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REPORT
GEOTECHNICAL STUDY
CULVERT STRUCTURES
UTAH LAKE DISTRIBUTOR CANAL, UTAH AND SALT LAKE CANAL, AND SOUTH JORDAN CANAL
12300 SOUTH DESIGN-BUILD PROJECT
***HPP-STP-0071(12)0**
DRAPER, UTAH

Submitted To:

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Submitted By:

AMEC Earth & Environmental, Inc.
Salt Lake City, Utah

December 13, 2002

Job No. 2-817-004066/4065

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GRW
12257 South Business Park Drive
Suite 108
Draper, Utah 84020

Attention: Mr. Con Wadsworth

Gentlemen:

Re: Report
Geotechnical Study
Culvert Structures
Utah Lake Distributor Canal, Utah and Salt Lake Canal,
and South Jordan Canal
12300 South Design-Build Project
*HPP-STP-0071(12)0
Riverton, Utah

1. GENERAL

1.1 INTRODUCTION

This report summarizes geotechnical design recommendations for new culvert structures where 12600 South crosses the Utah Lake Distributor Canal, the Utah and Salt Lake Canal, and the South Jordan Canal. The general locations of the culvert sites with respect to major topographic features and existing facilities, as of 1999, are presented on Figure 1, Vicinity Map. The planned layouts and cross sections of the culverts are presented on Figures 2A through 2C, Culvert Layout Plan. The locations of the borings drilled in conjunction with this study, and previous studies where applicable, are presented on Figures 3A through 3C, Exploration Location Plan.

The general conclusions and recommendations described herein were provided to the design-build team during the course of this study verbally, via email, and in memoranda The recommendations provided herein apply to the design and construction of the culvert structures and do not address roadway construction or design or construction of temporary shoring and bracing that may be needed. Please note that the conclusions and recommendations provided herein are subject to review and comment by external agencies and may be revised accordingly.

Geotechnical recommendations for the new culvert structure for the Jordan and Salt Lake Canal crossing were provided in a report dated November 22, 2002[1].

1.2 PROJECT DESCRIPTION

The 12300 South Design-Build Project (Project) will consist of widening 12300/12600 South Street. This will affect the following canals:

Canal	Project Station	Approximate Location
Utah Lake Distributor	49+15.27	3250 West 12300 South
Utah and Salt Lake	102+24.30	2260 West 12300 South
South Jordan	141+33.01	1530 West 12300 South
Jordan and Salt Lake	267+47.38	120 West 12300 South

The proposed construction for the Jordan and Salt Lake Canal culvert structure is discussed in our November 22 report. The following sections discuss the proposed construction at the other three culvert locations.

1.2.1 Utah Lake Distributor Canal

Currently, the Utah Lake Distributor Canal crosses beneath 12600 South Street through an existing reinforced concrete box culvert, which has a span width of approximately 12 feet. There is an 8-inch diameter, welded-steel water line crossing the Canal just south of the culvert. In order to widen the roadway, a longer culvert will replace the existing box culvert. Based on preliminary culvert design information, the new culvert will be a reinforced concrete, box structure with a length of about 106 feet, an inside width of 12 feet, and an inside height of 6 feet. The culvert lid and sidewalls will be 12 inches thick. It is anticipated that, in order to maintain traffic, the new culvert will consist of at least two sections constructed in separate phases.

Site earthwork will include excavation for the new culvert sections, placement of bedding fill, and placement of wall backfill. The invert elevation of the culvert will drop from 4561.71 feet at the south end to 4561.68 feet at the north end. As currently designed, the culvert will have a base slab thickness of 13 inches and be installed over a 1.5-foot thick bedding fill zone consisting of granular

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[1] "Report, Geotechnical Study, Jordan and Salt Lake Canal, Culvert Structure, 12300 South Design-Build Project, *HPP-STP-0071(12)0, Draper, Utah," AMEC Job No. 2-817-004066/4065.

borrow. Planned pavement grade at the culvert will be about 4572 feet at the roadway crown, which is projected to be slightly less than existing grades. The base of the required excavation is projected to extend about 13 to 14 feet below existing roadway grades.

1.2.2 Utah and Salt Lake Canal

Based on available information, the existing 12600 South canal crossing is a double-T, concrete bridge structure. In order to widen the roadway, a culvert will replace the existing bridge structure. Based on preliminary culvert design information, the culvert will be a reinforced concrete, box structure with a length of about 106.0 feet, an inside width of 16.0 feet, and an inside height of 6.75 feet. The culvert lid and sidewalls will be 13 and 12 inches thick, respectively. It is anticipated that, in order to maintain traffic, the new culvert will consist of at least two sections constructed in separate phases.

Site earthwork will include excavation for the culvert sections, placement of granular borrow bedding fill, and placement of granular borrow wall backfill. The invert elevation of the culvert will drop from 4475.29 feet at the south end to 4475.18 feet at the north end. As currently designed, the culvert will have a base slab thickness of 14 inches and be installed over a 1.5-foot thick bedding fill zone consisting of granular borrow. Planned pavement grade at the culvert will be about 4486 feet at the roadway crown, which is projected to be about 2.0 feet above existing grades. The base of the required excavation is projected to extend about 11.0 to 12.0 feet below existing roadway grades.

1.2.3 South Jordan Canal

In material provided with the Project RFP, the existing 12600 South canal crossing is described as a concrete-faced box culvert that has been widened several times. It has been speculated that the center of the structure may be 70 years old or more and could consist of a masonry/cobble structure covered with concrete. According to a 1964 as-built drawing[2] by the Utah Department of Highways (UDOH) provided in the RFP, the current crossing consists of an approximately 20-foot wide bridge consisting of pre-cast concrete beams supported by reinforced concrete abutments founded on timber piles.

Based on preliminary culvert design information, the new culvert will be a reinforced concrete, box structure with a length of about 111 feet, an inside width of 16 feet, and an inside height of 6 feet. The culvert lid and sidewalls will be 13 and 12 inches thick, respectively. It is anticipated that, in

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[2] Drawing D-758, Sheet 1 of 7, Titled "Draper Crossroads to Riverton, Jordan & South Jordan Canal Bridges, General Layout," dated February 3, 1964.

order to maintain traffic, the new culvert will consist of at least two sections constructed in separate phases.

Site earthwork will include excavation for the culvert sections, placement of granular borrow bedding fill, and placement of granular borrow wall backfill. The invert elevation of the culvert will drop from 4418.97 feet at the south end to 4418.95 feet at the north end. As currently designed, the culvert will have a base slab thickness of 14 inches and be installed over a 1.5-foot thick bedding fill zone consisting of granular borrow. Planned pavement grade at the culvert will be about 4429 feet at the roadway crown, which is projected to be about 3.0 feet above existing grades. The base of the required excavation is projected to extend about 12.0 to 13.0 feet below existing roadway grades.

1.2.4 Culvert Loads

We project that, under normal operations, the culverts will vary from about one-half full to nearly full for an extended period of several months each year. Assuming an even distribution of load across the base of the culvert, we have calculated maximum base contact pressures ranging from about 1,250 pounds per square foot at the Utah Lake Distributor Canal crossing to about 1,350 pounds per square foot at the Utah and Salt Lake Canal crossing under the maximum total loads of the culverts. The maximum total loads of the culverts would include the weight of the culvert, the weight of the water when full, the overlying pavement section and a traffic surcharge of 250 pounds per square foot. When no water is in the culverts, the maximum base contact pressures are calculated to range from 750 to 850 pounds per square foot.

2. PREVIOUS REPORTS AND INVESTIGATIONS

In the 1960's, the Utah Department of Highways (UDOH) completed the Draper Cross Roads to Riverton Project along 12300/12600 South Street. For that project, UDOH conducted soil borings at the canal crossings, including a boring at the South Jordan Canal crossing to a depth of about 30 feet below grade existing at that time. The log of that boring is included on a drawing prepared in 1961[3] for the canal crossings. The approximate location of that boring is indicated on Figure 3C, Exploration Location Plan. The approximate location of the boring (labeled UDOT-1) is projected from the location indicated on the 1961 UDOH drawing.

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[3] Drawing D-758, Sheet 7 of 7, Titled "Draper Cross Roads to Riverton, Jordan and South Jordan Canal Bridges, Soil Data"

3. EXISTING FACILITIES

The culvert locations are currently occupied by the existing canal structures as described in Section 1.2, Project Description, of this report, as well as by 12600 South Street pavement structures, including curbs and gutters. Gravel-surfaced canal service roads are located adjacent to each canal.

According to the 1964 UDOH as-built drawing, the Draper Cross Roads to Riverton Project included constructing a bridge crossing over the South Jordan Canal. That bridge consisted of pile-supported abutments supporting a deck spanning about 20 feet. At some point, the existing box culvert apparently replaced the bridge. If so, the timber piles supporting the bridge abutments may still be in place and could be encountered during excavation.

Numerous underground utilities extend along 12600 South Street at the canal crossings. At each crossing these utilities can include gas lines, numerous telephone lines, storm drain lines, a sanitary sewer line, and culinary water lines. Based on the limited cover projected to exist at each existing canal crossing structure, and the limited cover planned over the new structures, we project that the underground utilities pass beneath the existing canal crossing structures.

4. FINDINGS

4.1 SITE SURFACE CONDITIONS

Site conditions at each canal crossing are primarily defined by the existing site structures and other facilities occupying the sites as described in the previous sections of this report. All of the crossing sites are essentially flat, with the exception of the open-channel portions of the canals to the north and south of 12600 South Street. Areas not covered by gravel surfacing, asphalt pavement, or concrete curb and gutter are currently vegetated. North of 12300 South Street vegetation is sparse, consisting mostly of native grasses and weeds. South of 12300 South Street vegetation consists of native grasses and weeds, and scattered brush and trees.

4.2 GEOLOGY

The canal crossing sites are located at the eastern edge of the Bonneville Basin, a deep, sediment-filled structural basin along the eastern edge of the Basin and Range physiographic province. The Bonneville Basin covers most of northwestern Utah and is bounded immediately to the east of the site by the Wasatch Range of the Middle Rocky Mountain physiographic province.

The topography and near-surface geology at the sites are the result of deposition and erosion processes, as well as tectonic activities, over the past approximately 32,000 years. During the

Bonneville Lake cycle, which began approximately 32,000 years ago, Lake Bonneville began a slow transgression (rise), with several fluctuations and pauses, before reaching its highest level at about 5,200 feet above sea level about 16,000 years ago. Approximately 14,500 years ago, the lake level dropped rapidly to a level of about 4,880 feet above sea level as the result of catastrophic down cutting of the lake's natural dam at Red Rock Pass in southeastern Idaho. Isostatic rebound and rapid erosion of shoreline sands and gravels and deltaic deposits of the Bonneville phase generally accompanied the rapid decline in the lake level. Additional down cutting at Red Rock Pass and isostatic rebound, as well as changing climatic conditions, reduced the lake level to that near the present day level (4,210 feet above sea level) of the Great Salt Lake about 11,000 years ago.

During deeper lake periods, relatively thick lacustrine sequences of clays, silts, and laminated clays and silts were deposited in the Bonneville basin. As the lake level dropped, streams down-cut through the lake deposits along the mountain front, resulting in complex alluvial and deltaic deposits of granular silt, sand, and gravel that fingered out into the receding lake. In addition, shoreline processes resulted in beach sand and gravel deposits at various stages of the Lake Bonneville regression, and earthquake activity during the Holocene resulted in areas of liquefaction and consequent deformation of predominantly lacustrine sediments.

Based on conditions encountered in the borings, subsurface conditions at the canal crossing sites to depths of at least 30 feet consist predominantly of soils of lacustrine origin, including deltaic sand and gravel deposits from Rose and Butterfield Canyons to the west. The lacustrine soils are primarily fine-grained, consisting of layers of clays, silts, and fine sands, with occasional zones and layers of deltaic sands and gravels. Older, post-Bonneville alluvial deposits associated with the Jordan River are mapped west of the current river channel extending as far west as about 1300 West. Based on geologic mapping and conditions encountered in deeper borings conducted for the Project, the lacustrine soils are projected to extend to depths of over 100 feet and be underlain by coarse-grained non-lacustrine soils deposited during interglacial periods similar to conditions today.

4.3 GEOLOGIC HAZARDS

Geologic hazards at the canal crossing sites are considered to be primarily associated with seismic ground motion (versus fault hazard). Due to the locations of the sites, geologic hazards such as flooding, landslides, rock falls, and mud and debris flows will not occur.

4.4 FAULTS AND SEISMICITY

In general, the area in which the canal crossings are located is situated within the Intermountain Seismic Belt (Arabasz et al., 1992; Pechmann and Arabasz, 1995). This seismic zone extends from southern Nevada through the state of Utah northward to the Yellowstone area, and north along the mountainous part of western Montana. The Intermountain Seismic Belt is characterized by infrequent, yet moderate to large magnitude earthquakes with relatively shallow focal depths (typically less than 11 miles). Historically, the epicenter of the largest earthquake to occur within the Intermountain Seismic Belt was located near Hebgen Lake, Montana in 1959. That earthquake had a Moment magnitude of 7.3.

Geologic and geomorphic evidence shows that repeated, normal-slip surface faulting has occurred in the Salt Lake Valley through late Pleistocene to Holocene time. The Wasatch fault zone is the most obvious and continuous structural element of the prominent transition zone between the Basin and Range province to the west and the Colorado Plateau and Middle Rocky Mountain provinces to the east (Machette, et al., 1992). The Wasatch fault zone extends from Malad City, Idaho on the north to Fayette, Utah on the south, a distance of about 240 miles. Studies of the fault zone suggest that it is composed of 10 discrete segments, each of which may rupture independently during a major earthquake. Because the length of surface rupturing is generally dependent on earthquake magnitude, the largest earthquake on a single segment within the Wasatch fault zone is estimated to be a magnitude 7.3 event.

In general, earthquakes with magnitudes less than about 6.5 are not considered to cause surface rupturing. Therefore, the occurrence of these earthquakes is not limited to areas where faults have been mapped on the surface. Earthquakes with magnitudes between about 6.5 and 7.3 are expected in the region and are generally associated with identifiable faults, such as the Salt Lake segment of the Wasatch fault zone, that show evidence of recent seismic activity.

The Salt Lake Segment extends for about 28 miles from the Traverse Mountains to the south to the Salt Lake Salient to the north (Warm Springs area). The canal crossing sites are located between about five and one-quarter and six and seven-eighths miles west of the closest portion of the Salt Lake segment of the Wasatch fault zone, which presents the largest source of seismicity in the immediate project vicinity.

4.5 SUBSURFACE SOIL CONDITIONS

Our understanding of subsurface conditions at the canal crossing sites is based primarily on the results of our current field-exploration and laboratory-testing programs. Our field exploration program consisted of drilling five borings, AB-13 (South Jordan Canal), AB-14 and AB-15 (Utah and Salt Lake Canal), and AB-18 and AB-19 (Utah Lake Distributor Canal), to depths ranging from about 30.5 to 31.5 feet below existing ground surface. The approximate locations of the borings are indicated on Figures 3A through 3B, Exploration Location Plan. The subsurface exploration program included installation of temporary piezometers in Borings AB-15 and AB-18. A discussion of the field exploration procedures, together with our boring logs, is presented in Appendix A.

At the South Jordan Canal crossing, information provided on the log of the previous UDOH boring (UDOT-1) was used to further define subsurface conditions across the site. In addition, the information from our current field-exploration and laboratory-testing programs has been supplemented by current information developed at other Project sites by AMEC.

In general, the soils underlying the locations of the canal crossings to depths of about 30.5 to 31.5 feet consist primarily of fine-grained cohesive lacustrine soils, with occasional layers and zones of cohesionless fined-grained soils and coarse-grained deltaic sands and gravels. At all five boring locations, these natural lacustrine soils are overlain by about 0.5 to 1.5 feet of loose to medium dense, granular fill consisting of silty sand and gravels. These granular fills were placed as either roadway shoulder surfacing or canal service roadway surfacing.

The natural fine-grained lacustrine soils underlying the canal crossing sites consist primarily of lean silty clays and clayey silts encountered in moderately thick, relatively homogeneous to inter-layered zones. These lean silty clays and clayey silts are of generally low to moderate plasticity and contain varying amounts of fine sand and occasional layers of sandy silt, sand, and gravel. Silty clays encountered between the depths of about 12 and 23 feet in Boring AB-13 are moderately to highly plastic, and are classified as fat clays. Where encountered, these silty clay and clayey silt zones range in thickness from at least 5 feet (AB-19) to as much as 15 feet (AB-18). Based on drive sampler penetration resistance, these silty clays and clayey silts range from stiff to very stiff.

Below depths ranging from about 9 to 12 feet below ground surface, the borings encountered zones of cohesionless silts, sands, and gravels ranging in thickness from about 3 feet (AB-18 and AB-19) to as much as 13 feet or more (AB-19). Boring AB-13 encountered a 5-foot thick zone of clayey sand below the fat clays described in the previous paragraph. The cohesionless sands and gravels range from fine to coarse and contain varying amounts of silt. Based on drive sampler penetration resistance, these cohesionless soils range from medium dense to very dense.

The soils encountered at the location of Boring AB-13 generally correspond to those described on the log of the previous UDOT boring drilled at the site. The UDOT boring encountered moderately to highly plastic silty clays and clayey silts to a depth of about 22 feet below original site grade. Below the clays and silts, the boring generally encountered medium dense to dense, clean sands and gravels and silty fine to medium sands to the full depth explored of about 30 feet.

4.6 GROUNDWATER

Groundwater was not encountered during drilling at all five boring locations. Saturated soil conditions were observed in Boring AB-13 at a depth of about 10.0 feet, and wet to possibly saturated soils conditions were observed in Boring AB-19 below a depth of about 18.0 feet. A groundwater level of about 8.7 feet below ground surface is indicated on the log of the previous

UDOT boring, UDOT-1. It is not clear from the log if that depth represented stabilized groundwater conditions.

Piezometers were installed in Borings AB-15 and AB-18 to measure changes in static groundwater levels at the sites of the Utah and Salt Lake Canal and Utah Lake Distributor Canal crossings. Due to site restrictions, a piezometer could not be installed at the location of Boring AB-13. Measurement of stabilized groundwater levels at the piezometer locations was conducted on August 8, September 7, and October 22, 2002. At both piezometer locations, groundwater was not encountered at depths above the bottom of the piezometers (20 feet below ground surface).

It should be noted that the boring were drilled and the piezometers were measured during or near the end of summer when groundwater levels are typically near their highest level, and within the fourth year of an extended drought cycle. Seasonal and long-term groundwater levels are expected to fluctuate by one to two feet, with the lowest groundwater levels occurring during the late fall and winter months.

5. EARTHQUAKE CONSIDERATIONS

5.1 SEISMIC HAZARDS

Site faulting and seismicity are discussed in Section 4.4 of this report. Seismic hazards that could be expected at the site would include ground shaking and potential liquefaction.

5.2 DESIGN CRITERIA

5.2.1 Site Class

Based on available geologic information, subsurface conditions encountered at the canal crossing sites, and deep (over 100 feet) subsurface information developed at other Project locations, the site is considered to meet the criteria for Site Class "D" (stiff soil profile) as described in Table 1615.1.1 of the 2000 International Building Code (IBC 2000).

5.2.2 Ground Motion

The United States Geologic Survey (USGS), through the National Earthquake Hazards Reduction Program (NEHRP, 1997), has evaluated and mapped the general seismic characteristics of the conterminous United States, particularly the western United States. The UDOT Manual of Instruction requires that the NEHRP ground motion data be used in seismic design of highway structures. The NEHRP ground motion data are probabilistic peak horizontal ground accelerations associated with points mapped on a grid system. The ground motion data for a site can be determined based on the latitude and longitude coordinates of the site. The acceleration values apply to the dense soil to rock boundary between Site Classes "B" and "C" (Site Class "B-C" Boundary), as defined by NEHRP 1997.

The coordinates of the canal crossing sites are provided in the following table along with the ground motion values for the USGS grid point closest to each site location. The ground motion values in the table incorporate soil amplification factors for a Site Class "D" soil profile.

	Site Coordinates		**Probabilistic Peak Horizontal Ground Accelerations, PGA, With Soil Amplification (percent g)**	
Canal Crossing	**North Latitude (degrees)**	**West Longitude (degrees)**	**10% in 50 yr Event (475-yr return period)**	**2% in 50 yr Event (2475-yr return period)**
South Jordan	40.5222	-111.9347	0.30	0.50
Utah and Salt Lake	40.5223	-111.9487	0.29	0.50
Utah Lake Distributor	40.5222	-111.9677	0.29	0.49

5.2.3 Liquefaction

Liquefaction is defined as the condition when saturated, loose, and cohesionless, sand-type soils lose their support capabilities because of excessive pore water pressure that develops during a seismic event. Several conditions are generally necessary for liquefaction to develop: loose cohesionless soils, a moderate to high groundwater table, and sufficient ground motion to cause the soils to liquefy.

We have analyzed the liquefaction potential for the canal crossing sites for both the 10 percent in 50-year and the 2 percent in 50-year seismic events. Our analyses were conducted using methods that correlate liquefaction primarily to soil density determined from sampler driving resistance (standard penetration test (SPT) N-values).

The results of our liquefaction analyses indicate that liquefaction will not occur at the culvert crossing sites during the 10 percent in 50-year event, but may occur at the Utah and Salt Lake Canal and South Jordan Canal crossings during the 2 percent in 50-year event. Our analyses indicate that liquefaction at those sites would be limited to isolated, relatively thin (3.0 to 4.5 feet thick) zones of silty to clayey fine to medium sands at depths of about 23 feet below existing site grades.

The primary effect of potential liquefaction at the Utah and Salt Lake Canal and South Jordan Canal crossings under the 2 percent in 50-year event will be differential, post-earthquake ground-surface settlement. Calculations based on soil density relationships (SPT "N" values) indicate that potential ground-surface settlements ranging from about one-half to five-eighths of an inch may occur. These calculations do not consider the benefit provided by the non-liquefiable deposits overlying the potentially liquefiable layers. It should be noted that this effect of liquefaction would be felt broadly across the site vicinity, with similar post-earthquake ground surface settlements occurring along 12600 South Street and along adjacent portions of the canals.

Another significant effect of liquefaction is "lateral spreading," which can occur on sloping sites, sites with abrupt vertical faces intersecting liquefiable zones, or sites where the liquefiable soils are relatively thick and close to the ground surface. The ground surfaces surrounding the culvert structures are essentially flat, and the shallowest potentially liquefiable soil zones are considered to be about 23 feet below existing ground surfaces. Although canal banks to the north and south of each canal crossing site would be considered steep faces, available subsurface information would indicate that these banks do not intersect liquefiable soil zones. Accordingly, the potential for liquefaction-induced lateral spreading affecting the canal culvert structures is considered to be negligible.

6. LABORATORY TEST DATA

6.1 LABORATORY TESTING

A series of laboratory tests were performed on disturbed and undisturbed samples from our current explorations to assess geotechnical properties of the soils along the mainline alignment. Laboratory testing included evaluation of soil index properties and determination of soil strength and compressibility characteristics. A description of our laboratory program, including test procedures and results, is presented in Appendix C.

Classification testing was performed to determine soil index properties including natural moisture content, in-situ dry density, Atterberg Limits, and grain-size distribution. The index properties were determined for use in soil classification, correlation of field and other laboratory test data, and specific analyses, including liquefaction potential.

Laboratory vane shear strength testing was conducted on six relatively undisturbed samples to determine the undrained shear strength of fine-grained cohesive soils encountered in the explorations. Strength values from relevant tests were used to evaluate the bearing capacity of the near-surface fine-grained cohesive soils and in preparing recommendations for temporary cut slopes in those soils. The results of the vane shear tests indicate that the undisturbed fine-grained cohesive soils underlying the canal crossing sites possess moderate shear strengths ranging from about 1,850 to over 4,000 pounds per square foot.

One-dimensional consolidation testing was conducted on three relatively undisturbed samples of fine-grained cohesive soils to determine their compressibility characteristics. The results of these tests were used to evaluate settlement of the culvert structures. The results of the consolidation tests indicate that the fine-grained cohesive soils underlying the canal crossing sites are moderately to highly over-consolidated near the surface, with over-consolidation ratios (OCR) (ratio of past maximum effective stress to current effective stress) ranging from about 3.8 to 7.4 to the depths explored of between 30.5 and 31.5 feet. When loaded below the past maximum consolidation pressure, the fine-grained cohesive soils will exhibit relatively low compressibility characteristics.

To determine if the soils at the canal crossings will react detrimentally with concrete, pH and soluble sulfates tests were performed on three representative samples of the soils from the canal crossing sites. The results of those tests indicate that those soils are mildly to moderately alkaline and contain negligible amounts of water-soluble sulfates. Based on the above values, the potential of the site soils, particularly near-surface soils, to react detrimentally with concrete are considered to be negligible.

7. CULVERT STRUCTURES

7.1 GENERAL

The following sections provide geotechnical recommendations for design of the new culvert structures. Unless specifically noted, the recommendations provided in the following sections are applicable for all three canal crossing sites.

7.2 FOUNDATION DESIGN CRITERIA

7.2.1 Allowable Bearing Pressure

Since the depths of the culverts are less than one-half their width, the culverts are considered to be similar to a shallow, strip footing. In evaluating the allowable bearing pressures for the culverts, the relatively stiff cohesive soils encountered to depths of between about 18 and 25 feet below existing site grades were considered to be the controlling subsurface soils. Based on laboratory shear strength testing, these soils, when undisturbed, are considered to possess minimum undrained shear strengths of at least 1,850 pounds per square foot.

Based on the projection that the culverts will behave as shallow, strip footings, we have calculated an allowable bearing pressure of at least 3,100 pounds per square foot for all of the culvert structures. This value includes a factor of safety of 3. This allowable bearing pressure may be increased by one-third for total load conditions (dead plus transient live loads), including for evaluating edge pressure increases. Actual maximum pressures acting at the base of the culvert slab/foundation are projected to range from about 1,250 to 1,350 pounds per square foot, which are much less than the calculated allowable bearing pressure.

7.2.2 Settlement

As previously described in this report, we project that, under normal operations, the culverts will vary from about one-half full to nearly full for an extended period of several months each year. Assuming an even distribution of load across the base of the culverts, we calculate maximum base contact pressures of between 1,250 and 1,350 pounds per square foot under the maximum total loads of the culverts. The maximum total loads of the culverts would include the weight of the culvert, the weight of the water when full, the overlying pavement section and a traffic surcharge of 250 pounds per square foot. When no water is in the culverts, the maximum base contact pressures are calculated to be between about 750 and 850 pounds per square foot.

Based on the results of consolidation testing, the cohesive soils underlying the canal crossing sites are considered moderately to highly over-consolidated, with over-consolidation ratios above 3. The maximum anticipated based contact pressures will be less than the past consolidation pressures experienced by these cohesive soils. Accordingly, settlements due to consolidation of the underlying cohesive soils are expected to be elastic. For the above maximum base contact pressures, we have calculated maximum total settlements ranging from about one-half to five-eighths of an inch. Differential settlements along the culvert are expected to be negligible. Since settlement will be elastic, two-thirds to three-quarters of the expected settlement is expected to be complete within four to five weeks after construction of each culvert and placement of the backfill. The additional settlement will occur under total dead plus live load conditions, which are projected to include the full water depth in the culvert and a traffic surcharge of 250 pounds per square foot.

7.2.3 Lateral Resistance

For the base of each culvert established on at least one and one-half feet of compacted granular backfill borrow fill extending to undisturbed natural cohesive soils, we recommend using a coefficient of 0.45 for determining base sliding lateral resistance. If used in combination with resistance from passive earth pressures, the base-sliding coefficient must be reduced by a factor of safety of 1.5.

7.2.4 Installation

The culverts may be established on granular backfill borrow fill extending to undisturbed natural cohesive soils. Under no circumstances can the culverts be established directly on non-engineered fills, soft, wet, or disturbed soils, frozen soils, or within ponded water.

The excavations will encounter and likely terminate in undisturbed, natural, fine-grained cohesive soils. The base of the excavations for the Utah Lake Distributor Canal and the Utah and Salt Lake Canal are projected to be at least five feet above static groundwater. The base of the excavation for the South Jordan Canal may be below the static groundwater level. The natural, fine-grained, cohesive subgrade soils projected to underlie the culvert sites may degrade significantly during placement of forms and reinforcing steel, or other construction activities, where the base of the excavation is near or below the groundwater level and during wet periods of the year. It is our opinion that including the one and one-half feet of granular backfill borrow fill beneath the culvert will facilitate construction by limiting construction-related disturbance of the fine-grained, natural subgrade soils, particularly where those soils are saturated.

If very soft, saturated subgrade conditions are encountered, placement of the granular backfill borrow fill to the required density may be difficult, if not impossible. In that case, we recommend over-excavating the subgrade soils to a depth of at least 12 inches and replacing those soils with granular stabilizing fill as described in Section 8.3.2, Stabilizing Fill, of this report. Once the subgrade has been stabilized, a geotextile separation fabric must be placed over the stabilized fill prior to placing and compacting the granular backfill borrow. Alternatively, a geotextile reinforcing/separation fabric could be placed over the exposed subgrade before placement and compaction of the granular backfill borrow fill. If a separation fabric must be used, we recommend placing a two to three-inch layer of coarse gravel at the base of the excavation prior to placing the fabric. This will help limit displacement of the subgrade soil during placement of the initial backfill lift. If the granular backfill borrow fill becomes disturbed after placement and compaction, the fill must be re-compacted to UDOT's requirements for granular backfill borrow prior to pouring concrete.

The width of granular backfill borrow fill below the culvert should extend laterally at least six inches beyond the edges of the culvert for each foot of fill thickness beneath the culvert. For example, if the width of the culvert is 16.0 feet and the thickness of the fill beneath the culvert is 1.5 feet, the width of the fill zone at the base of the excavation would be a total of 17.5 feet.

7.3 LATERAL EARTH PRESSURES

The culverts will retain backfill placed between the structure and the temporary excavation cuts. Since the backfill will be placed after the culvert deck is constructed, the culvert sidewalls will be restrained, resulting in an at-rest earth pressure state.

To facilitate placement and compaction, we recommend that the backfill consist of granular backfill borrow. In evaluating lateral earth pressure parameters, we assigned the granular backfill borrow a moist unit weight of 130 pounds per cubic foot and an internal friction angle of 35 degrees.

The following table lists equivalent fluid densities for use in determining design lateral earth pressures under static and seismic load conditions. The seismic criteria have been developed for horizontal acceleration coefficients of 0.30 and 0.50, which are the upper values for the sites and correspond to average ground motion return periods of 475 and 2,350 years.

	Equivalent Fluid Density (pcf)		
Load Condition	**Static**	**475-Year Event**	**2,350-Year Event**
At-Rest (restrained)	55	39[1]	65[1]
Passive	492[2]	521[3]	384[3]

[1] At-rest seismic equivalent fluid densities additional to the static at-rest values
[2] Factor of safety of 1.5
[3] Factor of safety of 1.0

If materials other than those described above are used as backfill immediately adjacent to the culvert walls, the above equivalent fluid densities must be modified. Modified equivalent fluid densities could be significantly higher.

It should be noted that the equivalent fluid density values provided above are based on the assumption that the backfill materials will not become saturated. The equivalent fluid density values may be decreased by 50 percent if the backfill becomes saturated. However, full hydrostatic water pressures will have to be included.

In determining the lateral earth pressures acting on the bridge structures and other retaining walls, we recommend the following approaches:

1. The total at rest seismic earth pressure is the summation of the static and seismic components. At-rest static and seismic earth pressures are determined using the above equivalent fluid densities. The total static at-rest force is determined and applied using a triangular pressure distribution. This approach ignores higher compaction induced at-rest

earth pressure near the top of the wall, but this is not considered critical for the short and relatively thick culvert sidewalls. The total seismic at-rest force is determined using an inverted triangular pressure distribution that decreases with depth. The maximum pressure is based on the height of the wall times the seismic equivalent fluid density. The total seismic at-rest force is applied at a point above the base of the wall equivalent to six-tenths to one-half the height of the retained soil.

2. The passive static and seismic earth pressures can be determined using the above equivalent fluid densities and are both applied using a triangular pressure distribution.

8. EARTHWORK

8.1 SITE PREPARATION

Site preparation will include demolition of existing pavements, curbs and gutters, and the existing culvert structure, as well as removal of existing riprap and vegetation. All demolition debris and vegetation, and any other deleterious materials encountered, must be totally removed from the site.

The subgrade should be prepared in accordance with UDOT requirements. To avoid disturbance of potentially wet and soft subgrade soils, excavation to planned subgrade should be accomplished using a smooth-lipped bucket. Placement of granular backfill borrow and stabilizing fill, if necessary, should proceed immediately after the excavation is complete to avoid unnecessary subgrade disturbance.

The 1964 as-built drawings by UDOT indicate that the South Jordan Canal crossing consisted of a bridge constructed as part of the Draper Crossroads to Riverton Project. That bridge consisted of pile-supported abutments supporting a deck spanning about 20 feet. At some point, the existing box culvert apparently replaced the bridge. If so, the piles supporting the bridge may still be in place and could be encountered during excavation. Piles encountered in the excavation must be cut off at an elevation of at least two feet below the base of the culvert.

8.2 TEMPORARY EXCAVATIONS

Excavations for the culverts are projected to encounter primarily undisturbed, natural, fine-grained, cohesive soils overlain by roadway fills. Based on shear strength testing, the undisturbed, natural, cohesive soils at the canal crossing sites possess relatively high strength, and excavations within these soils are expected to remain stable even when cut at vertical or nearly vertical slopes.

Temporary construction excavations in the undisturbed, natural, cohesive soils not exceeding four feet in depth and not overlain by existing fills may be constructed with near-vertical side slopes.

Deeper excavations up to 14 feet in depth in undisturbed, natural, cohesive soils above or below the groundwater table may be constructed with side slopes no steeper than one-half horizontal to one vertical (0.5H:1V). Loose or disturbed surficial soils at the top of temporary side slopes must be laid back at slopes no steeper than one and one-half horizontal to one vertical (1.5H:1V).

At the sites of the Utah and Salt Lake Canal and the Utah Lake Distributor Canal, excavations deeper than about 10 feet are likely to encounter zones of relatively clean sands and gravels or cohesionless silts. At those locations, static groundwater levels are expected to be at depths of at least 18 feet, which is below the projected maximum depth of excavation. Excavation for the South Jordan Canal is projected to encounter static groundwater at depths of around 8 to 10 feet and possible thin (2- to 4-inches thick) layers of clean to silty sands.

If cohesionless fine-grained or granular soils are encountered, particularly below the groundwater table, flatter side slopes, shoring and bracing, and/or dewatering systems will be required. To maintain traffic during phased construction, vertical or near-vertical cuts to depths of 11 to 12 feet may be required adjacent to travel lanes. Those cuts will likely require shoring and possibly bracing during construction for construction safety and protection of the 12300 South travel lanes.

Groundwater seepage, if present, is expected to be low and manageable using typical diversion ditches, small local sumps, and portable pumping equipment.

Qualified personnel must inspect all excavations periodically. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated.

8.3 STRUCTURAL FILL MATERIALS AND COMPACTION

8.3.1 General

In general, structural fill materials and their placement must conform to UDOT specifications. We anticipate that most structural fills used at the culverts will conform to UDOT's requirements for granular backfill borrow. However, fills used to stabilize soft or saturated subgrade soils must meet the following requirements.

8.3.2 Stabilizing Fill

Stabilizing fill would be used to stabilize soft subgrade conditions or where structural fill is required below a level one foot above the water table at the time of construction. Stabilizing fill should consist of a mixture of coarse gravels and cobbles or a gap-graded, angular, one and one-half to two-inch-minus gravel. Stabilizing fill, if utilized, should be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface at least twice. Subsequent granular backfill borrow placed over coarse stabilizing fills must be separated from the underlying stabilizing fill by a geotextile separation fabric.

9. EXISTING UTILITIES

We understand that 12600 South contains numerous underground utilities that pass under the existing canal crossing structures. The new culverts will have base elevation less than one foot lower than the existing culvert. With the exception of over-excavation to install underlying granular backfill borrow, construction of the new culverts may not directly impact those utilities. Clearance requirements established by the canal companies or the individual utility entities should be followed.

The maximum base contact pressures generated by the new culverts are projected to be similar to those generated by existing culverts. Accordingly, the loads generated by the new culvert are expected to have a minor, if not negligible, effect on the existing utilities.

10. PROFESSIONAL STATEMENTS

Supporting data upon which our discussions and recommendations are based are presented in previous sections of this report. The recommendations presented herein are governed by the physical properties of the soils encountered in the various explorations, projected groundwater conditions, and the layout and design data discussed in Section 1.2. Project Description, of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, AMEC must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices in use locally at this time.

We appreciate the opportunity of providing this service for you. If you have any questions or require additional information, please do not hesitate to contact us.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

Wade Gilbert
J. Wade Gilbert, State of Utah No. 367656
Sr. Geotechnical Engineer

Reviewed By:

William J. Gordon, State of Utah No. 146417
Professional Engineer

No. 146417
WILLIAM
GORDON

JWG/WJG:ka

Encl. Figure 1, Vicinity Map
Figure 2A through 2C, Culvert Layout Plan
Figures 3A through 3C, Exploration Location Plan
Appendix A, Field Explorations and Instrumentation
Appendix B, Explorations by Others
Appendix C, Laboratory Testing

Addressee (1)
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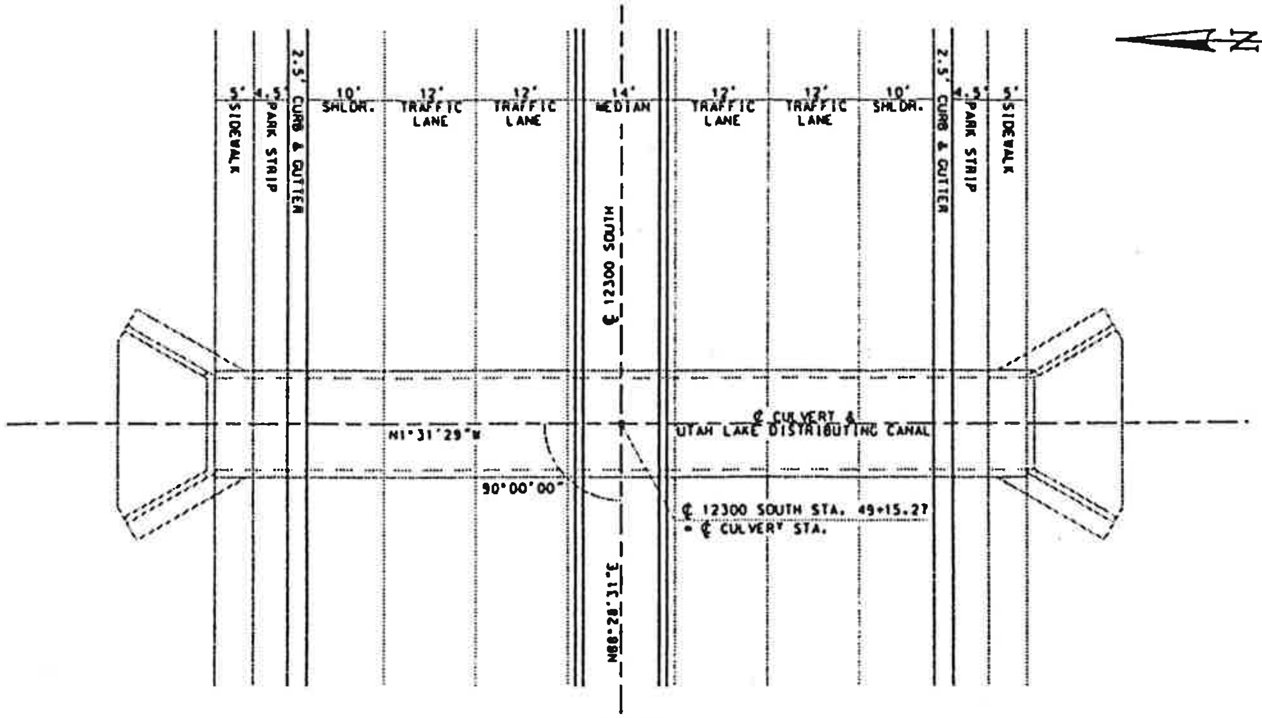
12300 SOUTH DESIGN-BUILD PROJECT *HPP-STP-0071(12)0
AMEC JOB NO. 2-817-004066 (4065)

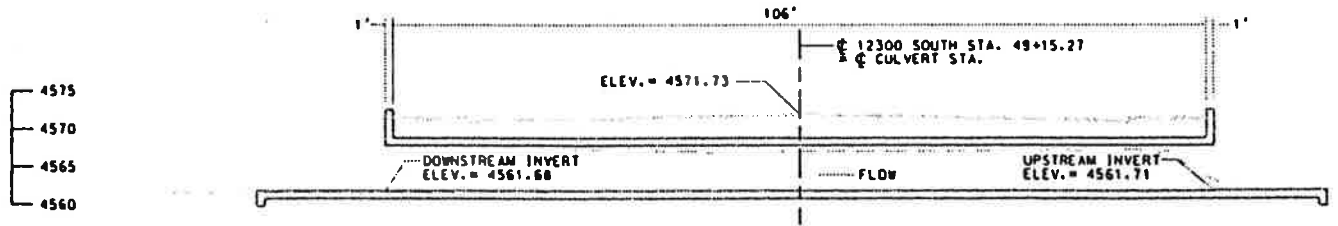
FIGURE 1
VICINITY MAP

REFERENCE:
USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAPS
TITLED "MIDVALE, UTAH" AND DRAPER, UTAH"
BOTH DATED 1963 PHOTOREVISED 1969 AND 1975

amec



PLAN



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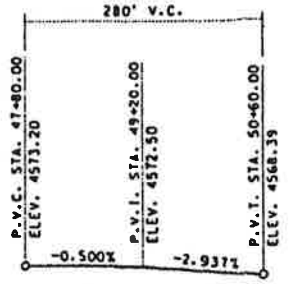
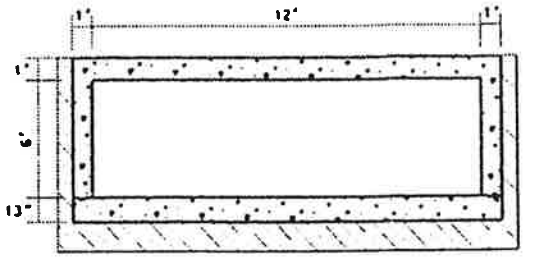


12300 SOUTH VERT. CURVE DATA



GRANULAR BACKFILL BORROW SHALL BE PLACED AROUND BARREL, WINGWALLS AND APRON AS SHOWN.

SECTION THROUGH BARREL

EXTRA EXCAVATION MAY BE REQUIRED AS DIRECTED BY THE ENGINEER FOR DEWATERING AND TO ENSURE THE CULVERT IS CONSTRUCTED ON UNIFORM, COMPETANT MATERIAL

QUANTITIES

ITEM	ESTIMATED	UNIT	AS CONSTRUCTED
CONCRETE		SQ. YD.	
REINFORCING STEEL (EPOXY COATED)		LB.	

GENERAL NOTES

1. ALL DIMENSIONS ARE SHOWN IN FEET AND INCHES. ALL STATIONS AND ELEVATIONS ARE SHOWN IN FEET.
2. PROVIDE 2" COVER TO REINFORCING STEEL UNLESS OTHERWISE SPECIFIED
3. ALL REINFORCING STEEL SHALL BE COATED. DEFORMED BILLET-STEEL BARS CONFORMING TO AASHTO M-31, GRADE 60.
4. CHAMFER EXPOSED CONCRETE CORNERS ¾ INCH EXCEPT WHERE NOTED OTHERWISE.
5. ALL CAST-IN-PLACE CONCRETE SHALL BE CLASS AA (AE).
6. ALL STRUCTURAL STEEL SHALL CONFORM TO AASHTO M-270, GRADE 36.
7. FOR CONSTRUCTION PHASING, SEE MAINTENANCE OF TRAFFIC PLANS.
8 CULVERT FLOWLINE ELEVATIONS ARE BASED ON SURVEY INFORMATION. FIELD VERIFY THE FLOWLINE ELEVATION FOR THE EXISTING CULVERT.
9. THE LOCATION OF THE EXISTING CULVERT IS BASED ON SURVEY INFORMATION. FIELD VERIFY THE LOCATION OF THE EXISTING CULVERT.

DESIGN DATA

HL-93 LOADING IN ACCORDANCE WITH CURRENT AASHTO LRFD SPECIFICATIONS.

CAST-IN-PLACE CONCRETE:
f'c = 3.65 KSI
FY (REINFORCEMENT) = 60 KSI

DESIGN DEPTH OF FILL = 2.34 FT.

MAXIMUM BEARING PRESSURE = 2000 PSF

DESIGN SPEED: 50 MPH 12300 SOUTH

HYDRAULIC DATA

DRAINAGE AREA = NA
DESIGN FREQUENCY = NA
VELOCITY AT OUTLET = ?.?? FOR 150 CFS, ?.?? FOR 300 CFS
100 YEAR DISCHARGE = NA
OVERTOPPING DISCHARGE = 300 CFS
FREQUENCY FOR OVERTOPPING FLOW = NA
WATER SURFACE ELEVATION FOR OVERTOPPING FLOW = ????.??

SUBGRADE PREPARATION

FOLLOWING EXCAVATION, THE SUBGRADE SHOULD BE PREPARED IN ACCORDANCE WITH THE REPORT OF THE GEOTECHNICAL INVESTIGATION BY AMEC EARTH AND ENVIRONMENT, THE GEOTECHNICAL ENGINEER, SUMMARIZED AS FOLLOWS:

REMOVE THE EXISTING STRUCTURE AND ALL DISTURBED SOILS, EXCESSIVELY SOFT SOILS, FROZEN SOILS, AND SOILS DISTURBED BY PLOUGHING, VEGETATION AND ANY TREES AND A MAJOR PORTION OF THEIR ROOT STRUCTURE BELOW SUBGRADE LEVEL AND REPLACE WITH GRANULAR MATERIAL.

PROVIDE ANY NECESSARY DEWATERING. DEWATERING MUST BE CONTINUALLY MAINTAINED ONCE STARTED.

PLACE AN EIGHTEEN-INCH MINIMUM THICKNESS OF GRANULAR BACKFILL BORROW AT THE BOTTTOM OF THE EXCAVATION.

EXTEND THE WIDTH OF STRUCTURAL REPLACEMENT GRANULAR MATERIAL BELOW THE FOOTING AT LEAST SIX INCHES LATERALLY BEYOND THE EDGES OF THE FOOTING IN ALL DIRECTIONS FOR EACH FOOT OF FILL THICKNESS BENEATH THE FOOTING.

APPROVED FOR CONSTRUCTION

JORDAN - SALT LAKE CITY CANAL DATE

RELEASE FOR CONSTRUCTION

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

RSC 10/02

12300 SOUTH INTERCHANGE
UTAH-LAKE DISTRIBUTION CANAL
SITUATION AND LAYOUT
PROJECT NUMBER #HPP-STP-0071(12)0

SALT LAKE

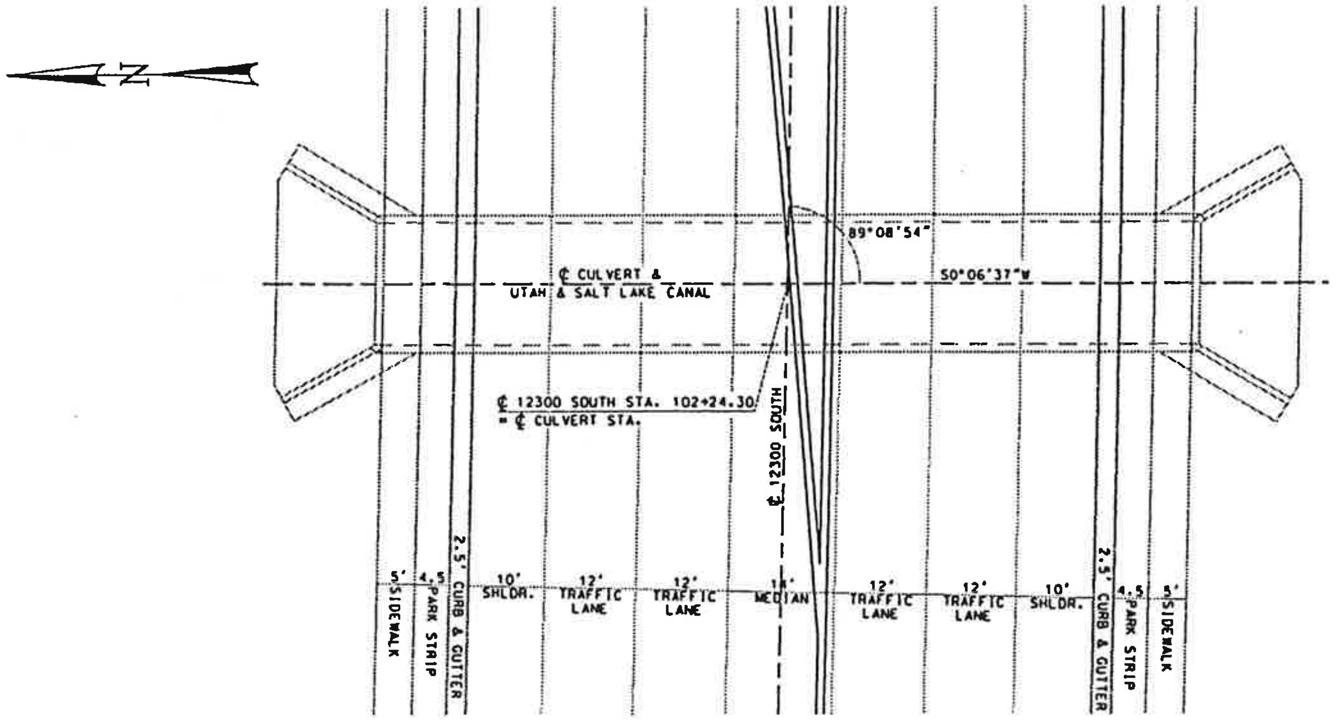
FIGURE 2A
CULVERT LAYOUT PLAN

NO SCALE

REFERENCE:
DRAWING PROVIDED BY
HW LOCHNER

amec

12300 SOUTH DESIGN-BUILD PROJECT *HPP-STP-0071(12)0
AMEC JOB NO. 2-817-004066 (4065)



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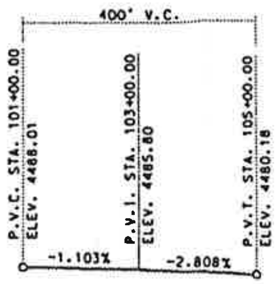
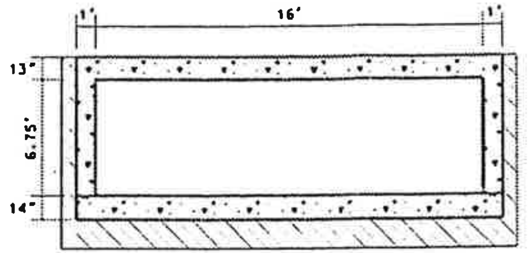


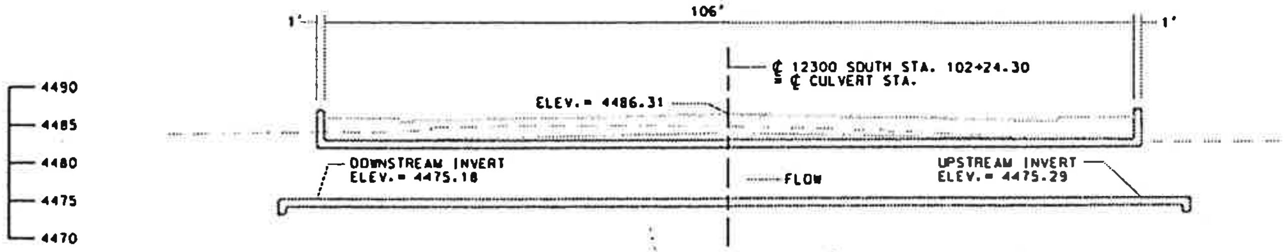
12300 SOUTH
VERT. CURVE DATA



GRANULAR BACKFILL BORROW SHALL BE PLACED AROUND BARREL. WINGWALLS AND APRON AS SHOWN.

SECTION THROUGH BARREL

EXTRA EXCAVATION MAY BE REQUIRED AS DIRECTED BY THE ENGINEER FOR DEWATERING AND TO ENSURE THE CULVERT IS CONSTRUCTED ON UNIFORM. COMPETANT MATERIAL



SECTION ON ℄

QUANTITIES

ITEM	ESTIMATED	UNIT	AS CONSTRUCTED
CONCRETE		SQ.YD.	
REINFORCING STEEL (EPOXY COATED)		LB.	

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FY (REINFORCEMENT) = 60 KSI

DESIGN DEPTH OF FILL = 2.34 FT.

MAXIMUM BEARING PRESSURE = 2000 PSF

DESIGN SPEED: 50 MPH 12300 SOUTH

HYDRAULIC DATA

DRAINAGE AREA = NA
DESIGN FREQUENCY = NA
VELOCITY AT OUTLET = ?.?? FOR 150 CFS. ?.?? FOR 300 CFS
100 YEAR DISCHARGE = NA
OVERTOPPING DISCHARGE = 300 CFS
FREQUENCY FOR OVERTOPPING FLOW = NA
WATER SURFACE ELEVATION FOR OVERTOPPING FLOW = ????.??

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RELEASE FOR CONSTRUCTION
REMARKS
NO.
DATE

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN
DRAWN RSC 10/20
CHECK
CHECK

12300 SOUTH INTERCHANGE
UTAH-SALT LAKE CANAL
SITUATION AND LAYOUT
PROJECT NUMBER #HPP-STP-0071(12)0
SALT LAKE

APPROVED FOR CONSTRUCTION

JORDAN - SALT LAKE CITY CANAL DATE

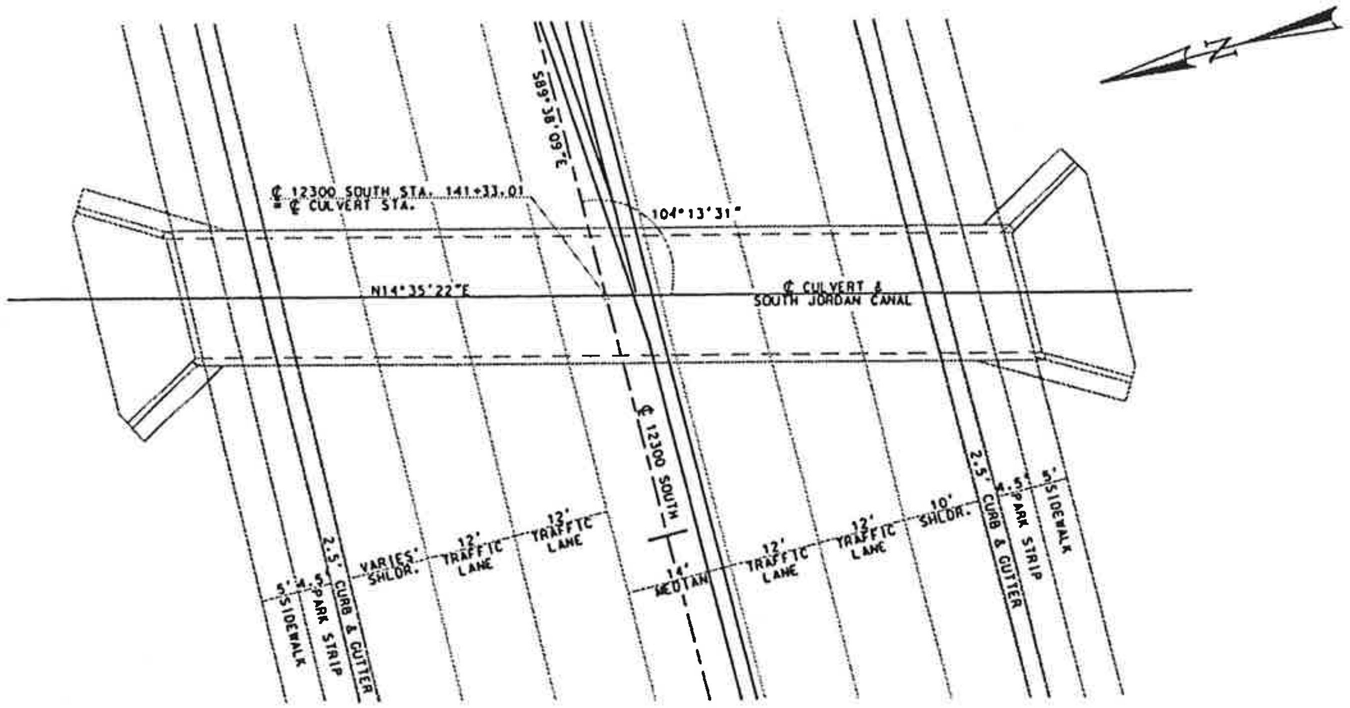
FIGURE 2B
CULVERT LAYOUT PLAN

NO SCALE

REFERENCE:
DRAWING PROVIDED BY
HW LOCHNER

N068544

12300 SOUTH DESIGN-BUILD PROJECT *HPP-STP-0071(12)0
AMEC JOB NO. 2-817-004066 (4065)



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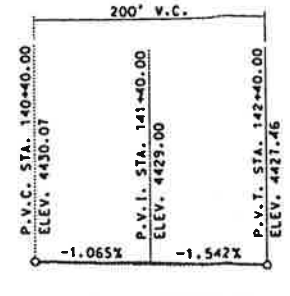
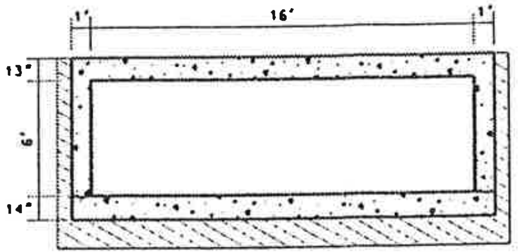


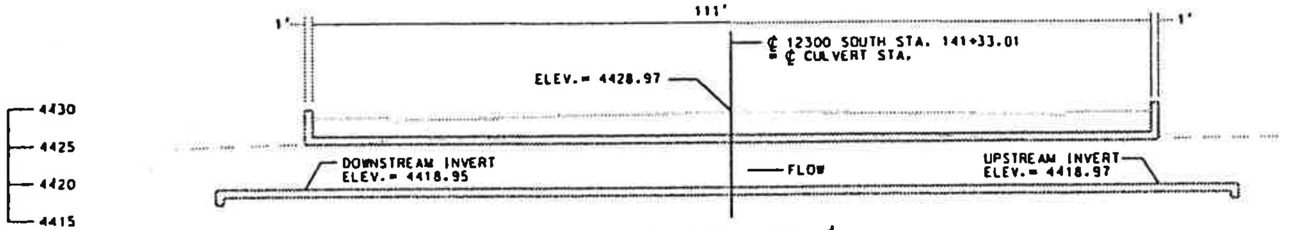
12300 SOUTH VERT. CURVE DATA



GRANULAR BACKFILL BORROW SHALL BE PLACED AROUND BARREL, WINGWALLS AND APRON AS SHOWN.

SECTION THROUGH BARREL

EXTRA EXCAVATION MAY BE REQUIRED AS DIRECTED BY THE ENGINEER FOR DEWATERING AND TO ENSURE THE CULVERT IS CONSTRUCTED ON UNIFORM, COMPETANT MATERIAL



SECTION ON ℄

QUANTITIES

ITEM	ESTIMATED	UNIT	AS CONSTRUCTED
CONCRETE		SQ.YD.	
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DESIGN SPEED: 50 MPH 12300 SOUTH

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DESIGN FREQUENCY = NA
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100 YEAR DISCHARGE = NA
OVERTOPPING DISCHARGE = 300 CFS
FREQUENCY FOR OVERTOPPING FLOW = NA
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APPROVED FOR CONSTRUCTION

JORDAN – SALT LAKE CITY CANAL DATE

RELEASE FOR CONSTRUCTION
REMARKS
NO. DATE

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DRAWN RSC 10/02

12300 SOUTH INTERCHANGE
SOUTH-JORDAN CANAL
SITUATION AND LAYOUT
PROJECT NUMBER #HPP-STP-0071(12)0

SALT LAKE
COUNTY

NO SCALE

FIGURE 2C
CULVERT
LAYOUT PLAN

REFERENCE:
DRAWING PROVIDED BY
HW LOCHNER

N068544

12300 SOUTH DESIGN-BUILD PROJECT *HPP-STP-0071(12)0
AMEC JOB NO. 2-817-004066 (4065)

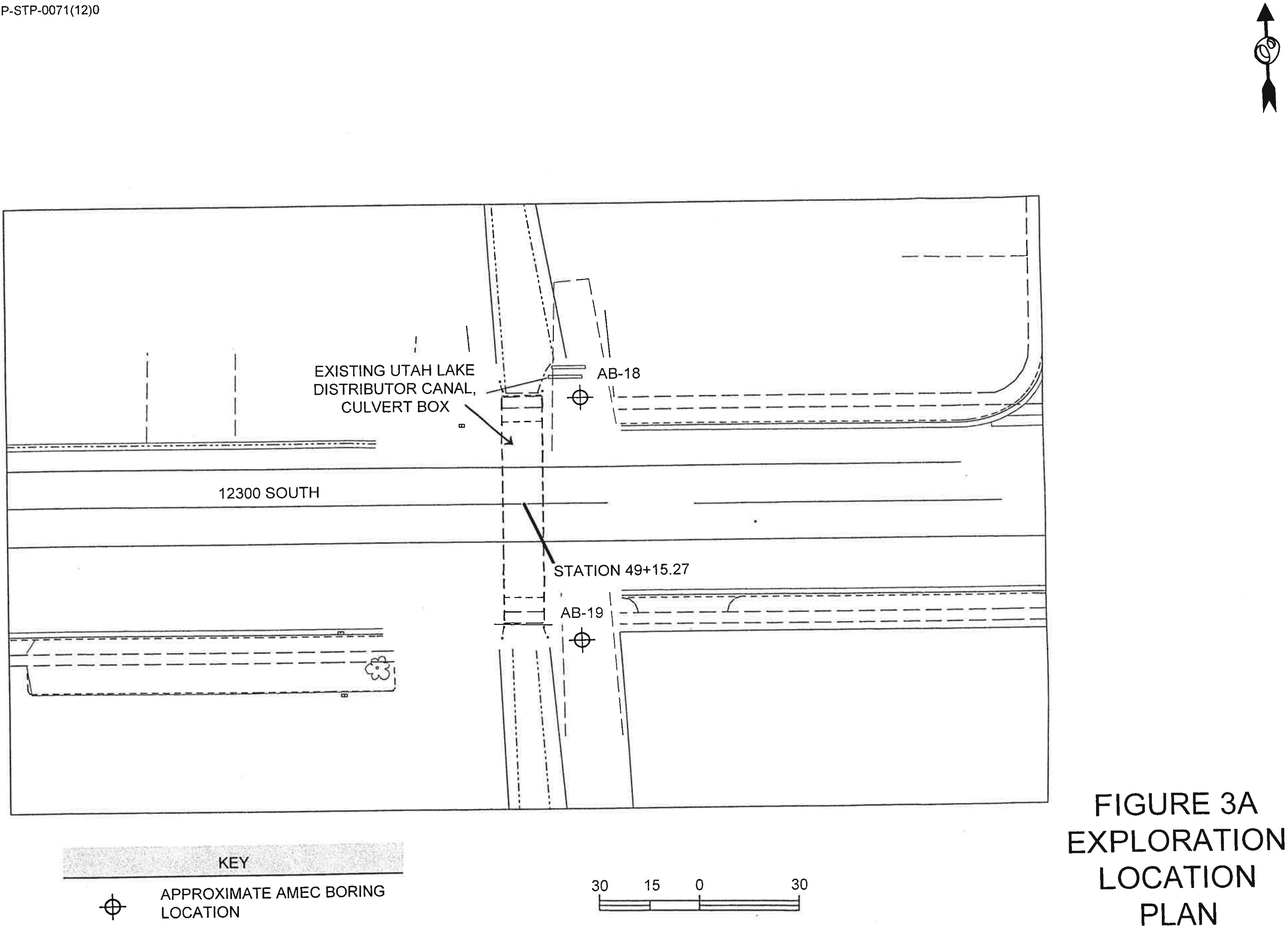
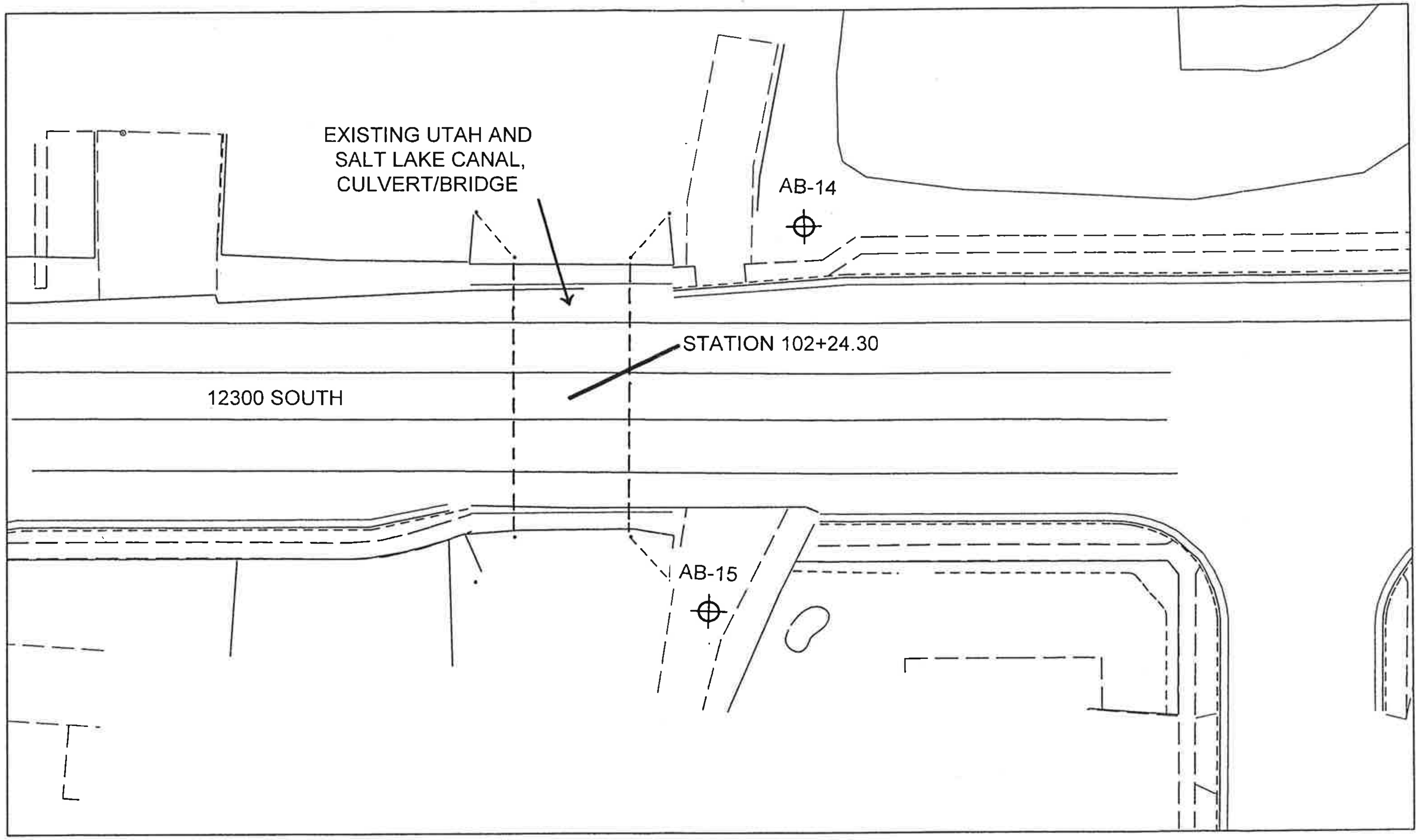


FIGURE 3A EXPLORATION LOCATION PLAN

REFERENCE:
ADAPTED FROM DRAWING
PROVIDED BY UDOT

N068544



KEY

⌖ APPROXIMATE AMEC BORING LOCATION

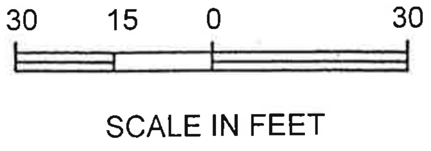
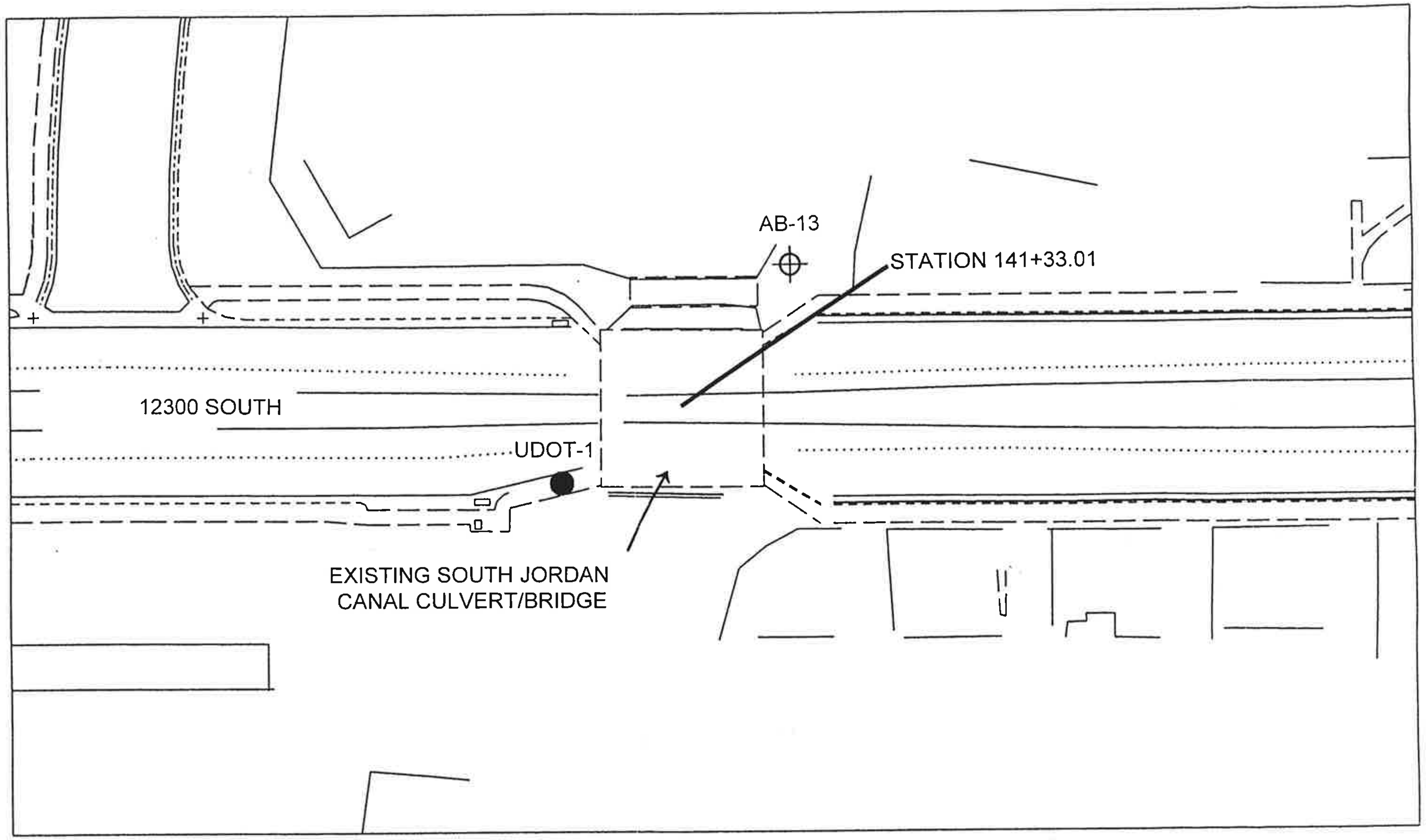


FIGURE 3B
EXPLORATION LOCATION PLAN

REFERENCE:
ADAPTED FROM DRAWING
PROVIDED BY UDOT

amec

12300 SOUTH DESIGN-BUILD PROJECT *HPP-STP-0071(12)0
AMEC JOB NO. 2-817-004066 (4065)



KEY

⌖	APPROXIMATE AMEC BORING LOCATION
●	APPROXIMATE LOCATION PREVIOUS BORING

40 20 0 40

SCALE IN FEET

FIGURE 3C
EXPLORATION LOCATION PLAN

REFERENCE:
ADAPTED FROM DRAWING
PROVIDED BY UDOT

amec

N068544

APPENDIX A

Field Explorations and Instrumentation

APPENDIX A
FIELD EXPLORATIONS AND INSTRUMENTATION

1. FIELD EXPLORATIONS

Subsurface soil and groundwater conditions at the culvert sites were explored by drilling one or two borings at each culvert location. Boring AB-13 was drilled at the South Jordan Canal crossing to a depth of about 30.5 feet below existing grades. Borings AB-14 and AB-15 were drilled at the Utah and Salt Lake Canal crossing to depths of about 31.5 and 30.5 feet, respectively. Borings AB-18 and AB-19 were drilled at the Utah Lake Distributor Canal crossing to depths of about 30.5 and 31.0 feet, respectively. L & L Drilling, under subcontract to AMEC, advanced the borings using a truck-mounted, Diedrich D120 drill rig equipped with hollow-stem augers. The approximate locations of the borings are indicated on Figures 3A through 3C, Exploration Location Plan.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. Our representative coordinated and monitored the drilling activities and the installation of piezometers in Borings AB-15 and AB-18. Our representative maintained a continuous log of the subsurface conditions encountered at each exploration location and obtained representative samples of the soils encountered in the explorations for subsequent laboratory testing and examination.

Relatively undisturbed samples and occasional disturbed samples of the soils encountered in the borings were obtained at 2.5- or 5.0-foot intervals. Relatively undisturbed soil samples were obtained using a D&M split-barrel sampler of the type illustrated on Figure A-1.

The sampler was driven into the undisturbed soil ahead of the auger bit with a 140-lb, automatic drop hammer falling a distance of 30 inches. The number of blows required to drive the sampler for the final foot of soil penetration, or part thereof, is noted on the boring log adjacent to the appropriate sample notation.

The soils encountered in the borings were classified in the field based upon visual and textural examination. These classifications were supplemented by subsequent examination and testing in our laboratory. Soils were classified in general accordance with ASTM D-2488, *Standard Recommended Practice for Description of Soils (Visual-Manual Procedure)*. Detailed graphical representations of the subsurface conditions encountered at each boring location are presented on Figures A-2 through A-6, Log of Test Boring. The exploration logs represent our interpretation of the field logs and the results of our laboratory classification testing. Figure A-7, Unified Soil Classification System, provides a key to the soil descriptions on the logs.

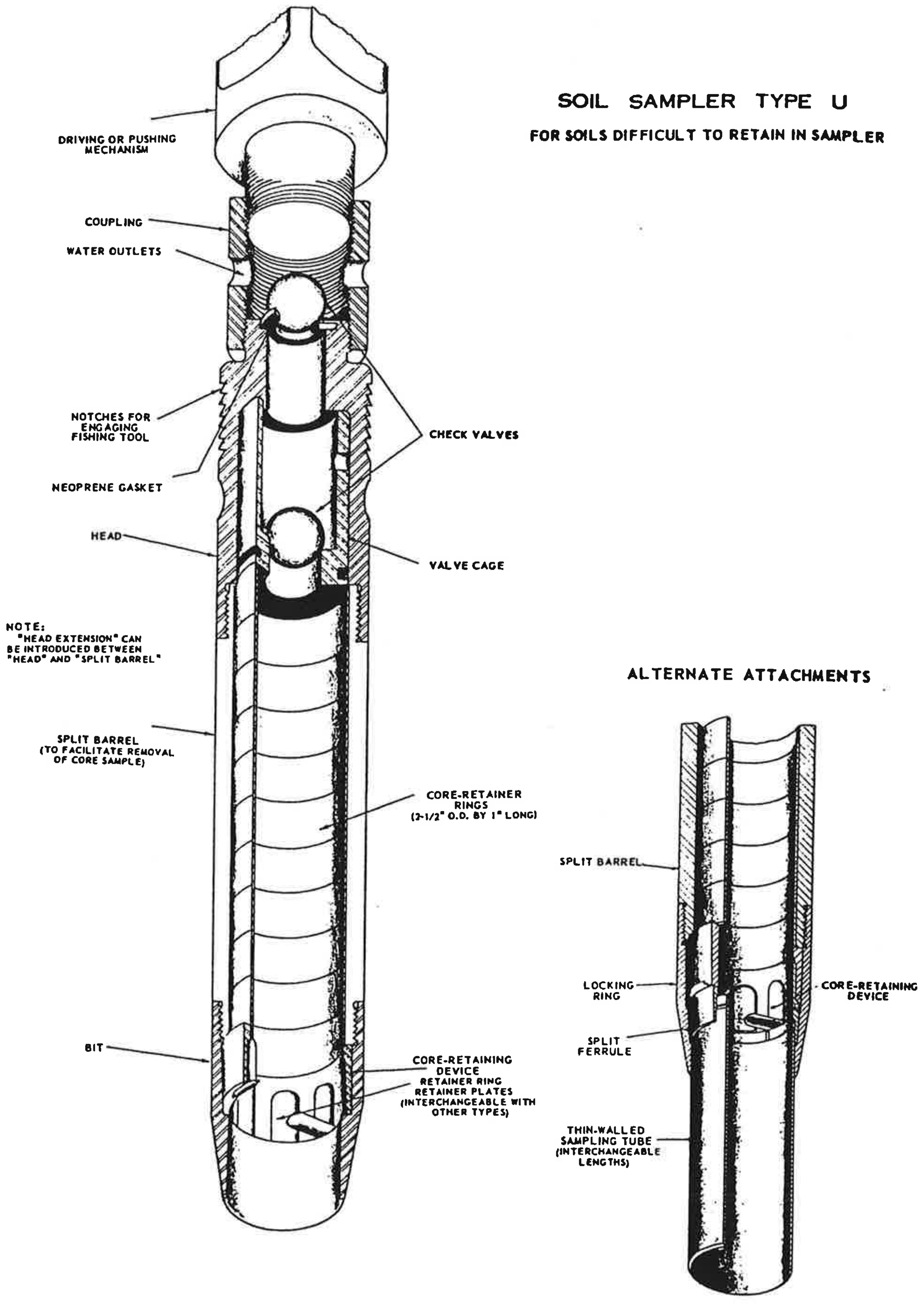
The explorations were located in the field by hand taping or pacing from existing physical features. The ground surface elevation shown on each log was determined by superimposing the exploration location on a map of site topographic contours provided by UDOT in the Project RFP. The exploration locations indicated on Figures 3A through 3C and the ground surface elevations indicated on the boring logs should be considered approximate.

2. INSTRUMENTATION

2.1 PIEZOMETER

Following completion of drilling operations, one and one-quarter-inch diameter slotted PVC pipes were installed to a depth of about 20 feet each in Borings AB-15 and AB-18 to provide a means of monitoring groundwater fluctuations at those boring locations.

Measurement of stabilized groundwater levels at the piezometer locations was conducted on August 8, September 7, and October 22, 2002. At both piezometer locations, groundwater was not encountered at depths above the bottom of the piezometer (20 feet below ground surface).



SOIL SAMPLER TYPE U

FOR SOILS DIFFICULT TO RETAIN IN SAMPLER

ALTERNATE ATTACHMENTS

FIGURE A-1

PROJECT 12300 South Design-Build Project
South Jordan Canal, Riverton, UT
JOB NO. 2-817-004066 DATE 08-13-02

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LOG OF TEST BORING NO.AB-13

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4425'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration 3Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/GM/FILL	slightly moist, "loose"	**SILTY SAND AND GRAVEL**; asphalt roadbase; FILL
								CL/ ML	moist, stiff	**LAYERED SILTY CLAY** with fine sand; brown
				D	17					
				D	13	106	15.2			
5										
				D	14	92	29.7		very moist to saturated	grades to layered silty clay and clayey silt with occasional layers of clean and silty fine to medium sand; layers 2" to 4" thick
10										
								CH	saturated, stiff	**SILTY CLAY** with fine sand; gray to olive-brown
				D	12	82	36.5			
15										
				D	10	55	75.7		medium stiff	grades with numerous rust-stained clayey silt layers to 3/4" thick
20										
								SC	saturated, medium dense	**CLAYEY SAND** with occasional gravel layers; fine to medium sand; fine gravel; brown
				D	30	107	15.4			
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-2

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PROJECT 12300 South Design-Build Project
South Jordan Canal, Riverton, UT
JOB NO. 2-817-004066 DATE 08-13-02

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LOG OF TEST BORING NO AB-13

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4425'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration 3Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25		▨	☒							
		░						SP/ GP	saturated, dense	**FINE TO COARSE SAND AND FINE AND COARSE GRAVEL;** brown
		░	☒	D	85					
30		░	☒							
										Stopped drilling at 29.0'. Stopped sampling at 30.5'. * Groundwater not encountered.
35										
40										
45										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
50										

GROUNDWATER

	DEPTH	HOUR	DATE
∇		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-2
(con't)

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PROJECT 12300 South Design-Build Project
Utah and Salt Lake Canal, Riverton, UT

JOB NO. 2-817-004066 DATE 08-08-02

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LOG OF TEST BORING NO. AB-14

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4483'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration 3Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/GM FILL	slightly moist, loose	**SILTY SAND AND GRAVEL**; fine to coarse sand; fine and coarse gravel; brown; FILL
								CL	slightly moist, stiff	**SILTY CLAY** with trace fine sand; dark brown
				D	12	112	6.3			grades to brown mottled with white
5				D	28	102	17.8		moist, very stiff	
10				D	13	69	50.2	SM/ ML	very moist to saturated, loose/stiff	**LAYERED BROWN SILTY FINE TO MEDIUM SAND AND GRAY CLAYEY SILT** with oxidation staining; layers 2" to 4" thick
15								SM	very moist to saturated, medium dense	**SILTY FINE TO MEDIUM SAND** with occasional sandy silt layers to 1" thick
				D	27	96	21.9			
								SP/ GP	very moist to saturated, very dense	**SAND AND GRAVEL**; fine to coarse sand; fine and coarse gravel; brown
20				D	158					
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-3

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PROJECT 12300 South Design-Build Project
Utah and Salt Lake Canal, Riverton, UT
JOB NO. 2-817-004066 DATE 08-08-02

LOG OF TEST BORING NO.AB-14

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4483'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration 3Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25				D	38					
								CL	saturated, stiff	**SILTY CLAYEY** with some fine sand; brown
30				D	14	100	22.9			grades with trace fine sand
										Stopped drilling at 30.0'. Stopped sampling at 31.5'. * Groundwater not encountered.
35										
40										
45										
50										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-3
(con't)

amec

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LOG OF TEST BORING NO. AB-15

PROJECT 12300 South Design-Build Project
Utah and Salt Lake Canal, Riverton, UT
JOB NO. 2-817-004066 DATE 08-09-02

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4483'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/GM FILL	slightly moist, "loose"	**SILTY FINE TO COARSE SAND AND FINE AND COARSE GRAVEL**; brown; FILL
								CL	slightly moist, very stiff	**SILTY CLAY** with trace fine sand; brown
				D	26					
									moist	
5										
				D	57					
								ML	moist, very stiff	**CLAYEY SILT** with rust-stained pockets; gray
				D	31	95	24.8		moist to very moist, medium dense	grades to sandy silt with occasional layers of silty fine to medium sand; layers to 2" thick; gray-brown
10										
				D	30	102	23.7		very moist to saturated, very stiff/ medium dense	grades with occasional silty clay layers to 2" thick and layers of fine to coarse sand and fine gravel to 3" thick
15										
								SP/ GP	very moist to saturated, very dense	**SAND AND GRAVEL**; fine to coarse sand; fine and coarse gravel; brown
				D	100/5"					
▼ 20										
								CL	saturated, stiff	**SILTY CLAY** with some fine sand and occasional silty fine sand layers to 2" thick
				D	19	107	18.7			
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	20.0		08-15-02
▼	20.0		10-22-02

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-4

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PROJECT 12300 South Design-Build Project
Utah and Salt Lake Canal, Riverton, UT

LOG OF TEST BORING NO AB-15

JOB NO. 2-817-004066 DATE 08-09-02

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4483'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25		▨	☒							
		▨	☒	D	19	102	20.4			grades with some fine to coarse sand
30		▨	☒							
										Stopped drilling at 29.0'. Stopped sampling at 30.5'. Installed 1- 1/4" diameter slotted PVC pipe to 20.0'.
35										
40										
45										
50										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

GROUNDWATER

	DEPTH	HOUR	DATE
▽	20.0		08-15-02
▼	20.0		10-22-02

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-4
(con't)

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LOG OF TEST BORING NO. AB-18

PROJECT 12300 South Design-Build Project
Utah Lake Distributing Canal, Riverton, UT
JOB NO. 2-817-004066 DATE 08-09-02

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4573'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/ GM FILL	slightly moist, "loose"	**SILTY SAND AND GRAVEL**; fine to coarse sand; fine gravel with trace coarse gravel; brown; FILL
								CL/ ML	moist, stiff	**SILTY CLAY/CLAYEY SILT** with some fine sand; dark brown
				D	20	95	20.7			
5										
				D	19	98	22.7			
				D	100/4"			SP/ GP	moist, very dense	**FINE TO COARSE SAND AND FINE AND COARSE GRAVEL** with trace silt; brown
10										
								ML	moist, stiff	**CLAYEY SILT** with some fine sand; dark brown
				D	21	96	22.8			
15										
				D	120					
▼ 20										grades with occasional layers of silty fine to coarse sand and fine and coarse gravel
				D	45				very stiff	
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	20.0		08-15-02
▼	20.0		10-22-02

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-5

amec

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PROJECT 12300 South Design-Build Project
Utah Lake Distributing Canal, Riverton, UT

LOG OF TEST BORING NO AB-18

JOB NO. 2-817-004066 DATE 08-09-02

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4573'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration 3Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25								SP/ GP	moist, medium dense	**SAND AND GRAVEL**; fine to coarse sand; fine gravel with occasional coarse gravel; brown
				D	79				dense	
30										Stopped drilling at 29.0'. Stopped sampling at 30.5'. Installed 1-1/4" diameter slotted PVC pipe to 20.0'.
35										
40										
45										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	20.0		08-15-02
▼	20.0		10-22-02

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-5
(con't)

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PROJECT 12300 South Design-Build Project
Utah Lake Distributing Canal, Riverton, UT

LOG OF TEST BORING NO. AB-19

JOB NO. 2-817-004066 DATE 08-09-02

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4573'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM/ GM FILL	slightly moist, loose	**SILTY FINE TO COARSE SAND**; fine and coarse gravel; brown; FILL
								CL	moist, very stiff	**SILTY CLAY** with rust-stained pockets; gray
5				D	42	100	22.3			
10				D	126			SP/ GP	moist, very dense	**FINE TO COARSE SAND AND FINE AND COARSE GRAVEL**; brown
								ML	very moist, very stiff	**CLAYEY SILT** with fine sand; brown
15				D	26	101	20.7			
								SM/ GM	very moist to possibly saturated, medium dense layered drilling with gravel zones	**SILTY SAND AND GRAVEL** with some clay; fine to coarse sand; fine and coarse gravel; gray-brown
20				D	42	101	25.9			
25										

FIGURE A-6

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

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PROJECT 12300 South Design-Build Project
Utah Lake Distributing Canal, Riverton, UT

LOG OF TEST BORING NO AB-19

JOB NO. 2-817-004066 DATE 08-09-02

RIG TYPE Diedrich D120 (L&L)
BORING TYPE 4-1/4" ID Hollow-Stem Auger
SURFACE ELEV. 4573'+/-
LOGGED BY Matt Gallegos

Depth in Feet	Continuous Penetration 3Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25				D	46					
30				D	100/4"				very dense	
										Stopped drilling at 30.0'. Stopped sampling at 31.0'. * Groundwater not encountered.
35										
40										
45										
										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽		*	
▼			

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

FIGURE A-6
(con't)

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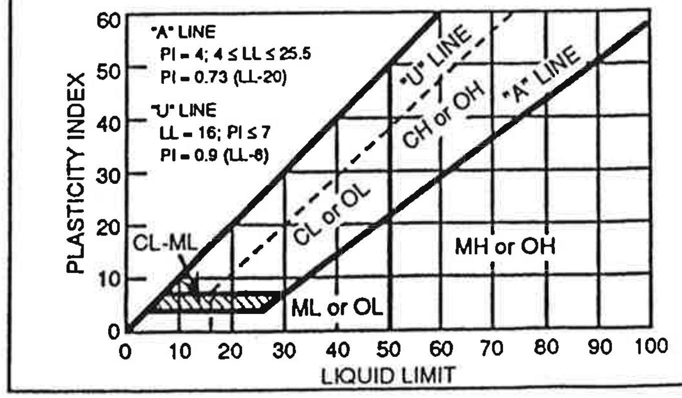
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified for engineering purposes by the Unified Soil Classification System. Grain-size analyses and Atterberg Limits tests often are performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. Graphic symbols are used on boring logs presented in this report. For a more detailed description of the system, see "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)" ASTM Designation: 2488-84 and "Standard Test Method for Classification of Soils for Engineering Purposes" ASTM Designation: 2487-85.

MAJOR DIVISIONS				GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		▨	GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures
				▨	GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	▨	GM	Silty gravels, gravel-sand-silt mixtures
			Limits plot above "A" line & hatched zone on plasticity chart	▨	GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		▨	SW	Well graded sands, gravelly sands
				▨	SP	Poorly graded sands, gravelly sands
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	▨	SM	Silty sands, sand-silt mixtures
			Limits plot above "A" line & hatched zone on plasticity chart	▨	SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS Limits plot below "A" line & hatched zone on plasticity chart	SILTS OF LOW PLASTICITY (Liquid Limit less than 50)		▨	ML	Inorganic silts, clayey silts of low to medium plasticity
		SILTS OF HIGH PLASTICITY (Liquid Limit 50 or more)		▨	MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts
	CLAYS Limits plot above "A" line & hatched zone on plasticity chart	CLAYS OF LOW PLASTICITY (Liquid Limit less than 50)		▨	CL	Inorganic clays of low to medium plasticity, gravelly, sandy, and silty clays
		CLAYS OF HIGH PLASTICITY (Liquid Limit 50 or more)		▨	CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity
	ORGANIC SILTS AND CLAYS	ORGANIC SILTS AND CLAYS OF LOW PLASTICITY (Liquid Limit less than 50)			OL	Organic silts and clays of low to medium plasticity, sandy organic silts and clays
		ORGANIC SILTS AND CLAYS OF HIGH PLASTICITY (Liquid Limit 50 or more)			OH	Organic silts and clays of high plasticity, sandy organic silts and clays
ORGANIC SOILS		PRIMARILY ORGANIC MATTER (dark in color and organic odor)			PT	Peat

NOTE: Coarse-grained soils with between 5% and 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone on the plasticity chart have dual classifications.

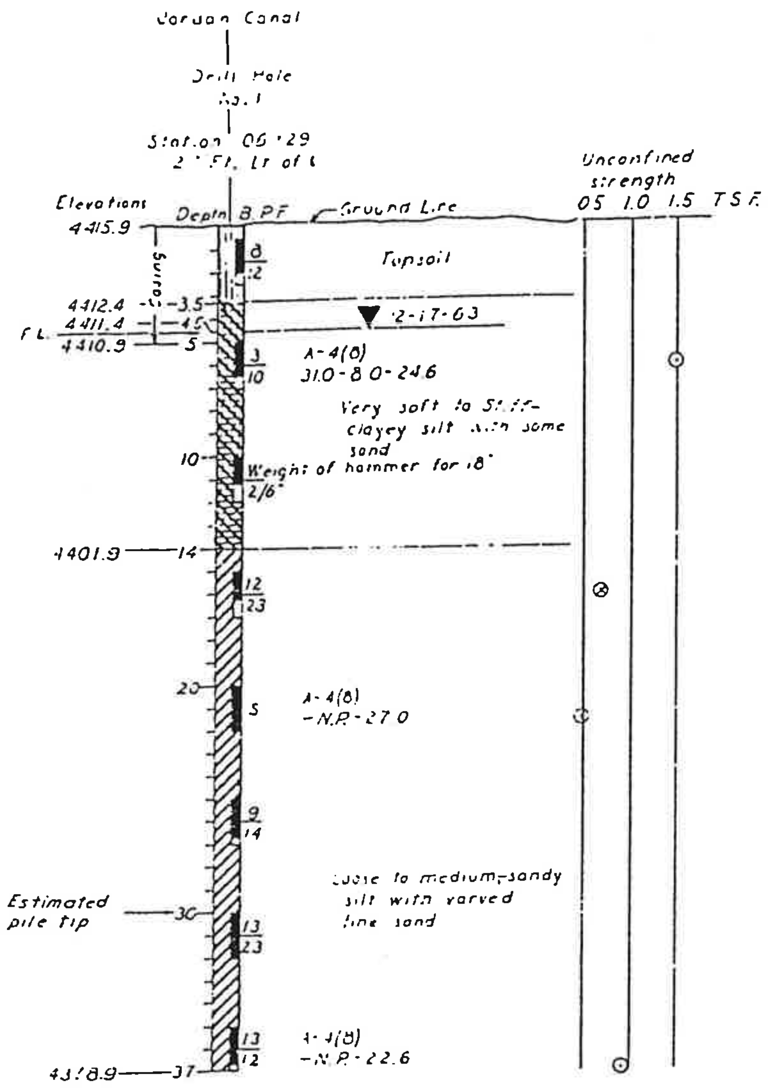
PLASTICITY CHART

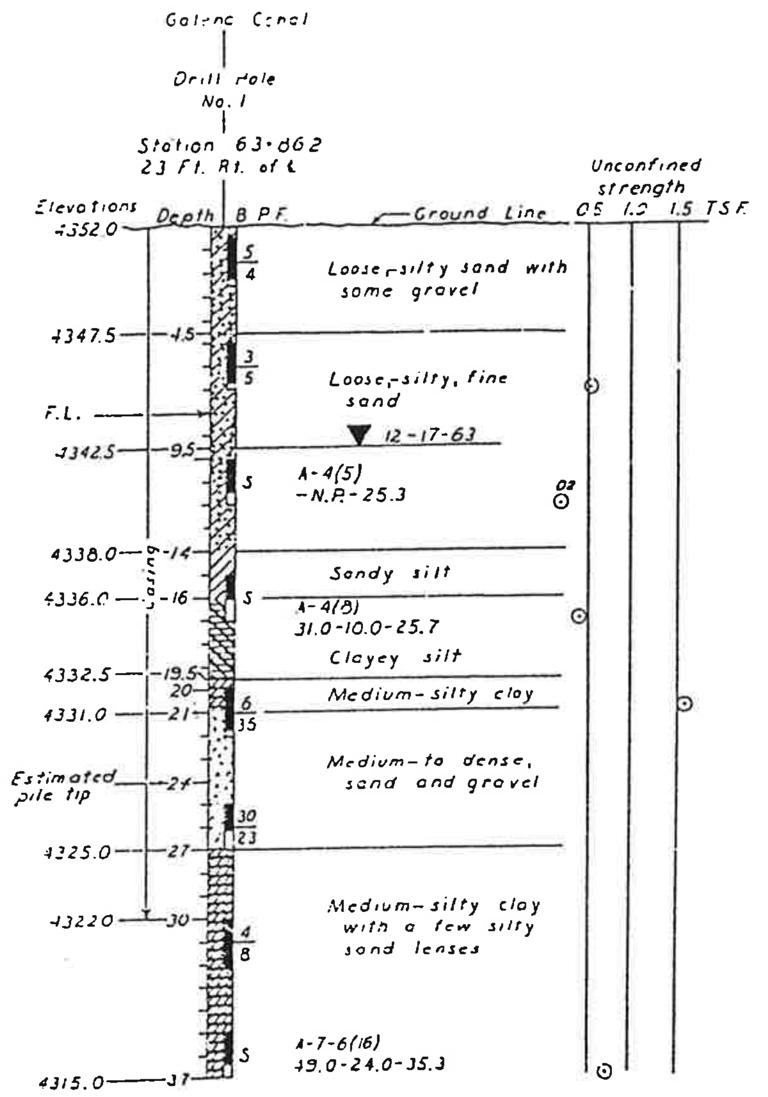


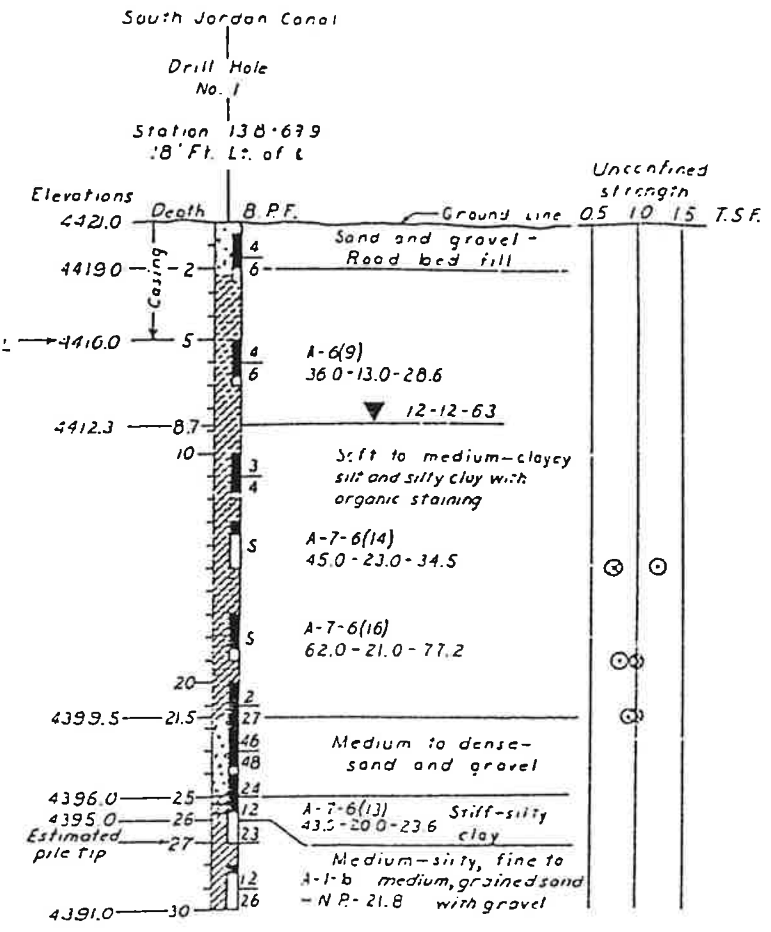
DEFINITION OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 12 in.
Cobbles	12 in. to 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 sieve
Sand	No. 4 to No. 200 sieve
Coarse sand	No. 4 to No. 10 sieve
Medium sand	No. 10 to No. 40 sieve
Fine sand	No. 40 to No. 200 sieve
Fines (silt and clay)	Less than No. 200 sieve

FIGURE A-7







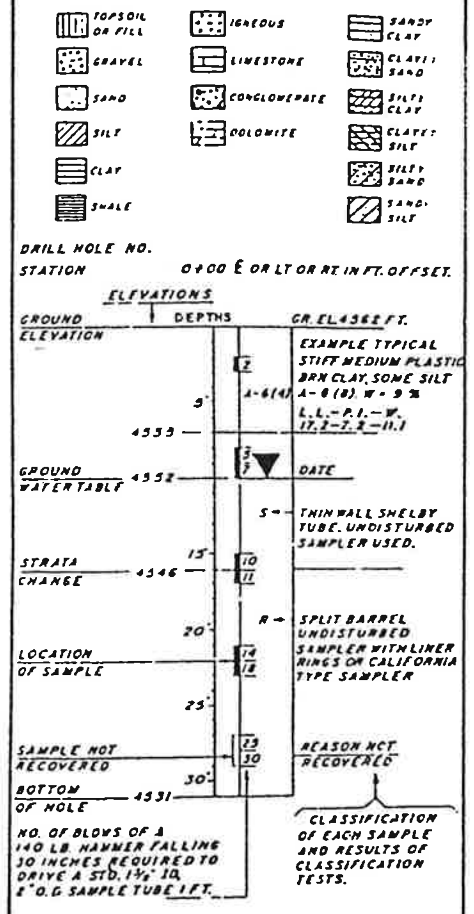
KEY TO DRILLING LOGS

RELATIVE DENSITY (SAND & SILT)

VERY LOOSE - LESS THAN 4 BLOWS PER FOOT.
LOOSE — 4 TO 10 BLOWS PER FOOT.
MEDIUM - 10 TO 30 BLOWS PER FOOT
DENSE - 30 TO 50 BLOWS PER FOOT.
VERY DENSE - MORE THAN 50 BLOWS PER FOOT.

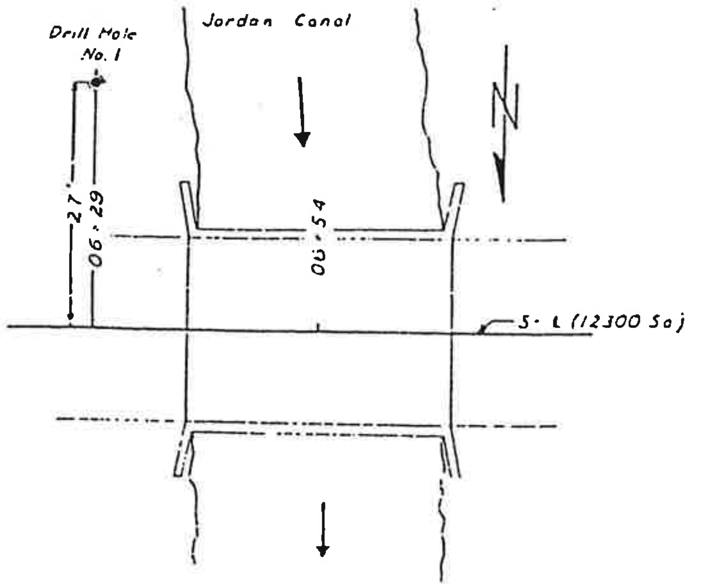
CONSISTENCY (CLAY)

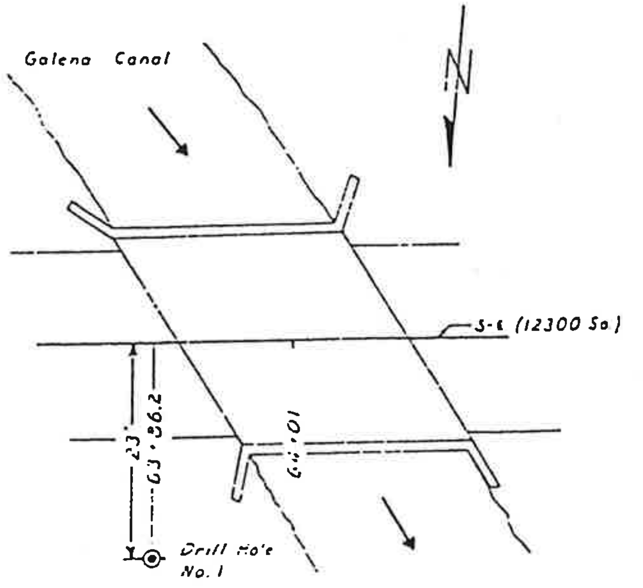
VERY SOFT - LESS THAN 2 BLOWS PER FOOT.
SOFT — 2 TO 4 BLOWS PER FOOT
MEDIUM - 4 TO 8 BLOWS PER FOOT.
STIFF — 8 TO 15 BLOW PER FOOT.
VERY STIFF 15 TO 30 BLOWS PER FOOT.
HARD — MORE THAN 30 BLOWS PER FOOT.

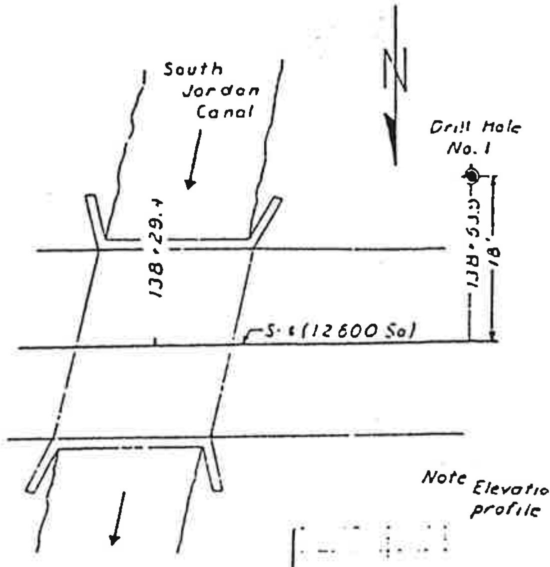


ABBREVIATIONS

L.L. — LIQUID LIMIT IN %
P.I — PLASTIC INDEX
w — NATURAL MOISTURE CONTENT IN %
⊙ — TEST RESULTS
⊗ — POCKET PENETROMETER
G.W.T. — GROUND WATER TABLE
B.P.F. — BLOWS PER FOOT.
N.P. — NON-PLASTIC
F.L. — FLOW LINE
⊕ — DRILL HOLE







Note Elevation from preliminary profile

UTAH STATE DEPARTMENT OF HIGHWAYS
SALT LAKE CITY, UTAH
MATERIALS AND RESEARCH DIVISION

DRAPER CROSS ROADS TO RIVERTON
JORDAN & SOUTH JORDAN CANAL BRIDGES
SOIL DATA

DRAWN BY Johnson
CHECKED BY W.S.W.
TRACED BY E.P.
CHECKED BY JTSH
QUANTITIES BY T.R. Sw
CHECKED BY LCH
APPROVED RECOMMENDED BY
DATE April 3, 1964 . D.L. Sargent
S-0153 (1)
PROJECT NUMBER
STA 24.5 Jordan Can. 138+61.4 S. Jordan
STATION
SALT LAKE
COUNTY
REVISIONS
DWG NO. D-758
7 of 7

APPENDIX B

Explorations by Others

APPENDIX B
EXPLORATIONS BY OTHERS

This appendix provides the log of an exploration conducted at the site of the South Jordan Canal crossing in the 1960's by the Utah State Department of Highways. The approximate location of the exploration, labeled UDOT-1, is shown on Figure 3C, Exploration Location Plan. This exploration log is provided for reference only.

APPENDIX C

Laboratory Testing

APPENDIX C
LABORATORY TESTING

1. GENERAL

Laboratory tests were performed on representative samples of the soils encountered in Borings AB-13, AB-14, AB-15, AB-18, and AB-19 to evaluate pertinent physical characteristics, aid in classifying the soils, and correlate other test data. The laboratory program included sample inspection to confirm AMEC's field soil descriptions and classification testing to determine natural moisture content, in-situ soil density, Atterberg limits, and grain-size distribution. Selected samples were evaluated for strength and consolidation characteristics by performing laboratory vane shear strength tests and one-dimensional consolidation tests. Chemical tests were also conducted on selected samples to determine the aggressiveness of those soils with respect to concrete.

Identification of the test procedures and summaries of selected test results are presented in the following sections of this appendix. An overall summary of the classification, strength, and consolidation test results is presented in Table C-1.

2. CLASSIFICATION TESTS

2.1 MOISTURE AND DENSITY TESTS

Determination of natural moisture content was performed in general accordance with ASTM D-2216 test procedures. Determination of the in-situ dry density of selected, relatively undisturbed samples was performed in general accordance with ASTM D-4564 test procedures. Natural moisture content and dry density, where determined, are presented adjacent to the corresponding sample notation on the boring logs included in Appendix A.

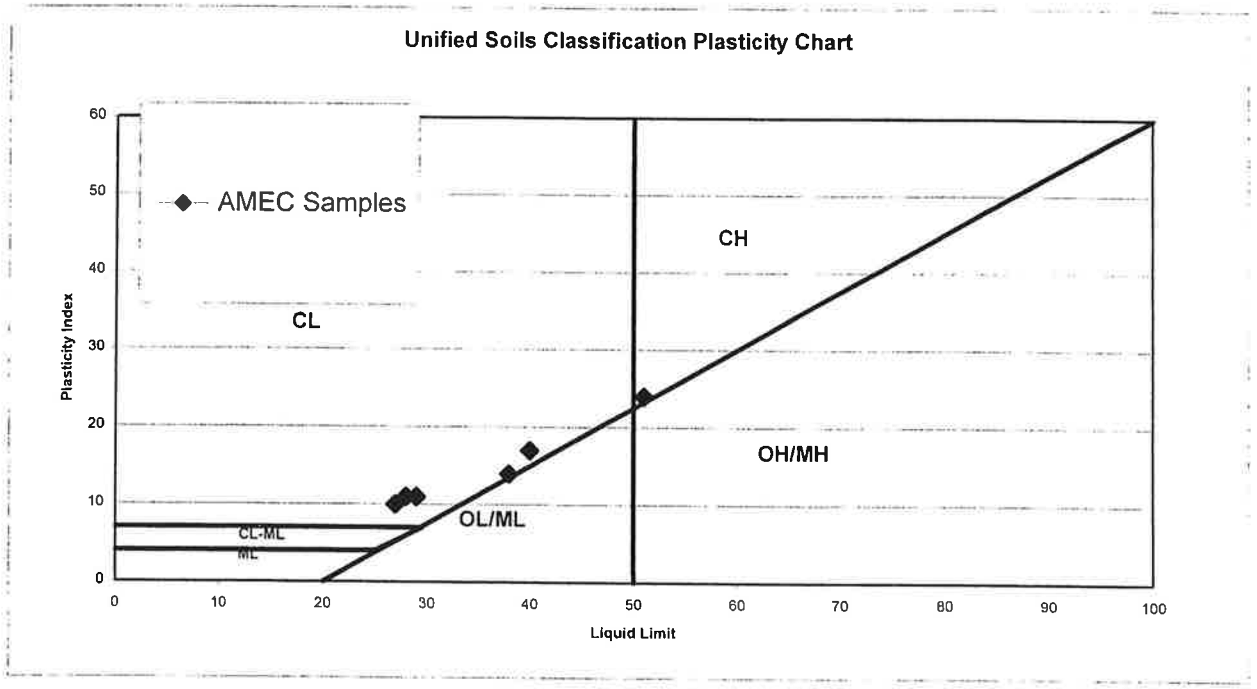
It should be noted that some relatively undisturbed samples were subjected to a variety of test procedures, resulting in more than one set of natural moisture and, where determined, in-situ dry density values. For these samples, the natural moisture and in-situ dry density test values obtained in conjunction with individual test procedures are listed in the summaries of those test procedures presented in the following sections. For samples with more than one set of test results for natural moisture and in-situ dry density, the averaged values of those test results are presented on the boring logs and in Table C-1.

2.2 ATTERBERG LIMITS TESTS

Determination of the Atterberg limits of selected samples was performed in general accordance with ASTM D-4318. Results from Atterberg limits testing are summarized in the table and plasticity chart on the next page, and in Table C-1.

Boring No.	Sample Depth (ft)	Unified Soil Classification System Group Symbol*	In situ Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
AB-13	4.5	CL/ML	15.2	28	17	11
AB-13	14.5	CH	36.5	51	27	24
AB-14	5.5	CL	17.8	40	23	17
AB-14	30.5	CL	22.9	29	18	11
AB-15	9.5	ML	24.8	--	--	NP
AB-15	29.5	CL	20.4	27	17	10
AB-18	3.5	CL/ML	20.7	38	24	14

* Based upon portion of the sample passing the No. 40 sieve.



2.3 GRAIN SIZE ANALYSES

Grain-size analyses were performed in general accordance with ASTM C-117, C-136, and D-1140 test procedures. Results from the grain-size analyses are summarized in the following table. The results of the fines content (percent material by weight passing the No. 200 sieve) portion of the analyses are also included in Table C-1.

Boring No.	Sample Depth (ft)	Percent Passing by Weight No 4	No. 40	No. 100	No. 200	Unified Soil Classification System Group Symbol
AB-14	15.5	100	83	57	33	SM
AB-19	20.5	90	62	48	35	SM

3. ONE-DIMENSIONAL CONSOLIDATION TESTS

One-dimensional consolidation testing was performed on relatively undisturbed, representative samples of the fine-grained cohesive soils encountered in Borings AB-13, AB-15, and AB-18. Consolidation testing was performed in general accordance with the ASTM D-2435 test procedures. Detailed results of the tests are maintained within our files and can be provided at your request.

4. LABORATORY VANE SHEAR STRENGTH TESTS

Undrained shear strength tests were performed on relatively undisturbed samples of fine-grained cohesive soils in general accordance with the ASTM D-4648 test procedure. Results from the vane shear strength tests are summarized in the following table and in Table C-1.

Boring No.	Sample Depth (ft)	Unified Soil Classification System Group Symbol	In situ Moisture Content (%)	Dry Density (pcf)	Average Peak Undrained Shear Strength (psf)
AB-13	4.5	CL/ML	15.2	106	3450
AB-13	14.5	CH	36.5	82	2300
AB-14	5.5	CL	17.8	102	>4000
AB-18	6.5	CL/ML	22.7	98	3300
AB-18	14.5	ML	22.8	96	1850
AB-19	5.5	CL	22.3	100	>4000

5. CHEMICAL TESTS

5.1 pH AND SOLUBLE SULFATES TESTS

To determine if the soils at the culvert crossing sites will react detrimentally with concrete, pH and soluble sulfates tests were performed on representative samples of the near-surface soils. The results of those tests are presented below:

Boring No.	Sample Depth (ft)	Unified Soil Classification System Group Symbol	pH	Soluble Sulfates Content (Percent by weight)
AB-13	4.5	CL/ML	8.1	0.038
AB-15	6.5	ML	8.1	<0.001
AB-18	6.5	CL/ML	7.7	0.055

The above test results indicate that the site soils are mildly to moderately alkaline and contain negligible amounts of water-soluble sulfates. Based on the above values, the potential of the site soils, particularly near-surface soils, to react detrimentally with concrete are considered to be negligible.

Table C-1

12300 South
Laboratory Testing Summary Sheet
12300 South - Canal Culvert Crossings
12/10/02

Boring No.	Sample No.	Sample Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Moist Density (pcf)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	P'c (psf)	P'o (psf)	OCR (Pc/Po)	-200 (%)	Vane Shear (psf)	AASHTO Classification
AB-13	1	2.5												
	2	4.5	15.2	105.7	121.8	28	17	11					3450	A-6
	3	9.5	29.7	92.4	119.8									
	4	14.5	36.5	82.1	112.1	51	27	24	9400	1400	6.71		2300	A-7-6
	5	19.5	75.7	55.1	96.8									
	6	24.5	15.4	107.1	123.6									
	7	29.5												
AB-14	1	3.0	6.3	111.7	118.7									
	2	5.5	17.8	102.2	120.4	40	23	17					>4000	A-6/A-7-6
	3	10.5	50.2	69.2	103.9									
	4	15.5	24.3	96.1	119.5							33.4		A-2-4
	5	20.5												
	6	25.5												
	7	30.5	22.9	99.6	122.4	29	18	11						
AB-15	1	3.5												
	2	6.5												
	3	9.5	24.8	94.5	117.9			NP						A-4
	4	14.5	23.7	102.0	126.2				9600	1300	7.38			
	5	19.5												
	6	24.5	18.7	106.6	126.5									
	7	29.5	20.4	102.0	122.8	27	17	10						A-4
AB-18	1	3.5	20.7	95.1	114.8	38	24	14						A-6
	2	6.5	22.7	97.9	120.1								3300	
	3	9.0												
	4	14.5	22.8	96.3	118.3				5400	1425	3.79		1850	
	5	24.5												
	6	29.5												

Table C-1

12300 South
Laboratory Testing Summary Sheet
12300 South - Canal Culvert Crossings
12/10/02

Boring No.	Sample No.	Sample Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Moist Density (pcf)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	P'c (psf)	P'o (psf)	OCR (Pc/Po)	-200 (%)	Vane Shear (psf)	AASHTO Classification
AB-19	1	5.5	22.3	99.6	121.8								>4000	
	2	10.5												
	3	15.5	20.7	100.5	121.3									
	4	20.5	25.9	100.8	126.9							35.2		A-2
	5	25.5												
	6	30.5												