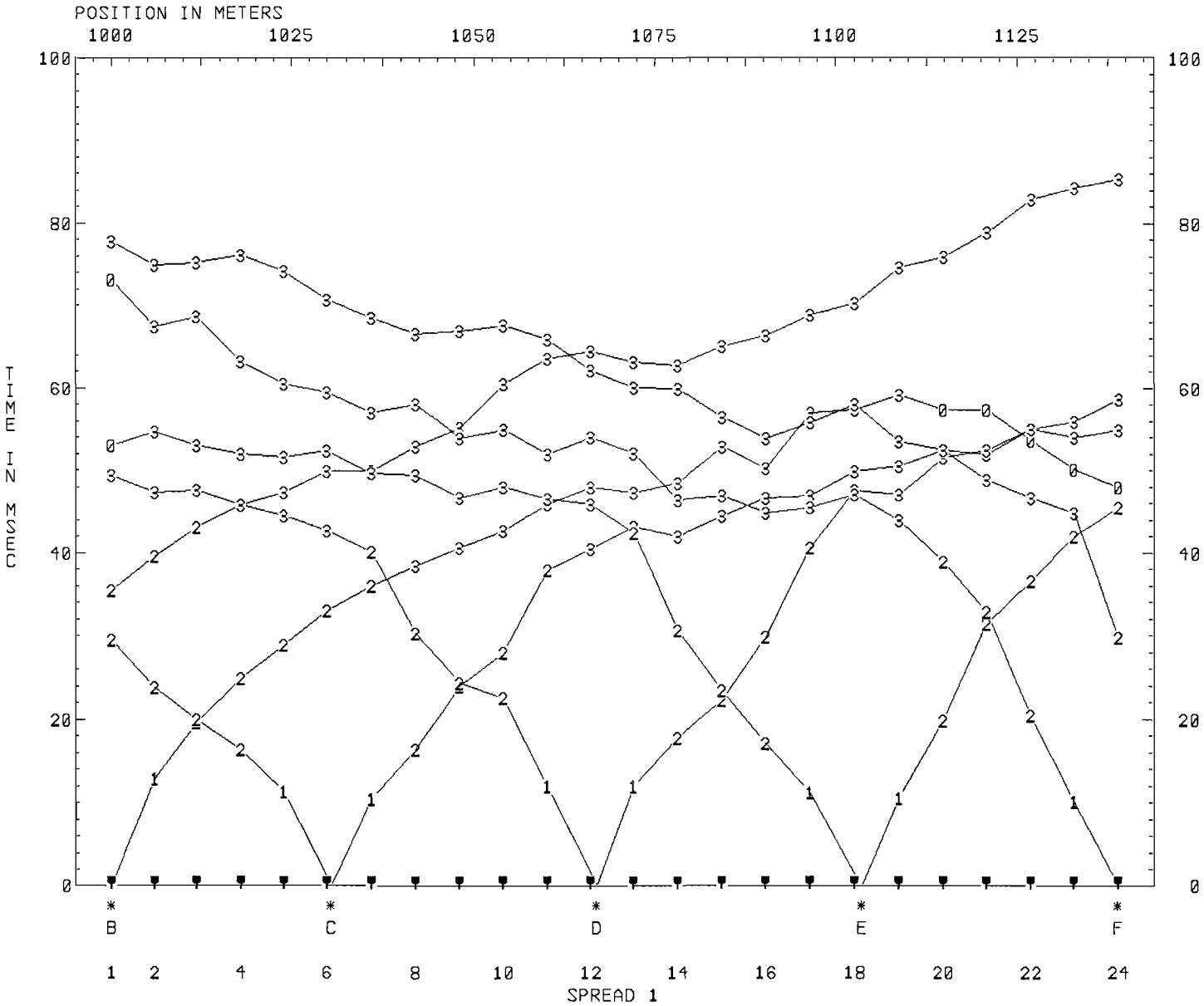
FILE LINEG6.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G6, SHOT JUNE 1, 1999 - RAW ARRIVAL TIMES



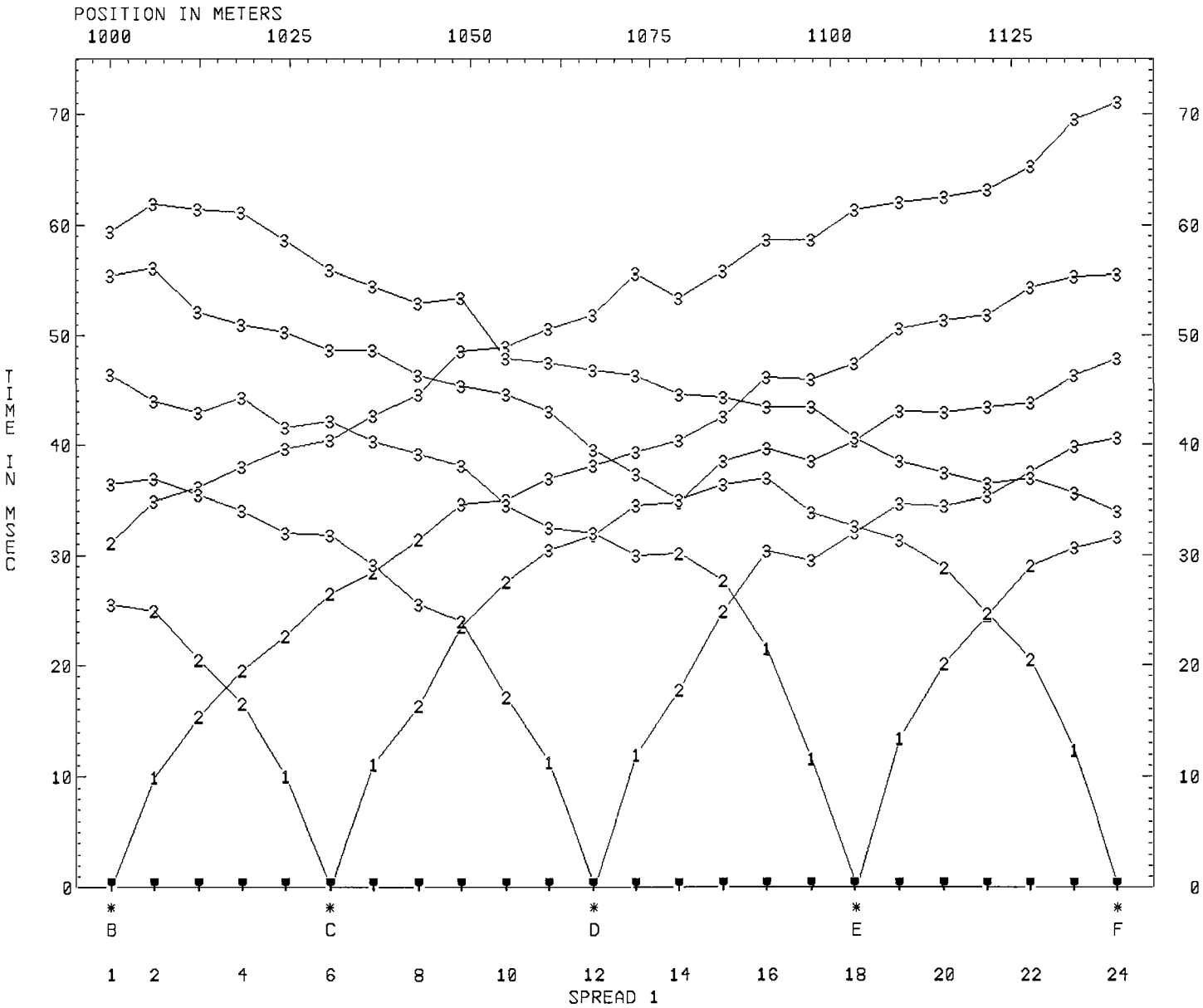
FILE LINEG7.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G7, SHOT JUNE 4, 1999 - RAW ARRIVAL TIMES



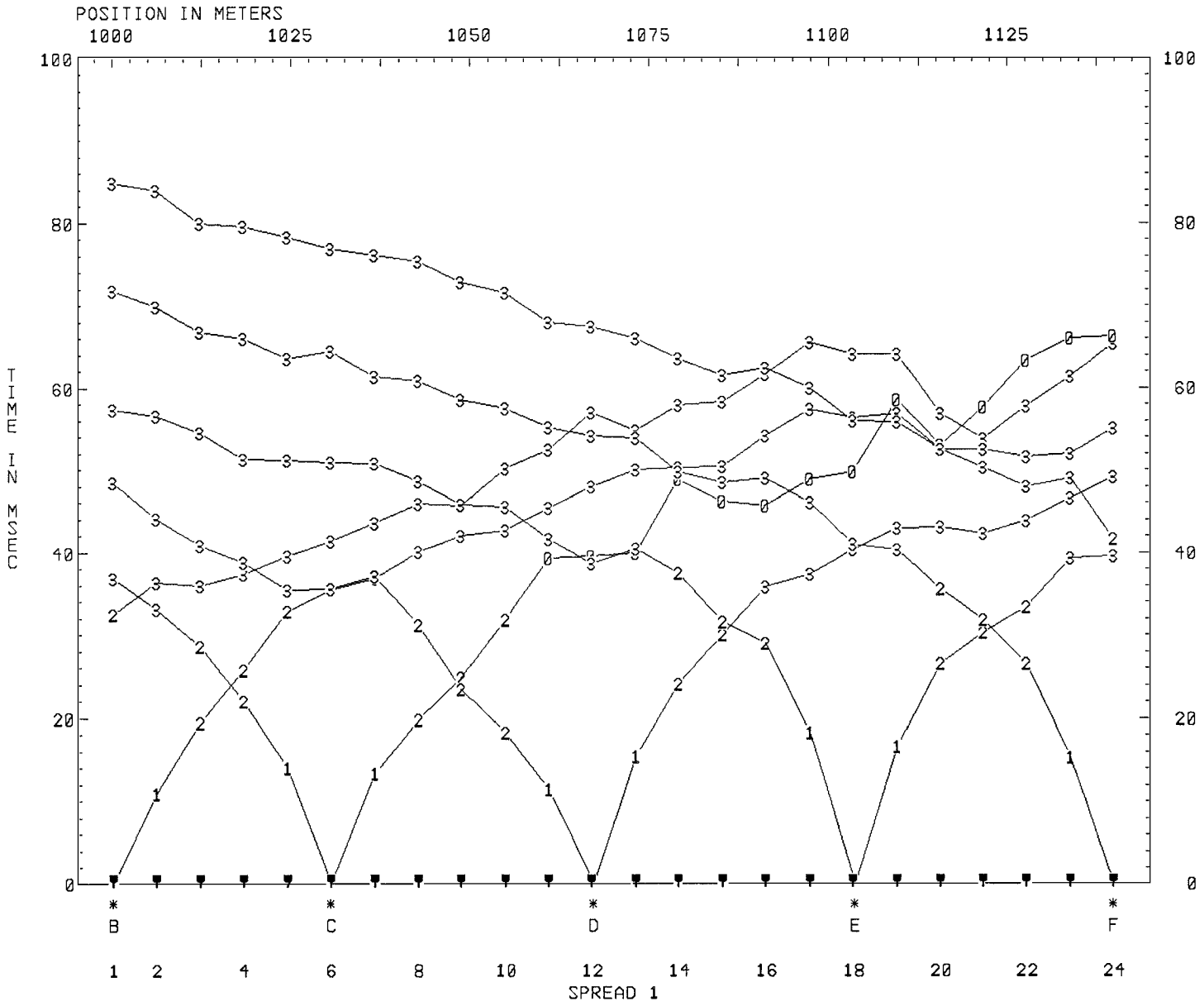
FILE LINEG8.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G8, SHOT JUNE 3, 1999 - RAW ARRIVAL TIMES



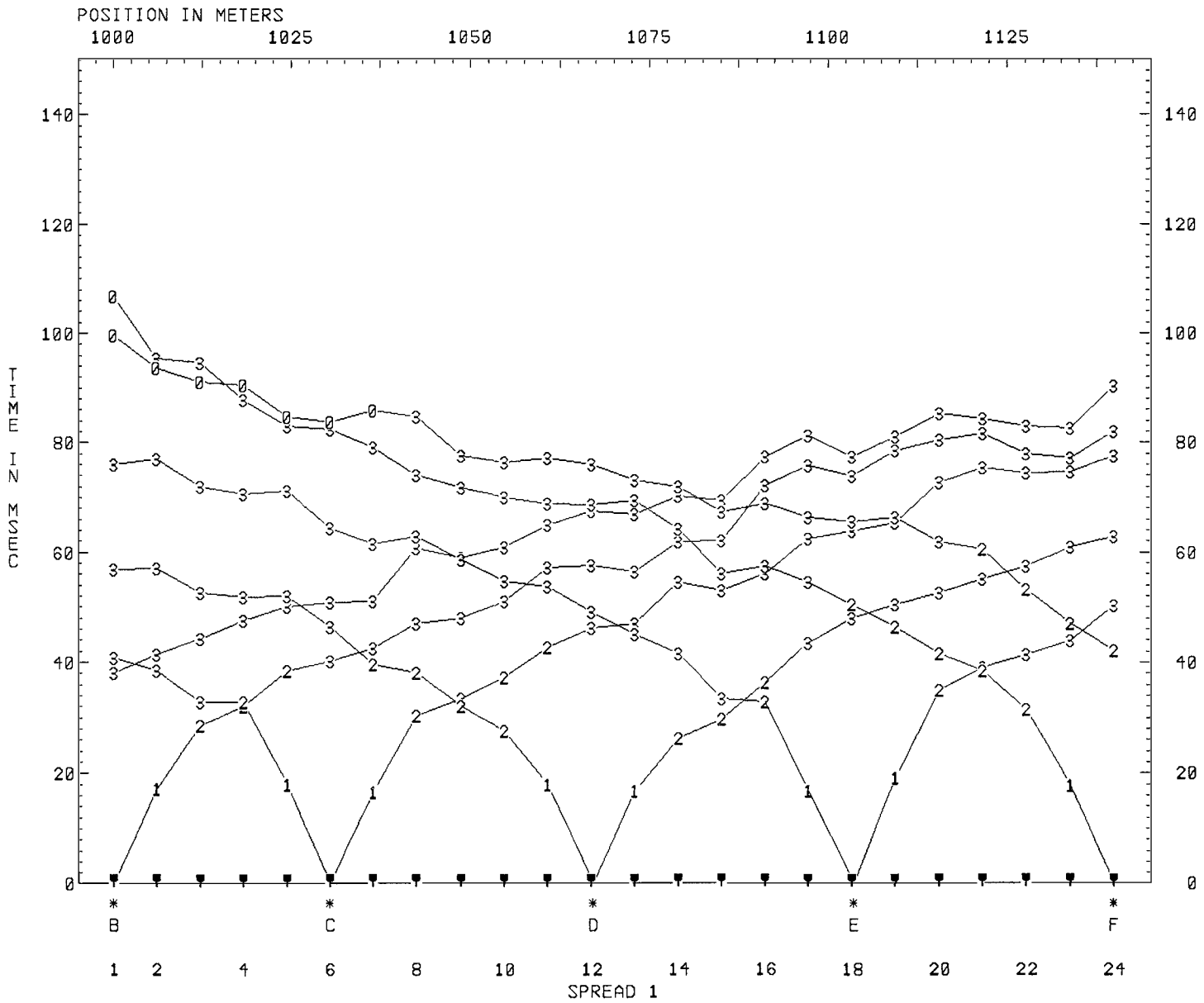
FILE LINEG9.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G9, SHOT MAY 28, 1999 - RAW ARRIVAL TIMES



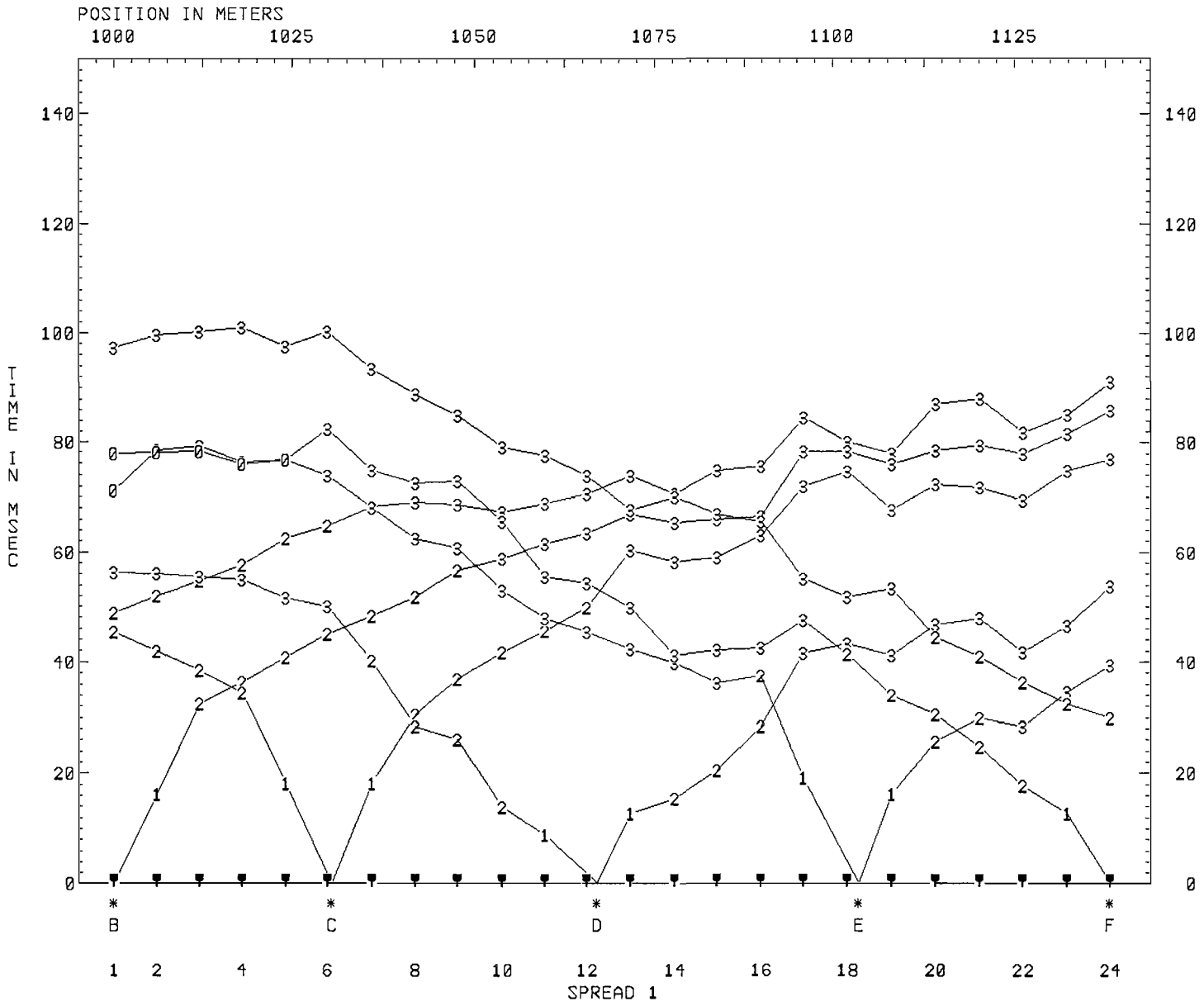
FILE LINEG10.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G10, SHOT MAY 28, 1999 - RAW ARRIVAL TIMES



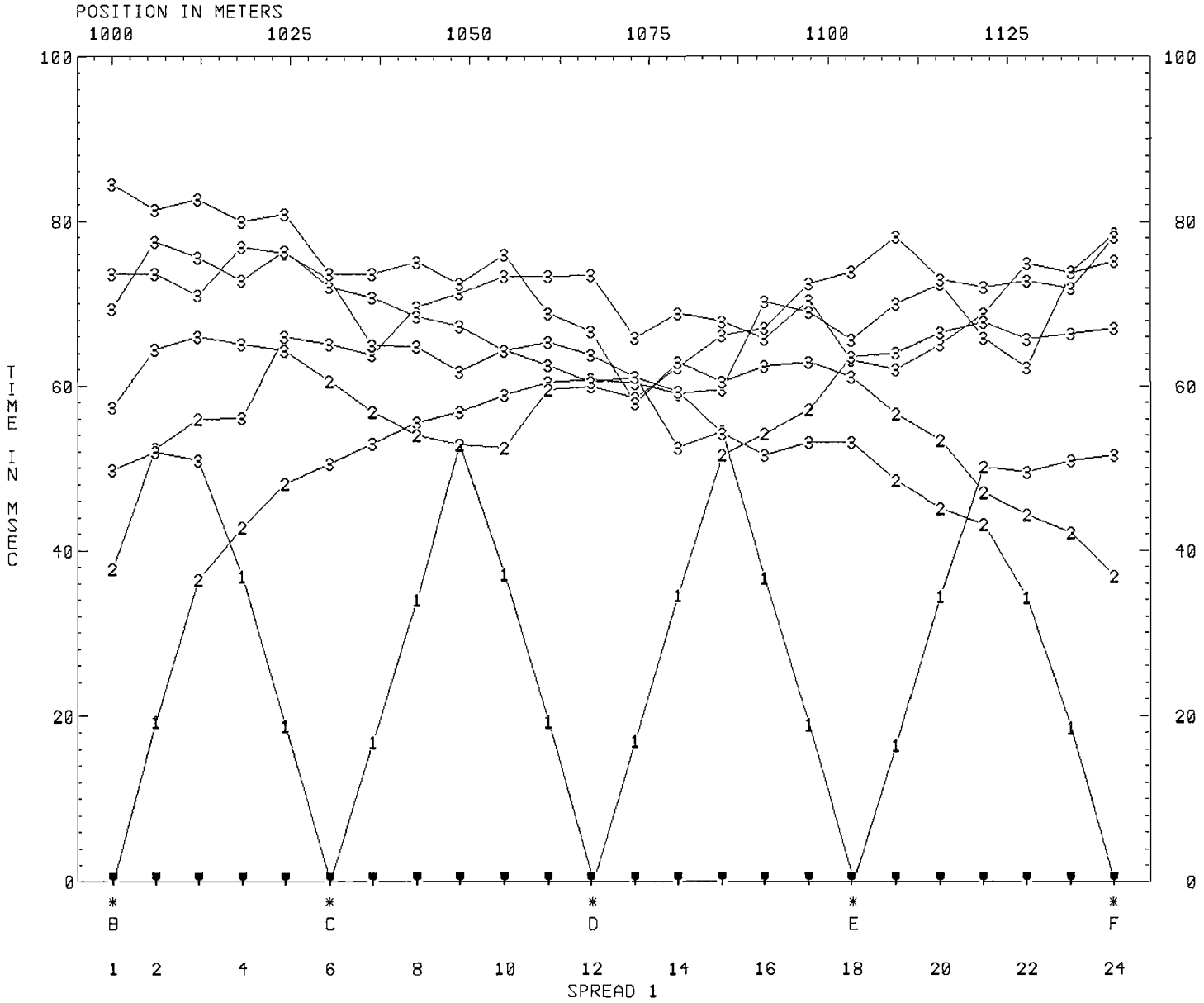
FILE LINEG11.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G11, SHOT JUNE 2, 1999 - RAW ARRIVAL TIMES



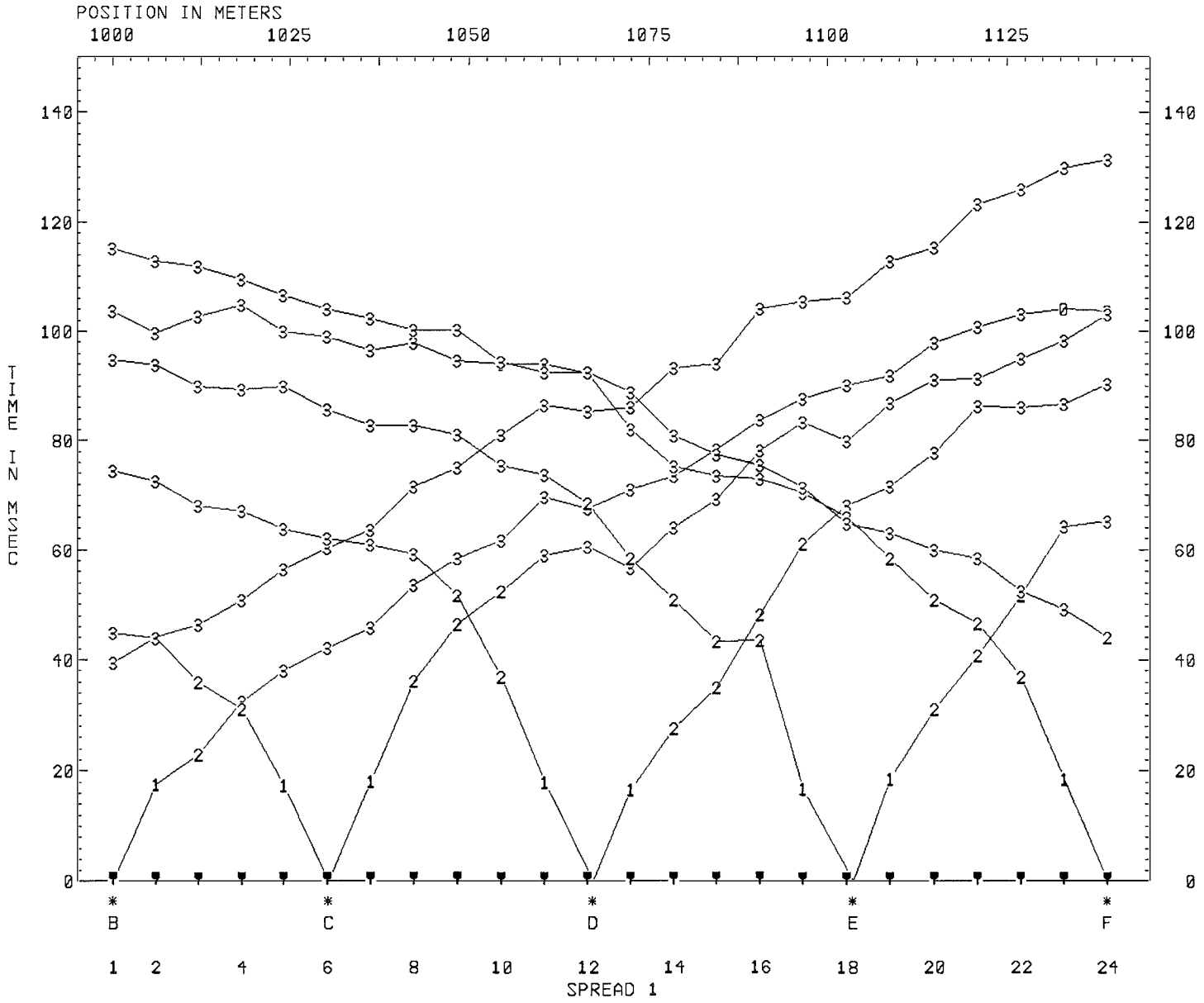
FILE LINEG12 SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G12, SHOT JUNE 3, 1999 - RAW ARRIVAL TIMES



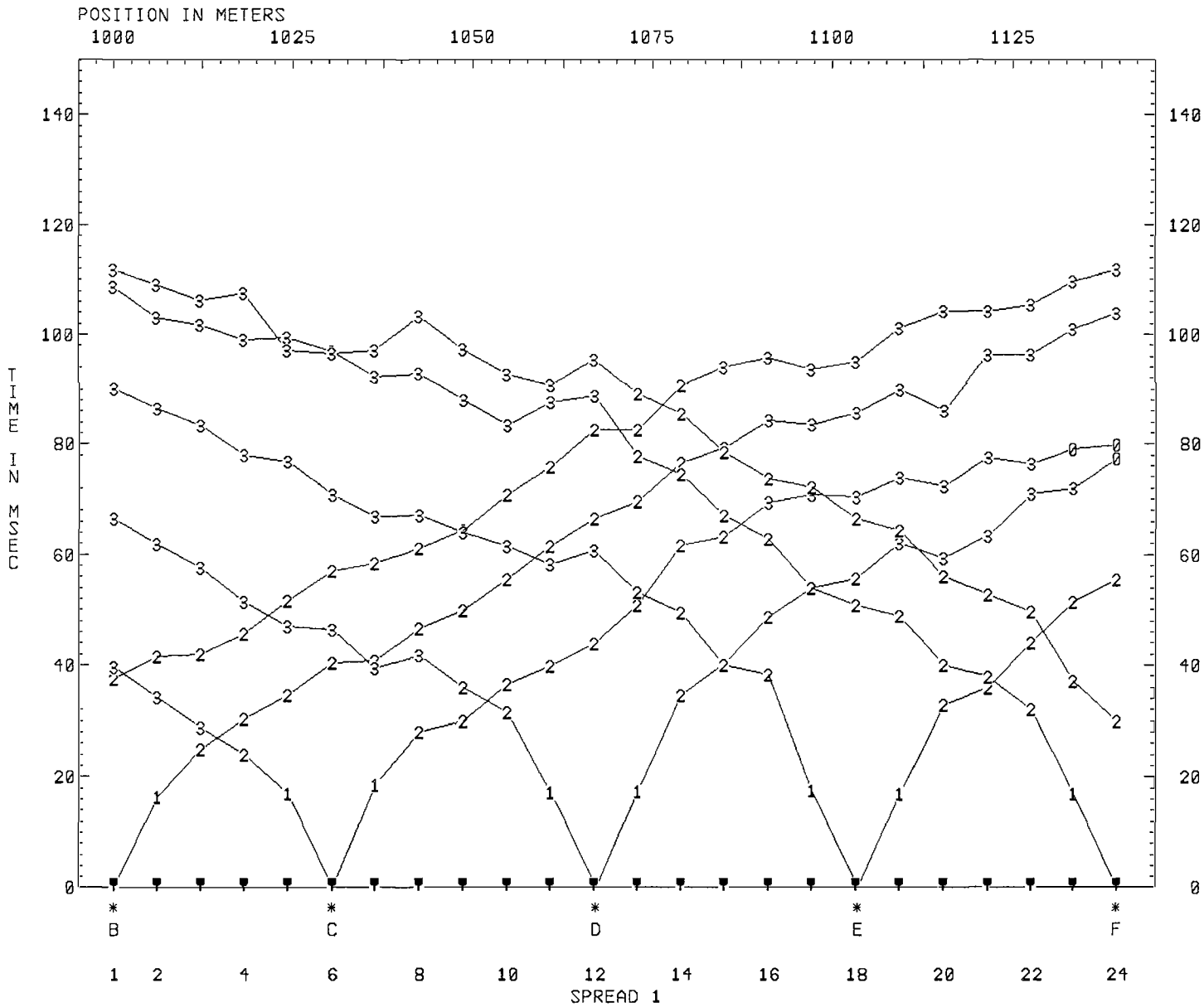
FILE LINEG13.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G13, SHOT JUNE 3, 1999 - RAW ARRIVAL TIMES



FILE LINEG14 SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G14, SHOT JUNE 10, 1999 - RAW ARRIVAL TIMES



FILE LINEG15.SIP
LOGAN CANYON - UDOT, DAMES & MOORE LINE G15, SHOT JUNE 10, 1999 - RAW ARRIVAL TIMES



DEPTH MODEL TABLES for LINEG1.SIP

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1743.2	1.1	1742.1	10.7	1732.5
C	1015.3	1744.4	0.1	1744.3	8.0	1736.4
D	1033.6	1746.6	1.4	1745.2	10.5	1736.1
E	1051.9	1749.5	1.9	1747.6	8.8	1740.7
F	1069.2	1750.9	1.6	1749.3	9.0	1741.9

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1743.2	1.1	1742.1	10.7	1732.5
2	1003.0	1743.8	1.4	1742.4	8.8	1735.0
3	1006.0	1744.2	1.5	1742.7	7.8	1736.4
4	1009.1	1744.5	1.1	1743.4	7.5	1737.0
5	1012.1	1744.0	0.5	1743.5	7.4	1736.6
6	1015.1	1744.4	0.1	1744.3	8.0	1736.4
7	1018.1	1744.9	0.4	1744.5	8.5	1736.4
8	1021.0	1745.9	1.2	1744.7	9.3	1736.6
9	1023.9	1746.6	2.4	1744.2	9.9	1736.7
10	1027.0	1746.2	2.1	1744.1	9.9	1736.3
11	1030.0	1746.3	2.3	1744.0	10.5	1735.8
12	1033.1	1746.6	1.4	1745.2	10.6	1736.0
13	1036.1	1747.1	1.7	1745.4	10.4	1736.7
14	1039.1	1747.9	2.5	1745.4	10.0	1737.9
15	1042.0	1747.7	1.9	1745.8	8.8	1738.9
16	1045.0	1748.5	2.0	1746.5	8.9	1739.6
17	1048.0	1748.7	1.7	1747.0	8.5	1740.2
18	1051.0	1749.5	2.1	1747.4	8.9	1740.6
19	1053.9	1750.2	2.2	1748.0	9.3	1740.9
20	1057.0	1750.0	1.2	1748.8	8.8	1741.2
21	1060.0	1750.3	1.1	1749.2	8.9	1741.4
22	1063.1	1750.5	1.2	1749.3	9.1	1741.4
23	1066.1	1750.9	1.6	1749.3	9.6	1741.3
24	1069.2	1750.9	1.6	1749.3	9.0	1741.9

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	397	1120	
Horizontal		1120	6298

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev
B	1000.0	1746.1	2.2	1743.9
C	1007.6	1746.4	2.3	1744.1
D	1016.8	1747.3	3.0	1744.3
E	1025.9	1747.6	3.2	1744.4
F	1034.9	1746.7	3.5	1743.2

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev
1	1000.0	1746.1	2.2	1743.9
2	1001.5	1746.1	2.0	1744.1
3	1003.1	1746.2	2.3	1743.9
4	1004.6	1746.2	2.4	1743.8
5	1006.1	1746.3	2.3	1744.0
6	1007.6	1746.4	2.3	1744.1
7	1009.2	1746.5	2.3	1744.2
8	1010.7	1746.7	2.3	1744.4
9	1012.2	1746.9	2.3	1744.6
10	1013.6	1747.2	2.7	1744.5
11	1015.2	1747.3	3.0	1744.3
12	1016.7	1747.3	3.0	1744.3
13	1018.2	1747.2	3.2	1744.0
14	1019.7	1747.1	3.2	1743.9
15	1021.3	1747.4	3.4	1744.0
16	1022.8	1747.5	3.3	1744.2
17	1024.3	1747.7	3.5	1744.2
18	1025.8	1747.6	3.2	1744.4
19	1027.4	1747.5	3.4	1744.1
20	1028.9	1747.5	3.7	1743.8
21	1030.4	1747.5	3.9	1743.6
22	1031.9	1747.4	4.1	1743.3
23	1033.4	1747.0	3.8	1743.2
24	1034.9	1746.7	3.5	1743.2

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2
Vertical	363	
Horizontal		3741

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1761.7	2.5	1759.2	17.7	1744.0
C	1030.5	1769.7	5.4	1764.3	18.1	1751.6
D	1067.1	1772.0	4.2	1767.8	13.0	1759.0
E	1103.7	1771.1	3.5	1767.6	13.0	1758.1
F	1138.3	1766.8	3.8	1763.0	17.8	1749.0

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1761.7	2.5	1759.2	17.7	1744.0
2	1005.8	1763.5	2.5	1761.0	19.4	1744.1
3	1011.6	1765.5	3.5	1762.0	19.1	1746.4
4	1017.4	1767.5	4.2	1763.3	19.4	1748.1
5	1023.4	1768.6	5.2	1763.4	19.0	1749.6
6	1029.4	1769.7	5.5	1764.2	18.6	1751.1
7	1035.4	1770.6	5.8	1764.8	16.9	1753.7
8	1041.4	1771.3	5.8	1765.5	16.3	1755.0
9	1047.5	1771.8	5.8	1766.0	16.4	1755.4
10	1053.6	1771.8	5.0	1766.8	15.1	1756.7
11	1059.7	1771.9	4.6	1767.3	13.9	1758.0
12	1065.8	1772.0	4.2	1767.8	12.6	1759.4
13	1071.9	1772.2	4.5	1767.7	14.8	1757.4
14	1078.0	1772.5	4.9	1767.6	14.2	1758.3
15	1084.1	1773.2	5.1	1768.1	14.5	1758.7
16	1090.2	1773.2	5.1	1768.1	14.5	1758.7
17	1096.2	1772.3	4.3	1768.0	12.4	1759.9
18	1102.2	1771.1	3.2	1767.9	12.7	1758.4
19	1108.1	1769.6	2.8	1766.8	12.5	1757.1
20	1114.1	1768.6	3.0	1765.6	16.6	1752.0
21	1120.2	1768.2	3.7	1764.5	12.4	1755.8
22	1126.2	1767.6	3.7	1763.9	8.1	1759.5
23	1132.3	1767.3	3.9	1763.4	13.0	1754.3
24	1138.3	1766.8	3.8	1763.0	17.8	1749.0

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	419	3510	
Horizontal		3510	4899

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1894.3	1.7	1892.6	8.4	1885.9
C	1015.2	1894.5	0.8	1893.7	9.2	1885.3
D	1033.5	1894.9	0.0	1894.9	10.9	1884.0
E	1051.9	1895.3	0.5	1894.8	13.6	1881.7
F	1070.2	1895.7	0.8	1894.9	12.3	1883.4

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1894.3	1.7	1892.6	8.4	1885.9
2	1003.1	1894.4	1.7	1892.7	8.4	1886.0
3	1006.1	1894.5	1.6	1892.9	7.9	1886.6
4	1009.2	1894.5	1.5	1893.0	8.5	1886.0
5	1012.2	1894.5	1.3	1893.2	8.9	1885.6
6	1015.3	1894.5	0.8	1893.7	9.2	1885.3
7	1018.3	1894.6	0.5	1894.1	9.3	1885.3
8	1021.4	1894.6	0.3	1894.3	9.4	1885.2
9	1024.4	1894.7	0.3	1894.4	9.7	1885.0
10	1027.5	1894.7	0.1	1894.6	10.1	1884.6
11	1030.5	1894.8	0.0	1894.8	10.5	1884.3
12	1033.6	1894.9	0.0	1894.9	10.9	1884.0
13	1036.6	1894.9	0.0	1894.9	10.9	1884.0
14	1039.7	1894.9	0.1	1894.8	11.3	1883.6
15	1042.7	1895.0	0.3	1894.7	11.9	1883.1
16	1045.8	1895.1	0.5	1894.6	12.8	1882.3
17	1048.8	1895.2	0.3	1894.9	13.6	1881.6
18	1051.9	1895.3	0.5	1894.8	13.6	1881.7
19	1054.9	1895.3	0.1	1895.2	13.2	1882.1
20	1058.0	1895.5	0.4	1895.1	12.9	1882.6
21	1061.0	1895.5	0.8	1894.7	13.0	1882.5
22	1064.1	1895.5	0.7	1894.8	12.9	1882.6
23	1067.1	1895.5	0.8	1894.7	12.5	1883.0
24	1070.2	1895.7	0.8	1894.9	12.3	1883.4

Spread 2 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1054.9	1895.3	0.1	1895.2	13.2	1882.1
C	1070.2	1895.7	0.8	1894.9	12.3	1883.4
D	1088.4	1895.6	1.7	1893.9	8.6	1887.0
E	1106.8	1895.2	1.6	1893.6	6.7	1888.5
F	1124.9	1894.6	3.8	1890.8	6.0	1888.6
G	1155.5	1893.6	6.5	1887.1	6.5	1887.1

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1054.9	1895.3	0.1	1895.2	13.2	1882.1
2	1058.0	1895.5	0.4	1895.1	13.2	1882.3
3	1061.0	1895.5	0.8	1894.7	13.0	1882.5
4	1064.1	1895.5	0.7	1894.8	12.9	1882.6
5	1067.1	1895.5	0.8	1894.7	12.7	1882.8
6	1070.2	1895.7	0.8	1894.9	12.3	1883.4
7	1073.2	1895.8	1.0	1894.8	11.6	1884.2
8	1076.3	1895.7	1.3	1894.4	10.8	1884.9
9	1079.3	1895.7	1.5	1894.2	9.9	1885.8
10	1082.4	1895.7	1.7	1894.0	9.8	1885.9
11	1085.4	1895.6	1.8	1893.8	9.2	1886.4
12	1088.5	1895.6	1.7	1893.9	8.6	1887.0
13	1091.5	1895.5	1.8	1893.7	8.1	1887.4
14	1094.6	1895.4	1.4	1894.0	7.9	1887.5
15	1097.6	1895.5	1.1	1894.5	7.9	1887.6
16	1100.7	1895.3	1.3	1894.0	7.4	1887.9
17	1103.7	1895.3	1.5	1893.8	7.1	1888.2
18	1106.8	1895.2	1.6	1893.6	6.7	1888.5
19	1109.8	1895.1	2.6	1892.5	6.0	1889.1
20	1112.8	1894.9	3.4	1891.5	5.7	1889.2
21	1115.8	1894.9	3.9	1891.0	5.7	1889.2
22	1118.9	1894.9	4.0	1890.9	6.0	1888.9
23	1121.9	1894.8	3.6	1891.2	6.0	1888.8
24	1125.0	1894.6	3.8	1890.8	3.8	1890.8

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	450	973	
Horizontal		973	2182

Spread 2	Layer 1	Layer 2	Layer 3
Vertical	450	973	
Horizontal		973	2182

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1988.5	3.3	1985.2	5.8	1982.7
C	1030.5	1994.0	3.8	1990.2	8.6	1985.4
D	1067.1	1998.0	2.4	1995.6	9.5	1988.5
E	1103.7	1999.8	2.5	1997.3	7.6	1992.2
F	1139.4	1999.4	0.4	1999.0	4.7	1994.7

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1988.5	3.3	1985.2	5.8	1982.7
2	1006.0	1989.8	3.9	1985.9	5.8	1984.0
3	1011.9	1991.1	4.5	1986.6	6.3	1984.8
4	1017.9	1992.2	4.3	1987.9	7.0	1985.2
5	1024.0	1993.1	4.1	1989.0	7.7	1985.4
6	1030.0	1994.0	3.9	1990.1	8.6	1985.4
7	1036.0	1994.8	3.7	1991.1	9.3	1985.5
8	1042.1	1995.5	3.3	1992.2	9.7	1985.8
9	1048.2	1996.0	2.3	1993.7	9.6	1986.4
10	1054.2	1996.8	1.8	1995.0	9.5	1987.3
11	1060.3	1997.4	2.1	1995.3	9.4	1988.0
12	1066.4	1998.0	2.5	1995.5	9.5	1988.5
13	1072.4	1998.5	2.4	1996.1	9.7	1988.8
14	1078.5	1999.0	2.3	1996.7	9.8	1989.2
15	1084.6	1999.3	2.4	1996.9	9.2	1990.1
16	1090.7	1999.5	2.4	1997.1	8.6	1990.9
17	1096.8	1999.6	2.4	1997.2	8.1	1991.5
18	1102.9	1999.8	2.5	1997.3	7.7	1992.1
19	1109.0	1999.9	2.5	1997.4	7.1	1992.8
20	1115.1	2000.0	2.5	1997.5	6.4	1993.6
21	1121.2	2000.2	2.7	1997.5	5.8	1994.4
22	1127.2	2000.2	2.6	1997.6	5.2	1995.0
23	1133.3	1999.6	1.3	1998.3	4.1	1995.5
24	1139.4	1999.4	0.4	1999.0	4.7	1994.7

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	369	979	
Horizontal		979	2438

DEPTH MODEL TABLES for LINEG6.SIP

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1986.4	2.4	1984.0	2.4	1984.0
C	1030.5	1988.5	2.6	1985.9	16.3	1972.2
D	1067.1	1992.1	2.6	1989.5	14.7	1977.4
E	1103.7	1991.1	3.2	1987.9	10.3	1980.8
F	1139.7	1988.8	1.7	1987.1	5.1	1983.7

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1986.4	2.4	1984.0	3.1	1983.3
2	1006.1	1986.7	2.5	1984.2	3.6	1983.1
3	1012.2	1986.9	2.3	1984.6	4.0	1982.9
4	1018.3	1987.4	2.9	1984.5	7.5	1979.9
5	1024.4	1987.7	2.7	1985.0	13.2	1974.5
6	1030.4	1988.5	2.6	1985.9	16.3	1972.2
7	1036.5	1988.9	4.2	1984.7	16.6	1972.3
8	1042.6	1989.2	3.7	1985.5	14.1	1975.1
9	1048.7	1989.7	2.8	1986.9	15.6	1974.1
10	1054.7	1990.6	1.8	1988.8	20.2	1970.4
11	1060.7	1991.5	1.9	1989.6	18.9	1972.6
12	1066.8	1992.1	2.6	1989.5	14.9	1977.2
13	1072.9	1992.3	2.3	1990.0	10.0	1982.3
14	1079.0	1992.4	3.2	1989.2	9.1	1983.3
15	1085.1	1992.2	3.6	1988.6	8.0	1984.2
16	1091.2	1991.9	3.7	1988.2	8.5	1983.4
17	1097.3	1991.4	3.2	1988.2	11.0	1980.4
18	1103.4	1991.1	3.2	1987.9	10.5	1980.6
19	1109.4	1990.6	2.9	1987.7	6.6	1984.0
20	1115.5	1989.8	2.5	1987.3	5.0	1984.8
21	1121.6	1989.2	2.1	1987.1	5.5	1983.7
22	1127.5	1988.6	1.0	1987.6	5.0	1983.6
23	1133.6	1988.7	1.2	1987.5	5.2	1983.5
24	1139.7	1988.8	1.7	1987.1	5.1	1983.7

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	411	1677	
Horizontal		1677	1855

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2014.4	2.3	2012.1	3.9	2010.5
C	1030.5	2015.2	4.1	2011.1	6.0	2009.2
D	1067.1	2017.3	2.7	2014.6	9.3	2008.0
E	1103.7	2016.3	2.5	2013.8	7.0	2009.3
F	1140.1	2015.6	3.7	2011.9	4.0	2011.6

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2014.4	2.3	2012.1	3.9	2010.5
2	1006.1	2014.6	2.7	2011.9	5.3	2009.3
3	1012.2	2015.3	3.6	2011.7	5.9	2009.4
4	1018.3	2015.4	4.1	2011.3	6.0	2009.4
5	1024.4	2015.3	4.1	2011.2	6.0	2009.3
6	1030.5	2015.2	4.1	2011.1	6.0	2009.2
7	1036.6	2015.4	3.8	2011.6	6.3	2009.1
8	1042.6	2015.9	3.8	2012.1	6.8	2009.2
9	1048.7	2016.3	3.9	2012.4	7.0	2009.3
10	1054.8	2016.6	3.8	2012.8	7.4	2009.2
11	1060.9	2017.0	3.4	2013.6	8.2	2008.8
12	1067.0	2017.3	2.7	2014.6	9.3	2008.0
13	1073.1	2017.3	2.6	2014.7	10.3	2007.0
14	1079.2	2017.3	2.6	2014.7	10.5	2006.8
15	1085.3	2017.1	2.7	2014.4	10.1	2007.0
16	1091.4	2016.9	2.4	2014.5	9.1	2007.8
17	1097.5	2016.6	2.4	2014.2	8.0	2008.6
18	1103.6	2016.3	2.5	2013.8	7.0	2009.3
19	1109.7	2016.2	3.3	2012.9	6.3	2009.9
20	1115.8	2016.1	4.2	2011.9	6.0	2010.1
21	1121.9	2015.9	4.4	2011.5	5.7	2010.2
22	1127.9	2015.7	4.2	2011.5	5.5	2010.2
23	1134.0	2015.7	4.0	2011.7	5.1	2010.6
24	1140.1	2015.6	3.7	2011.9	4.0	2011.6

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	353	875	
Horizontal		875	1670

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2034.8	2.8	2032.0	11.4	2023.4
C	1030.5	2040.3	1.2	2039.1	13.8	2026.5
D	1067.1	2045.6	2.7	2042.9	15.5	2030.1
E	1103.7	2047.2	3.1	2044.1	15.5	2031.7
F	1139.1	2046.3	5.8	2040.5	12.0	2034.3

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2034.8	2.8	2032.0	11.4	2023.4
2	1006.0	2036.1	2.7	2033.4	12.1	2024.0
3	1011.9	2037.3	2.3	2035.0	12.8	2024.5
4	1018.0	2038.3	1.9	2036.4	13.2	2025.1
5	1024.0	2039.3	1.7	2037.6	13.6	2025.7
6	1030.0	2040.3	1.3	2039.0	13.8	2026.5
7	1036.0	2041.3	1.2	2040.1	14.2	2027.2
8	1042.1	2042.1	1.0	2041.1	14.4	2027.7
9	1048.1	2042.9	1.3	2041.6	14.8	2028.1
10	1054.1	2044.0	1.6	2042.4	15.5	2028.5
11	1060.2	2044.8	2.5	2042.3	15.7	2029.1
12	1066.2	2045.6	2.8	2042.8	15.6	2030.0
13	1072.2	2046.4	3.0	2043.4	15.6	2030.8
14	1078.3	2046.6	1.9	2044.7	15.2	2031.4
15	1084.4	2047.0	0.9	2046.1	15.1	2031.9
16	1090.5	2047.1	1.7	2045.4	14.9	2032.2
17	1096.6	2047.3	2.8	2044.5	15.3	2032.0
18	1102.7	2047.2	2.9	2044.3	15.5	2031.7
19	1108.8	2047.1	3.8	2043.3	15.2	2031.9
20	1114.9	2047.2	5.2	2042.0	14.5	2032.7
21	1121.0	2047.1	6.7	2040.4	13.3	2033.8
22	1127.0	2047.2	7.9	2039.3	12.5	2034.7
23	1133.1	2047.6	8.0	2039.6	12.6	2035.0
24	1139.1	2046.3	5.8	2040.5	12.0	2034.3

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	543	1044	
Horizontal		1044	3629

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2026.9	2.3	2024.6	12.2	2014.7
C	1030.5	2028.4	1.4	2027.0	13.5	2014.9
D	1067.1	2029.9	1.5	2028.4	12.1	2017.8
E	1103.7	2031.5	4.1	2027.4	11.5	2020.0
F	1140.1	2033.4	3.4	2030.0	12.3	2021.1

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2026.9	2.3	2024.6	12.2	2014.7
2	1006.1	2026.7	1.6	2025.1	11.8	2014.9
3	1012.2	2027.3	1.3	2026.0	12.6	2014.7
4	1018.3	2027.4	1.2	2026.2	13.0	2014.4
5	1024.3	2028.0	1.4	2026.6	13.3	2014.7
6	1030.4	2028.4	1.4	2027.0	13.5	2014.9
7	1036.5	2028.5	1.2	2027.3	13.2	2015.3
8	1042.6	2029.0	1.8	2027.2	13.1	2015.9
9	1048.7	2029.5	3.5	2026.0	12.6	2016.9
10	1054.8	2029.6	3.5	2026.1	11.8	2017.8
11	1060.9	2030.1	2.9	2027.2	12.2	2017.9
12	1067.0	2029.9	1.5	2028.4	12.1	2017.8
13	1073.0	2030.2	2.4	2027.8	12.1	2018.1
14	1079.1	2030.2	2.9	2027.3	11.5	2018.7
15	1085.2	2030.7	3.9	2026.8	11.6	2019.1
16	1091.3	2031.0	4.0	2027.0	11.6	2019.4
17	1097.4	2031.2	4.0	2027.2	11.6	2019.6
18	1103.5	2031.5	4.1	2027.4	11.5	2020.0
19	1109.6	2032.0	3.8	2028.2	11.8	2020.2
20	1115.7	2032.3	3.4	2028.9	11.8	2020.5
21	1121.8	2032.7	3.3	2029.4	12.1	2020.6
22	1127.8	2033.0	3.4	2029.6	12.5	2020.5
23	1133.9	2033.1	3.3	2029.8	12.7	2020.4
24	1140.0	2033.4	3.4	2030.0	12.3	2021.1

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	544	1360	
Horizontal		1360	4303

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2034.5	1.8	2032.7	11.1	2023.4
C	1030.5	2034.8	2.1	2032.7	13.9	2020.9
D	1067.1	2036.3	1.9	2034.4	16.2	2020.1
E	1103.7	2036.8	4.2	2032.6	13.7	2023.1
F	1139.9	2037.4	3.4	2034.0	13.7	2023.7

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2034.5	1.8	2032.7	11.1	2023.4
2	1006.1	2034.1	2.1	2032.0	11.2	2022.9
3	1012.2	2034.0	2.8	2031.2	13.0	2021.0
4	1018.3	2034.0	3.0	2031.0	12.8	2021.2
5	1024.4	2034.3	2.8	2031.5	13.0	2021.3
6	1030.5	2034.8	2.1	2032.7	13.9	2020.9
7	1036.6	2035.1	2.2	2032.9	14.6	2020.5
8	1042.6	2036.1	2.9	2033.2	15.7	2020.4
9	1048.7	2036.4	2.6	2033.8	16.1	2020.3
10	1054.8	2036.7	2.7	2034.0	16.5	2020.2
11	1060.9	2036.5	2.3	2034.2	16.4	2020.1
12	1066.9	2036.3	1.8	2034.5	16.2	2020.1
13	1073.0	2035.9	2.0	2033.9	15.8	2020.1
14	1079.1	2036.3	3.0	2033.3	16.0	2020.3
15	1085.2	2036.0	3.1	2032.9	15.2	2020.8
16	1091.3	2036.3	3.6	2032.7	15.0	2021.3
17	1097.4	2036.5	3.9	2032.6	14.6	2021.9
18	1103.5	2036.8	4.3	2032.5	13.8	2023.0
19	1109.6	2037.5	4.1	2033.4	12.7	2024.8
20	1115.6	2037.2	3.0	2034.2	10.1	2027.1
21	1121.7	2037.4	2.8	2034.6	8.5	2028.9
22	1127.7	2037.4	2.6	2034.8	7.9	2029.5
23	1133.8	2037.4	3.0	2034.4	8.2	2029.2
24	1139.9	2037.4	3.4	2034.0	13.7	2023.7

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	437	1135	
Horizontal		1135	3793

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2040.9	3.2	2037.7	9.4	2031.5
C	1030.5	2040.8	3.2	2037.6	13.1	2027.7
D	1067.1	2043.8	2.9	2040.9	14.2	2029.6
E	1103.7	2042.7	3.5	2039.2	13.9	2028.8
F	1139.8	2044.0	4.0	2040.0	9.3	2034.7

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2040.9	3.2	2037.7	9.4	2031.5
2	1006.1	2041.2	3.5	2037.7	10.1	2031.1
3	1012.2	2041.4	3.8	2037.6	12.2	2029.2
4	1018.3	2041.7	4.1	2037.6	13.0	2028.7
5	1024.4	2041.5	3.9	2037.6	13.0	2028.5
6	1030.4	2040.8	3.2	2037.6	13.1	2027.7
7	1036.5	2041.1	2.6	2038.5	13.6	2027.5
8	1042.5	2042.4	3.4	2039.0	14.8	2027.6
9	1048.6	2042.9	3.1	2039.8	14.4	2028.5
10	1054.7	2043.3	2.9	2040.4	14.2	2029.1
11	1060.7	2043.6	2.9	2040.7	14.1	2029.5
12	1066.8	2043.8	2.9	2040.9	14.2	2029.6
13	1072.9	2043.9	3.0	2040.9	14.4	2029.5
14	1079.0	2043.9	3.0	2040.9	14.7	2029.2
15	1085.1	2043.5	2.9	2040.6	14.5	2029.0
16	1091.2	2043.2	3.5	2039.7	14.3	2028.9
17	1097.3	2043.1	3.7	2039.4	14.3	2028.8
18	1103.4	2042.7	3.5	2039.2	14.0	2028.8
19	1109.5	2042.8	3.5	2039.3	13.6	2029.2
20	1115.6	2042.9	4.0	2038.9	12.8	2030.1
21	1121.7	2042.7	4.0	2038.7	11.4	2031.3
22	1127.7	2043.1	4.1	2039.0	10.4	2032.7
23	1133.8	2043.2	3.7	2039.5	8.6	2034.6
24	1139.8	2044.0	4.0	2040.0	9.3	2034.7

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	350	1207	
Horizontal		1207	2425

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2039.5	5.7	2033.8	16.9	2022.6
C	1030.5	2044.9	4.8	2040.1	23.8	2021.1
D	1067.1	2052.7	2.6	2050.1	25.6	2027.1
E	1103.7	2051.6	4.3	2047.3	12.6	2039.0
F	1138.4	2054.8	2.8	2052.0	11.1	2043.7

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2039.5	5.7	2033.8	16.9	2022.6
2	1006.0	2040.5	5.7	2034.8	17.2	2023.3
3	1012.0	2041.5	5.5	2036.0	16.5	2025.0
4	1018.0	2042.6	5.4	2037.2	19.8	2022.8
5	1024.1	2043.6	5.1	2038.5	21.9	2021.7
6	1030.0	2044.9	5.0	2039.9	23.9	2021.0
7	1036.0	2046.1	4.4	2041.7	23.9	2022.2
8	1042.0	2046.9	3.1	2043.8	24.3	2022.6
9	1047.9	2048.5	3.3	2045.2	25.6	2022.9
10	1053.8	2050.0	3.1	2046.9	27.9	2022.1
11	1059.8	2051.3	3.7	2047.6	27.1	2024.2
12	1065.7	2052.7	2.8	2049.9	26.2	2026.5
13	1071.8	2053.6	2.7	2050.9	24.7	2028.9
14	1077.9	2053.9	1.9	2052.0	22.5	2031.5
15	1083.9	2053.5	2.4	2051.1	19.2	2034.3
16	1090.0	2052.7	3.8	2048.9	16.8	2035.9
17	1096.0	2051.5	3.5	2048.0	14.4	2037.1
18	1102.1	2051.6	4.4	2047.2	13.1	2038.5
19	1108.2	2052.0	4.4	2047.6	11.9	2040.1
20	1114.2	2052.6	4.0	2048.6	11.1	2041.5
21	1120.3	2053.5	4.0	2049.5	10.3	2043.3
22	1126.3	2053.8	3.4	2050.4	8.8	2045.0
23	1132.4	2054.0	2.8	2051.2	8.6	2045.4
24	1138.4	2054.8	2.8	2052.0	11.1	2043.7

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	429	1361	
Horizontal		1361	2743

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	2045.7	3.7	2042.0	20.5	2025.2
C	1030.5	2048.2	6.3	2041.9	23.9	2024.3
D	1067.1	2048.8	7.5	2041.3	19.4	2029.4
E	1103.7	2049.1	6.2	2042.9	18.0	2031.1
F	1140.0	2049.9	5.3	2044.6	14.8	2035.1

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	2045.7	3.7	2042.0	20.5	2025.2
2	1006.1	2046.3	5.5	2040.8	21.0	2025.3
3	1012.1	2046.9	6.6	2040.3	20.3	2026.6
4	1018.2	2047.2	6.8	2040.4	21.8	2025.4
5	1024.3	2047.8	7.0	2040.8	22.9	2024.9
6	1030.4	2048.2	6.3	2041.9	23.9	2024.3
7	1036.5	2048.4	5.6	2042.8	24.9	2023.5
8	1042.6	2048.5	5.6	2042.9	25.1	2023.4
9	1048.6	2047.8	5.7	2042.1	24.2	2023.6
10	1054.7	2048.1	5.8	2042.3	23.0	2025.1
11	1060.8	2048.4	6.6	2041.8	21.5	2026.9
12	1066.9	2048.8	7.5	2041.3	19.4	2029.4
13	1073.0	2048.6	7.1	2041.5	17.3	2031.3
14	1079.1	2048.3	6.6	2041.7	16.4	2031.9
15	1085.2	2048.6	6.6	2042.0	16.7	2031.9
16	1091.3	2048.8	6.0	2042.8	17.2	2031.6
17	1097.4	2048.9	6.0	2042.9	17.5	2031.4
18	1103.5	2049.1	6.3	2042.8	18.0	2031.1
19	1109.6	2049.3	5.7	2043.6	18.1	2031.2
20	1115.7	2049.6	5.4	2044.2	17.6	2032.0
21	1121.8	2049.6	5.4	2044.2	16.8	2032.8
22	1127.8	2049.7	5.4	2044.3	16.4	2033.3
23	1133.9	2049.8	5.5	2044.3	15.3	2034.5
24	1140.0	2049.9	5.3	2044.6	14.8	2035.1

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	341	1626	
Horizontal		1626	4865

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1976.0	1.3	1974.7	5.6	1970.4
C	1030.5	1979.5	3.9	1975.6	8.3	1971.2
D	1067.1	1985.3	0.8	1984.5	14.3	1971.0
E	1103.7	1986.3	4.0	1982.3	12.6	1973.7
F	1139.1	1984.3	5.4	1978.9	9.3	1975.0

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1976.0	1.3	1974.7	5.6	1970.4
2	1006.1	1976.6	1.9	1974.7	5.9	1970.7
3	1012.1	1977.1	2.4	1974.7	6.3	1970.8
4	1018.2	1978.0	3.0	1975.0	7.1	1970.9
5	1024.2	1978.7	3.4	1975.3	7.7	1971.0
6	1030.3	1979.5	3.9	1975.6	8.3	1971.2
7	1036.3	1980.4	4.0	1976.4	9.3	1971.1
8	1042.4	1981.3	4.0	1977.3	10.4	1970.9
9	1048.3	1982.5	4.0	1978.5	11.8	1970.7
10	1054.4	1983.5	3.2	1980.3	13.0	1970.5
11	1060.4	1984.6	2.3	1982.3	14.0	1970.6
12	1066.4	1985.3	0.9	1984.4	14.4	1970.9
13	1072.5	1986.0	0.8	1985.2	14.5	1971.5
14	1078.4	1987.3	1.6	1985.7	15.2	1972.1
15	1084.5	1987.1	1.3	1985.8	14.4	1972.7
16	1090.6	1986.6	3.1	1983.5	13.5	1973.1
17	1096.7	1986.1	3.2	1982.9	12.8	1973.3
18	1102.8	1986.3	4.0	1982.3	12.7	1973.6
19	1108.9	1986.3	4.1	1982.2	12.4	1973.9
20	1115.0	1986.3	4.7	1981.6	12.2	1974.1
21	1121.1	1986.2	5.6	1980.6	11.8	1974.4
22	1127.1	1986.2	6.3	1979.9	11.8	1974.4
23	1133.1	1985.2	6.0	1979.2	10.5	1974.7
24	1139.1	1984.3	5.4	1978.9	9.3	1975.0

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	347	701	
Horizontal		701	1693

Spread 1 Depth and Elev of layers directly beneath SPs and Geos

SP	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
B	1000.0	1967.9	3.8	1964.1	3.8	1964.1
C	1030.5	1970.8	2.8	1968.1	4.4	1966.4
D	1067.1	1973.7	2.7	1971.0	15.1	1958.6
E	1103.7	1973.1	5.0	1968.1	10.9	1962.2
F	1139.7	1969.4	3.4	1966.0	4.1	1965.3

Geo	Surface X-Loc	Surface Elev	Layer 2 Depth	Layer 2 Elev	Layer 3 Depth	Layer 3 Elev
1	1000.0	1967.9	3.8	1964.1	3.8	1964.1
2	1006.1	1968.5	3.9	1964.6	3.9	1964.6
3	1012.2	1968.9	3.2	1965.7	3.2	1965.7
4	1018.2	1969.5	3.0	1966.5	3.1	1966.4
5	1024.3	1970.0	2.9	1967.1	3.3	1966.7
6	1030.4	1970.8	2.8	1968.0	4.4	1966.4
7	1036.4	1971.2	1.9	1969.3	5.9	1965.3
8	1042.5	1971.9	2.2	1969.7	8.0	1963.9
9	1048.6	1972.4	2.0	1970.4	10.6	1961.8
10	1054.7	1972.8	2.1	1970.7	13.1	1959.7
11	1060.7	1973.5	2.0	1971.5	14.7	1958.8
12	1066.8	1973.7	2.7	1971.0	15.1	1958.6
13	1072.9	1973.7	3.3	1970.4	14.1	1959.6
14	1079.0	1973.8	3.9	1969.9	14.7	1959.1
15	1085.1	1973.9	4.1	1969.8	15.1	1958.8
16	1091.2	1973.8	4.9	1968.9	15.2	1958.6
17	1097.3	1973.6	5.1	1968.5	14.5	1959.1
18	1103.4	1973.1	4.9	1968.2	10.9	1962.2
19	1109.5	1972.8	5.5	1967.3	9.2	1963.6
20	1115.5	1972.1	5.3	1966.8	8.8	1963.3
21	1121.6	1971.2	5.3	1965.9	8.0	1963.2
22	1127.6	1970.8	5.7	1965.1	6.9	1963.9
23	1133.6	1970.1	5.0	1965.1	5.5	1964.6
24	1139.7	1969.4	3.4	1966.0	4.1	1965.3

Velocities used to formulate the Depth Model

Spread 1	Layer 1	Layer 2	Layer 3
Vertical	355	1225	
Horizontal		1225	1516

APPENDIX G

Appendix G

UDOT Geotechnical Division Supplemental Retaining Wall Evaluation

Memorandum UTAH DEPARTMENT OF TRANSPORTATION

DATE: August 2000 (Finalized November 2000)

TO: Wes Starkenburg, P.E.- Project Manager

FROM: Grant Gummow, P.E.- Staff Geotechnical Engineer
Jim Higbee, P.E.- UDOT Geotechnical Engineer

CC: Keith Brown, P.E.- Chief, Geotechnical Engineering Division

SUBJECT: Supplemental Geotechnical Evaluation and Recommendations
MSE and Gabion Retaining Walls
SR-89 Logan Canyon Reconstruction Project- Tony Grove to Franklin Basin
*NH-0089(29)393

As discussed, we have performed geotechnical evaluation and provided design recommendations for the proposed mechanically stabilized earth (MSE) walls on the Logan Canyon Reconstruction Project for which no subsurface exploration had been performed; together with a selected three of the proposed gabion (rock-filled wire basket) walls for the project.

Background

The firm of Dames & Moore (now URS Corporation) was contracted in April 1999, to conduct a geotechnical investigation for the project. The scope of work for the investigation was to include exploratory drilling, analyses, and design recommendations for the proposed MSE walls. During the contract scope/negotiation process, it was determined that in order to reduce the cost of the investigation, some number of exploratory borings for proposed MSE walls would be eliminated. The walls for which borings were eliminated were deemed at that time to consist of those whose foundation bearing conditions appeared to be more favorable. Additionally, a number of walls which were originally slated to be gabion walls (which typically have no investigation performed), were later changed to MSE walls. The final number of MSE and gabion walls are 20 and 6, respectively.

After a field reconnaissance where the settings of the proposed walls located up-station of the Upper Twin bridge were inspected, it was decided that some additional site evaluation/ exploration should be performed at locations for the following proposed MSE walls:

R-376E, R-376F, R-376G, R-376H, R-376I, R-376O, R-376P
And gabion walls R-377E and R-377F

In addition, it was determined that some minimal stabilization rock should be placed for stability purposes and improved bearing capacity beneath several other proposed walls as discussed in the Recommendations section, which follows.

Wall Setting Conditions

The canyon opens significantly throughout these segments of the proposed roadway widening and many springs and branches of the Logan River feed the river throughout the length of this portion of the project. Highway 89 follows the Logan River and crosses it (or one of its tributaries) several times

throughout the length of these segments. Several of the proposed walls will allow widening of these bridges and their approaches while minimizing encroachment of the river and surrounding areas.

In general, the proposed walls that we evaluated ranged from about 1.8 m (6 ft) to 3.6 m (12 ft) in height, and were located about 2 m (6 ft) to 7 m (23 ft) away from the existing roadway shoulders on very gentle to steep existing slopes with moderate to heavy vegetation.

Stability Analyses

In order to maintain a factor of safety for stability of 1.3, a minimum unconfined compression strength was determined for two of the proposed walls, using the program PCStable6. A surcharge load over the traffic lanes equivalent to 13 kPa (0.27 ksf) was used to represent traffic loads as recommended by AASHTO in Articles 3.20.3 and 5.8. As the foundation soils for these walls was determined to be primarily cohesive in nature, a soil friction angle of 0 degrees was used. The minimum unconfined compressive strength (qu) to maintain a factor of safety for stability of 1.3 under static conditions was determined for Wall R-376I and R-376O to be 81 kPa (1.7 ksf) and 48 kPa (1 ksf), respectively.

Bearing Capacity Analyses

Terzaghi's modified general ultimate bearing capacity equation was used to evaluate the bearing capacity of the proposed walls. Any beneficial effect of wall embedment was neglected due to the potential of the soil being removed through natural or manmade processes during its service life (e.g. erosion, utility installation, etc.). A surcharge load over the traffic lanes equivalent to 13 kPa (0.27 ksf) was used to represent traffic loads as recommended by AASHTO in Articles 3.20.3 and 5.8. As discussed above, a soil friction angle of 0 degrees was used for the foundation soils. For several of the highest walls, the minimum unconfined compressive strength (qu) to maintain a factor of safety for bearing capacity of 2.5 under static conditions was determined to be about 48 kPa (1 ksf). During the site explorations a layer of soft material was found at the surface at several proposed wall locations, which are to be mitigated as described in the following Recommendations section.

Recommendations

Based on the information gathered during the field reconnaissance and the subsequent additional site explorations, a selected number of the proposed walls should be placed on a layer of stabilization rock, for either increased stability or foundation bearing capacity, or both.

- To account for the observed layers of soft material, the following walls should be placed on 0.3m stabilization rock: Northern half of R-376G
- R-376L
- Most of R-376M
- R-377F
- Southern 3/4 of R-376O
- Southern 3/4 of R-376P
- R-376R
- Southern end of R-376T

To account for what appears to be less thick soft material and/or somewhat firmer material, MSE wall R-376K and most of gabion wall R377E should be founded on 0.15 m stabilization rock.

Additionally, although the following MSE walls are to be founded on what appears to be firm material, we recommend that the base of the walls (i.e. their leveling pad) be extended in depth to provide additional stability, because of the steepness of the slopes where they are located.

- Northern half of R-376F
- R-376I
- R-376J
- R-376Q