FINAL REPORT

GEOTECHNICAL INVESTIGATION FOUR BRIDGES BEARTOOTH HIGHWAY, U.S. 212, PARK COUNTY, WYOMING

Prepared for
Federal Highway Administration
Central Federal Lands Highway Division
Lakewood, CO

November 6, 2002

URS

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URS Project No. 68-FHAT0039.00 (22234609.00300)
FHWA T.O. No. DTFH68-01-T-00039

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Geotechnical investigations were conducted between 2000 and 2002 at selected locations along the Beartooth Highway in Park County, Wyoming. This investigation was conducted to gather subsurface information at four sites (Beartooth Lake Outlet Bridge, Little Bear Creek Bridges No. 1 and No. 2 and Long Lake Outlet Bridge) for foundation and geotechnical design. The investigation consisted of drilling exploratory borings, laboratory testing and geotechncial analyses.

The investigation at the Beartooth Outlet Bridge showed alluvial sands and silts to the maximum depth investigated 32.5 meters. The silts are soft and highly compressible granite bedrock at the face of the wall. Within the overburden, very large (greater than 1.5 m in diameter) boulders exist in the upper 3 to 6 meters. Freewater was encountered at a depth of about 2 meters in the borings.

The investigation at Little Bear Creek Bridge No. 1 encountered gravel and boulders overlying sandstone and gneiss bedrock. Bedrock was encountered at depths of 4 to 8 meters. Freewater was measured at depths of 1.2 to 2.9 meters at the time of drilling.

The investigation at Little Bear Creek Bridge No. 2 encountered 2 to 3 meters of sand, gravel, cobbles and boulders overlying sandstone bedrock. Freewater was measured at depths of 2 to 3.3 meters at the time of drilling.

The investigation at the Long Lake Outlet Bridge showed the subsurface to consist of overlying granite bedrock. The bedrock surface varies between 1.7 and 3.9 meters below grade. Freewater was encountered at depths of 1.0 to 1.3 meters below the existing road grade.

There are several foundation alternatives for structures at the four sites. The proposed bridges require deep foundation systems to provide scour protection and to place foundations in bearing material with sufficient capacity to support the structures.

Structures at all sites may be founded on micropiles. Structures at the Fen Mitigation Area may also be founded in drilled piers on driven H-piles.

Micropiles may be designed for a rock bond of 0.5 Mpa and soil bond of 19 kPa. There will be difficulty in grouting micropiles through the cobbles and boulders. A method to manage grout takes will be necessary.

Drilled piers may be designed for an allowable end bearing pressure of 1.5 to 2.5 MPa depending on location. Allowable skin friction should be 10 percent of allowable end bearing capacity. Driven H-piles may be designed for an steel working stress of 82.8 MPa. Driven H-piles will require tip protectors.

Geotechnical design criteria is presented in the report.

This report presents the results of geotechnical investigations for four bridge replacement structures along the Beartooth Highway U.S. 212, Park County, Wyoming. The structures include:

- Beartooth Lake Outlet Bridge
- Little Bear Creek Bridge No. 1
- Little Bear Creek Bridge No. 2
- Long Lake Outlet Bridge

The investigations were conducted between 2000 and 2002 under FHWA Contract No. DTF68-97-D-0003 Task Orders DTFH68-01-T-00027 and DTFH68-01-T-00039.

The investigations consisted of exploring drilling, laboratory testing, analyses and report preparation. A total of 12 test holes were drilled for the four structures. The investigations were performed to evaluate subsurface conditioning and to develop foundation and geotechnical design recommendations.

2.1 INVESTIGATION

Three test holes, THB-6, THB-7, and THB-23 were drilled at the bridge on the right shoulder of the existing road. The holes were drilled using an H-size or NX-size core barrels, hollow stem augers SPT split spoon samples were generally collected at the end of each core run (1.5 m) unless the run ended in a boulder or bedrock. The test hole locations and results are summarized in Table 2-1. The test hole locations are shown on Figures 2-1 and 2-2, summary logs are shown on Figure 2-1, and individual logs are provided in Appendix A.

Table 2-1

TEST HOLE SUMMARY, BEARTOOTH LAKE OUTLET BRIDGE

Test Hole Number	Stationing	Offset (m)	Elevation (m)	Depth to Bedrock (m)	Depth to Water[1] (m)	Test Hole Depth (m)
THB-6	42+238	0	2715.1	N.E.	2.3	22.9
THB-7	42+378	0.6 R	2716.1	N.E.	3.0	32.0
THB-23	42+220	2.5L	2715.0	N.E.	1.2	20.0

Notes: 1) Encountered in test hole at time of drilling. N.E. = Not Encountered

2.1.1 Site Characteristics

The Beartooth Lake outlet bridge will replace the existing single span bridge with a new 31.5 meter single span bridge. The bridge will be 14 meters wide and will include two travel lanes and a pedestrian walkway. The bridge is in a very visible location, at the outlet of the largest lake along the alignment, and near a popular campground. The replacement bridge will have an appearance similar to the existing bridge.

2.1.2 Subsurface Characteristics

The upper 9.3 to 11.5 meters consists of loose to medium dense sand, with some gravel, cobbles and boulders (THB-6, THB-7 and THB-23), or loose to medium dense sand interbedded with gravel, cobbles and boulders with loose to medium dense sand matrix (THB-7 and THB-23). The longest length of boulder cored was 0.3 meters. Larger boulders are evident on the ground surface below the road. Standard Penetration Tests (SPT's) were generally conducted at the end of each 1.5 meter core run. N-values range from 6 to 26, with most values being less than 13. The presence of gravel, cobbles, and boulders may have impacted some SPT results, causing them to be higher than the density would indicate. The summary logs show recovery for core runs in the overburden and the SPT results. Core intervals include overcoring (reaming) the interval of the hole sampled with the SPT split spoon sampler. Recovery (based on the full length of the run) varied from 0 to 40 percent in these coarse grained deposits. Most runs had recovery of less than 20 percent. This may be indicative of the particle sizes encountered in the overburden.

Clay and silt are present below the coarse grained deposits. The clay/silt layer continues to at least 23.3 meters in THB-6 (the bottom of the hole), to 27.7 meters depth in THB-7 and to 20.0 meters in THB-23. The clay/silt is stiff to very stiff, clayey, with some sand, and with N-values

of 10 to 26. Recovery (based on the full length of the run) varied from 0 to 77 percent in the fine grained deposits. Medium dense sand, gravel, cobbles and boulders exist below the clay/silt layer in THB-7 to a depth of at least 32.5 meters, the bottom of the hole.

Water was encountered in the holes at depths of 1.2 to 3.0 meters. These levels correspond to the water elevation in Beartooth Creek. Drilling notes include observations of heaving sands at several locations, primarily in the upper, coarse grained soils.

Laboratory tests on selected samples of the fine grained soils indicated the soils is a CL-ML or ML, with 80 to 91 percent fines. One sample of CL tested had a dry density of 1539 kg/m^3 and a water content of 27.7 percent. The laboratory test results are summarized in Table 2-2.

Table 2-2

SUMMARY OF LABORATORY TEST RESULTS
BEARTOOTH LAKE OUTLET BRIDGE

Test Hole	Depth (m)	Moisture Content (%)[1]	Classification[2]	% Gravel[3]	% Sand[4]	% Fines[5]	Plasticity Index[6]	Liquid Limit[6]
THB-6	12.50		CL-ML		20	80		
THB-6	17.00		CL-ML	3	8	89	5	23
THB-6	23.10	27.7	CL					
THB-7	11.00		ML		13	87		
THB-7	14.00		ML		13	87	3	21
THB-23	10.00	16.4	ML					
THB-23	12.50	23.4	ML			80	NP	
THB-23	15.00	24.6	ML			91	34	15

(1) Dry unit weight test performed in general accordance with ASTM D 2216.
(2) USCS = Unified Soil Classification System, based on visual observation when grain size data and plasticity data not available. Grain size distribution performed in general accordance with ASTM D422. Visual classification performed in general accordance with ASTM D 2488.
(3) Percent greater than the No. 4 sieve size.
(4) Percent finer than the No. 4 sieve size and coarser than the No. 200 sieve size.
(5) Percent finer than the No. 200 sieve size. Includes silt and clay sizes.
(6) Atterberg limits performed in general accordance with ASTM D 4318.

2.2 INTERPRETATION AND ANALYSIS

Observations and data on soil and bedrock have been interpreted and analyzed to develop geotechnical recommendations. At this site the overburden soil has been evaluated for foundation support and lateral earth pressure.

2.3 RECOMMENDATIONS

2.3.1 Foundations

The Beartooth Lake Outlet Bridge site appears suitable for the proposed construction from a geotechnical engineering point of view.

The following foundation systems were evaluated for bridge support at the site:

- driven friction-bearing pile (H-pile) or (closed-end pipe pile) foundation systems;

- micropiles; and
- straight shaft piers drilled into the underlying clay-silt layer.

Driven H-piles or closed-end pipe piles and micropiles are the more suitable foundation systems for this site due to the presence of shallow ground water and granular soils. Driven piles and micropiles should be installed in accordance with the Project Specifications.

Driven Piles

Steel H-piles (HP 10 x 57) or 300 mm diameter closed end pipe piles driven into the underlying cohesive soil layer at least 6 meters will have an allowable capacity of 110 to 130 kN. Actual capacity is defined in Section 551.06 of the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-96 (1996).

Bearing elevations and pile penetration into the cohesive layer to attain capacity have been estimated and are presented below. Note that the cohesive layer surface varies, so the presented values should be considered as typical.

Location	Typical Elevation (meters)	Estimated Layer Penetration (meters)
Beartooth Outlet Bridge		
Abutment 1	2703	6
Abutment 2	2705	6

Individual pile settlement should be 15 mm or less when designed according to the criteria presented herein.

Groups of piles required to support concentrated loads will require appropriate reductions of the axial, uplift and lateral capacities based on the effective envelope of the pile group. This reduction can be avoided by spacing piles at a minimum distance of at least three diameters center to center. Piles spaced less than three diameters center to center should be evaluated on an individual basis to determine appropriate reductions in axial, uplift and lateral capacities.

The contractor should select a driving hammer and cushion combination which is capable of installing the selected piling without overstressing the pile material. Pile capacities should be evaluated during pile installation using the Pile Driving Analyzer (PDA).

The pile hammer should be operated at the manufacturer's recommended stroke when measuring penetration resistance. Piles should be provided with driving shoes to protect the pile tips from damage when penetrating cobbles. Pile driving operations should be observed under the direction of a qualified geotechnical engineer. Each pile should be observed and checked for buckling, crimping and alignment, in addition to recording penetration resistance, depth of embedment, and general pile driving operations. No specific minimum loading is required, and it is not necessary to consider downdrag in the embankment.

Lateral resistance can be provided by the bending resistance of the piles, or by battered piles. Recommendations provided in the following section for micropiles are applicable to driven piles, as well.

Micropiles

The proposed bridge may be founded on micropiles bearing in the underlying cohesive soil layer. Micropiles should be designed and constructed in accordance with FHWA report FHWA-SA-97-070, Micropile Design and Construction Guidelines Implementation Manual, 2000, and the recommendations presented herein. Type A micropoiles are recommended (FHWA, 2000).

The geotechnical design for micropiles should be based on an allowable bond stress of the grout/soil bond of 19 kPa. Micropiles in the range of 254 to 305 mm will have capacities of 15 to 18 kN/m. Micropiles should be constructed with permanent steel casing extending at least 2 meters into the underlying cohesive soil. The piles should extend at least 6 meters into the clay/silt layer. Can they be driven that far? (piles that is - last section).

The structural design of micropiles should be based on an allowable load of 0.47 times the lower yield stress of the steel casing or reinforcement, and 0.4 times the unconfined compressive strength of the grout. The structural design should also provide for sufficient length for the grout to steel bond.

The casing should meet the physical properties of ASTM A-252 Grade 3, except that the minimum yield strength should be 552 MPa. Reinforcing steel may be Grade 60, 75 or 80 reinforcing rod (ASTM A615, A616 or A617). The grout should consist of neat cement and water mixed with a high shear colloidal type mixer. The grout should have a fluid consistency, a water/ cement ratio of about 0.45 and a minimum unconfined compressive strength of 27.6 MPa at 28 days.

Micropiles provide lateral resistance from the horizontal response of the adjacent soils and can sustain significant lateral deflection within the available structural pile capacity. Increased bending capacity can be provided by increasing the diameter of the pile or the thickness of the pipe. Lateral resistance can also be provided by battered piles. The vertical and horizontal components of the load will depend on the batter inclinations. Pile batters typically should be limited not to exceed 4:1 (vertical:horizontal).

We understand that resistance to lateral load will be evaluated by the L-Pile or FLPier computer programs. Soil properties for lateral capacity analysis are presented as follows:

Material	Soil Type*	Subgrade Modulus (GPa/m)	ϕ (degrees)	c (kPa)	ε_{50}	Effective Unit Weight (kN/m^3)
Compacted Embankment Fill	4	41	35	0	---	21.2
Silty Clay and Silt	2	22	0	72	0.015	18.8
Silty Sand with Gravel	4	54	35	0	---	11.8

*Soil Type 4 is sand

*Soil Type 2 is stiff clay below the water table

2.3.2 Abutment Walls and Retaining Walls

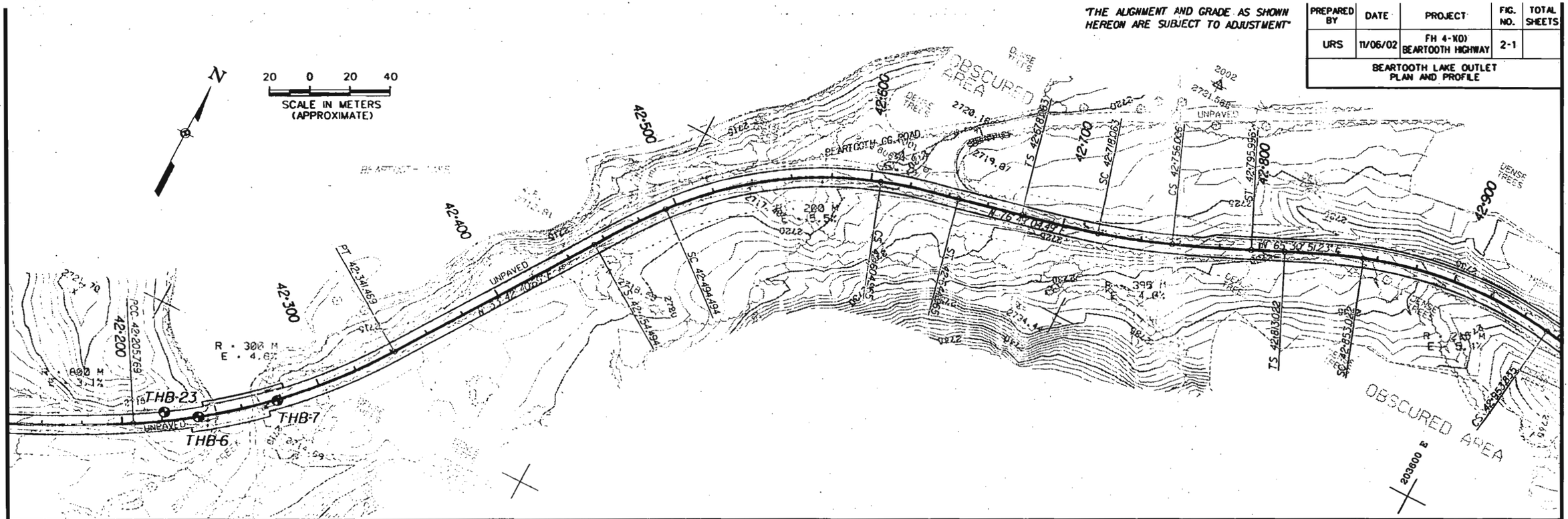
The use of free draining granular soils for backfilling behind bridge abutments and retaining walls is recommended. Granular soils result in lower lateral earth pressures and provide better subsurface drainage. Abutments and retaining walls should be provided with an underdrain

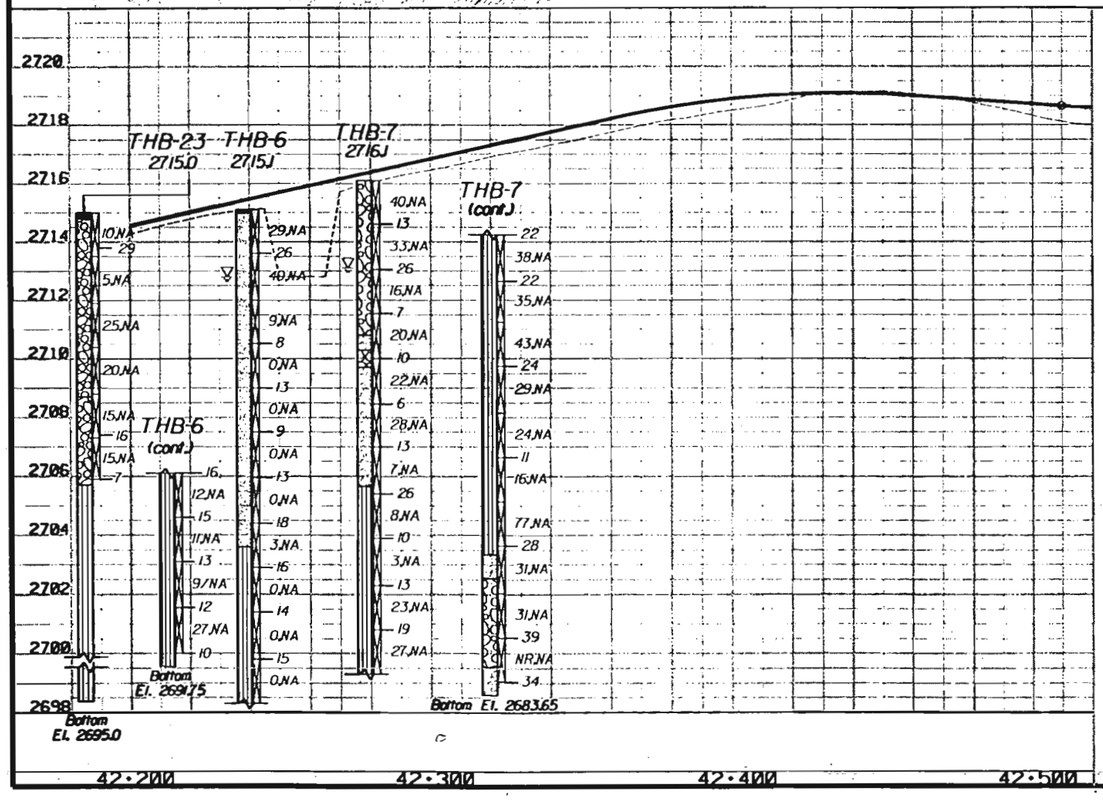
system consisting of a front drainage zone and an underdrain pipe at the base of the wall. The front drainage zone may consist of a vertical layer of either a granular soil layer meeting FP-96 Section 210 or a geocomposite drain meeting FP-96 Section 605.05. The underdrain pipe should consist of a minimum 100 mm PVC pipe encased in a geotextile wrapped granular layer or a geocomposite sheet drain. The pipe should be sloped to daylight at a minimum slope of 2 percent.

Abutment walls and retaining walls which can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 5.9 kN/m^3. This pressure assumes a free draining backfill. Retaining structures should be designed for appropriate surcharge pressures such as traffic, construction equipment and upward sloping backfill.

"THE ALIGNMENT AND GRADE AS SHOWN HEREON ARE SUBJECT TO ADJUSTMENT"

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-1(X0) BEARTOOTH HIGHWAY	2-1	
BEARTOOTH LAKE OUTLET PLAN AND PROFILE				





LEGEND FOR BEARTOOTH LAKE OUTET BRIDGE

- ASPHALT PAVEMENT
- GRAVEL, COBBLE, AND BOULDERS, MEDIUM DENSE (BASED ON BLOWCOUNTS), BROWN, UNWEATHERED TO SLIGHTLY WEATHERED CLASTS
- SAND, SW, SP, OCCASIONALLY SILTY, SM, LOOSE TO MEDIUM DENSE, FINE TO COARSE GRAINED, BROWN, GRAY, SOME GRAVEL AND COBBLES, OCCASIONAL BOULDERS, MOIST TO SATURATED
- SILT, ML, SILTY CLAY, CL-ML STIFF TO VERY STIFF, BROWN, GRAY, CLAYEY, SOME SAND, MOIST TO SATURATED

THB-6 ⊙ TEST HOLE LOCATION

— 12 INDICATES TOP OF INTERVAL FOR STANDARD PENETRATION TEST (SPT). INDICATES THE BLOWCOUNT (N-VALUE) FOR THE FINAL 300 MM OF 450 MM TOTAL PENETRATION IS 12. THE SPT CONSISTS OF RECORDING BLOWS OF A 63.5 KG HAMMER FALLING 760 MM TO DRIVE A 50 MM O.D. SPLIT SPOON SAMPLER. WHERE TWO VALUES ARE SHOWN SEPARATED BY A SLASH, REFUSAL WAS MET BEFORE 450 MM PENETRATION. THE FIRST NUMBER IS THE BLOWCOUNT, THE SECOND NUMBER IS THE PENETRATION DEPTH.

☒ 90,30 INDICATES SPLIT TRIPLE-TUBE CORE BARREL WAS USED TO ADVANCE HOLE. 90,30 INDICATES 90% RECOVERY FOR INTERVAL INDICATED AND A ROCK QUALITY DESIGNATION (RQD) OF 30. RQD IS 100 TIMES THE TOTAL LENGTH OF SOUND CORE OVER 100 MM (40 IN.) LONG DIVIDED BY THE LENGTH OF RUN INDICATED. WHERE SPT INTERVALS PRECEDE CORE INTERVALS, THE SPT INTERVAL IS SUBSEQUENTLY OVER-CORED. RECOVERY AND RUN ARE BASED ON A CORE RUN LENGTH THAT INCLUDES THE OVER-CORED LENGTH.

NA NOT APPLICABLE

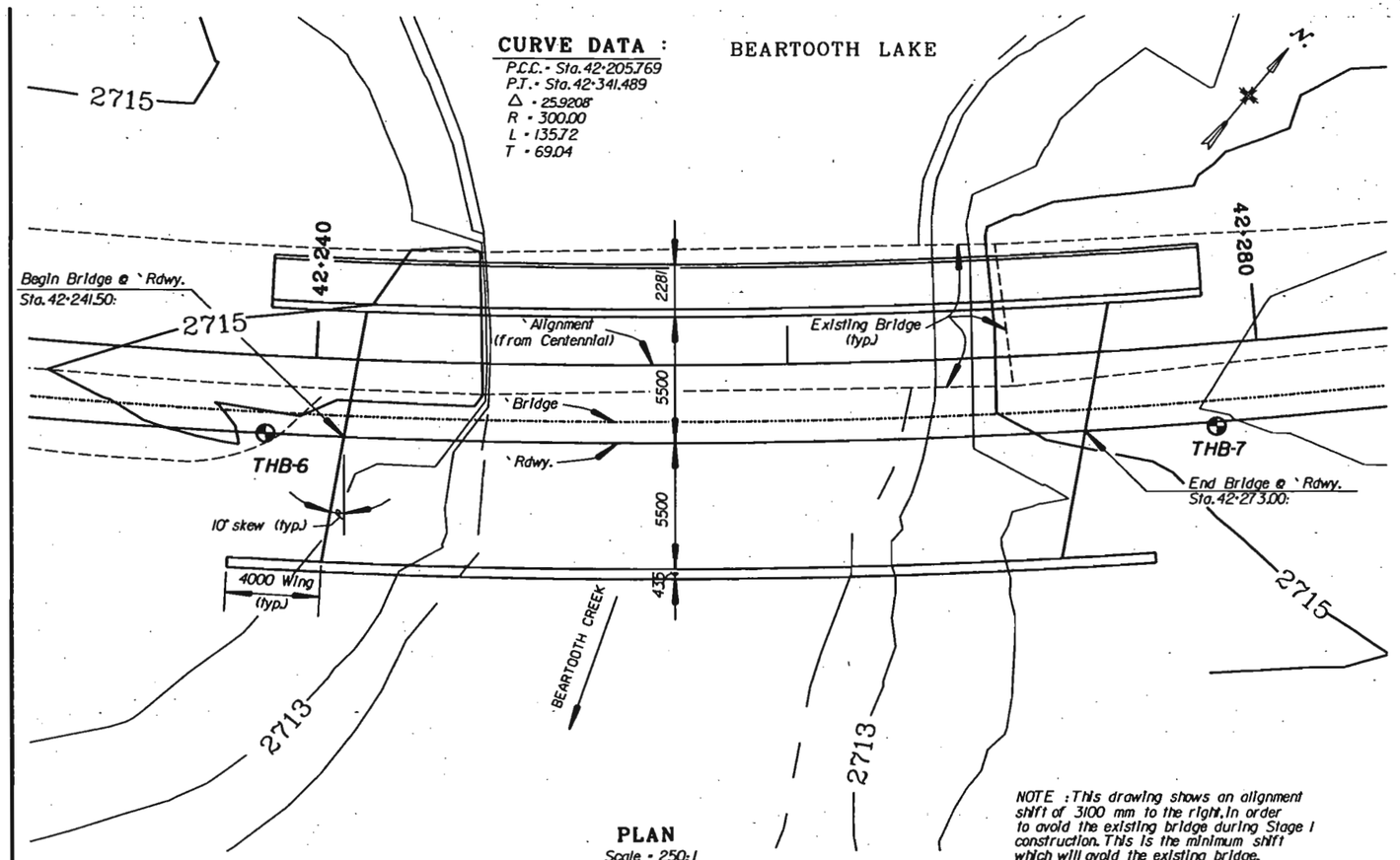
NR NOT RECORDED

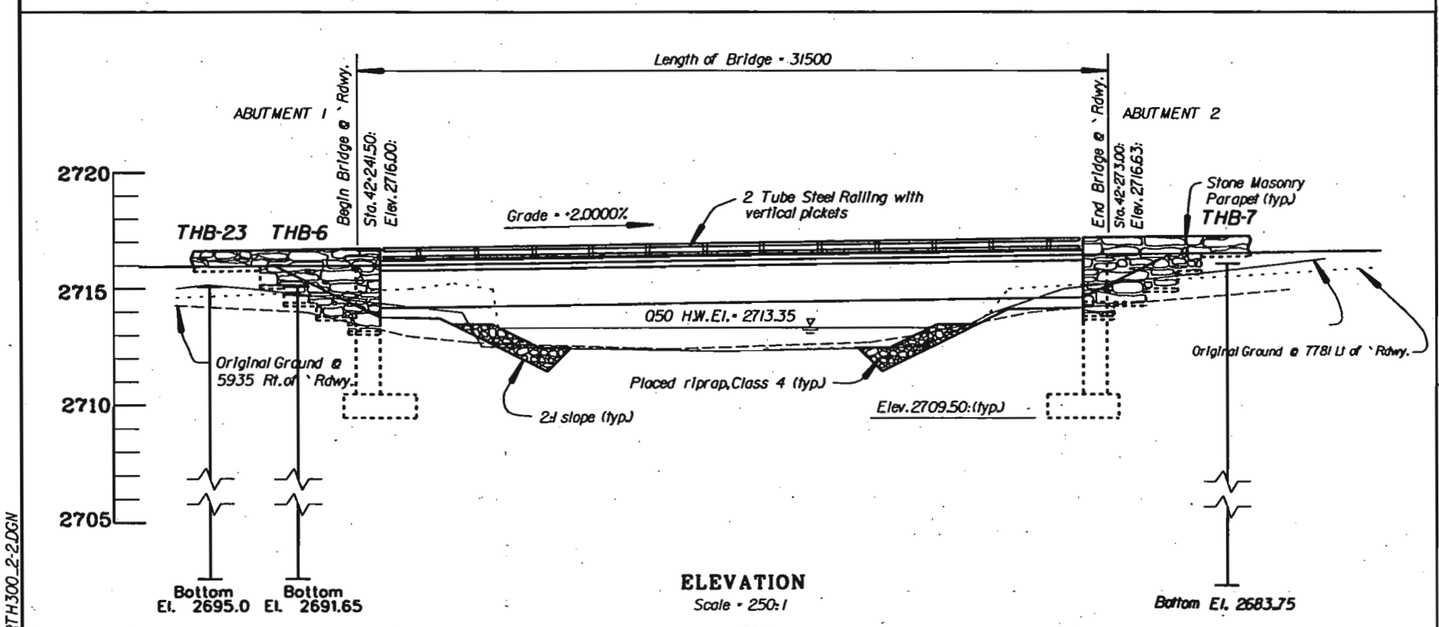
⊽ INDICATES WATER LEVEL AT TIME OF DRILLING

NOTES:

1. TEST HOLES THB-6 AND THB-7 WERE DRILLED ON 8/17/00 THROUGH 9/15/00 BY HAZTECH DRILLING, INC., USING A BK-81 (TRUCK MOUNT) RIG AND AN HQ SPLIT TRIPLE-TUBE CORE BARREL. TEST HOLE THB-23 WAS DRILLED ON 5/15/02 THROUGH 5/18/02 BY DAKOTA DRILLING USING A CME-55 (TRUCK MOUNT) RIG AND 6" HOLLOW STEM AUGER.
2. BASE MAPS OBTAINED FROM DESIGN FIGURES PROVIDED BY THE FHWA.
3. TEST HOLE LOCATIONS ARE APPROXIMATE AND WERE LOCATED BY TAPE MEASUREMENT ON OR BESIDE THE EXISTING ROAD AT DESIGNATED STATIONS. MEASUREMENTS WERE REFERENCED TO MARKINGS AND STAKES PLACED ALONG THE EXISTING ROAD BY THE FHWA.
4. TEST HOLE LOGS IN THIS REPORT ARE SUBJECT TO LIMITATIONS, EXPLANATIONS, AND CONCLUSIONS OF THIS REPORT. SEE INDIVIDUAL LOGS IN APPENDICES FOR MATERIAL DESCRIPTIONS AT EACH TEST HOLE.

BRTH300_2-1.DGN





BRTH300_2-2.DGN

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-K(1) BEARTOOTH HIGHWAY	2-2	
BEARTOOTH LAKE OUTLET BRIDGE PLAN AND ELEVATION				

NOTES:

1. Summary test hole logs are shown on Figure 2-1.
2. See Figure 2-1 for legend and notes.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION, DENVER, COLORADO

PRELIMINARY LAYOUT

BRIDGE NAME Beartooth Lake Outlet Bridge STREAM NAME Beartooth Creek
ROUTE NAME AND NUMBER Beartooth Highway, WY FS 4-1(1)
PREPARED BY FHWA (Base Drawing Only)
SCALE: As Shown DATE: October 16, 2000

3.1 INVESTIGATION

Three test holes were drilled at each of two bridges crossing Little Bear Creek (Bridge No. 1 · THB-8, THB-24 and THB-25) and (Bridge No. 2 THB 11, THB-30 and THB-31). The holes were drilled on the right side of the existing road and advanced using an H-size core barrel. SPT split spoon samples were generally collected at the end of each core run (1.5 m) unless the run ended in a boulder or bedrock. The test hole locations and results are summarized in Table 3-1. The test hole locations are shown on Figures 3-1 through 3-4, summary logs are shown on Figures 3-2 and 6-4, and individual logs and photos are provided in Appendix A.

Table 3-1

TEST HOLE SUMMARY, LITTLE BEAR CREEK BRIDGES

Test Hole Number	Stationing	Offset (m)	Elevation (m)	Depth to Bedrock (m)	Depth to Water[1] (m)	Test Hole Depth (m)
THB-8	45+300	2.7 R	2838.8	8.6	2.9	11.7
THB-24	45+305	0	2839	4.0	1.2	9.6
THB-25	45+330	0	2839	8.7	2.7	12.3
THB-11	46+601	5.8 R	2858.7	3.0	3.4	6.1
THB-30	46+575	0	2858	2.0	2.0	5.2
THB-31	46+660	2.0 R	2858.5	3.0	2.0	7.6

Notes: (1) Encountered in test hole at time of drilling. N.E. = Not Encountered

3.1.1 Site Characteristics

The two Little Bear Creek bridges are in a broad valley near the Top of the World store. The road and creek are approximately parallel except where the creek meanders beneath the road. The valley is probably in its existing location in part because of an ancestral fault that places younger sedimentary bedrock adjacent to Precambrian igneous bedrock. The fault trace appears to be within a few meters of Little Bear Creek Bridge No. 2. Both bridges are replacements for the existing bridges. Little Bear Creek Bridge No. 1 will have a span of 25.5 meters and Little Bear Creek Bridge No. 2 will have a span of 25.0 meters.

3.1.2 Subsurface Characteristics

Little Bear Creek Bridge Number 1

Based on THB-8, THB-24 and THB-25, the subsurface conditions at Little Bear Creek Bridge No. 1 consist of 4.0 to 8.7 meters of loose to medium dense gravel, cobbles and boulders. The longest length of cobble cored was 0.25 meters. Larger boulders are evident on the ground surface and in the stream channel. N-values range from 7 to 54, increasing consistently with depth. The presence of gravel, cobbles, and boulders has probably impacted some SPT results, causing them to be higher than the density would indicate.

The summary logs show recovery for core runs in the overburden, as well as the SPT results. Core intervals include overcoring (reaming) the interval of the hole sampled with the SPT split spoon sampler. Despite coring through this disturbed material, recovery (based on the full length of the run) generally varied from 31 to 66 percent in these deposits. One run, where sandier materials were encountered, had recovery of only 18 percent. This suggests percent recovery may correlate with the particle sizes encountered in the overburden.

Water was encountered in the holes at depths of 1.2 to 2.9 meters. This appears to be at or about 0.5 meters below the channel bottom, based on the centerline elevation shown on Figure 3-1.

Bedrock consists of strong, slightly weathered gneiss. Recovery was 70 to 80 percent and the RQD is 10 to 11. The unconfined compressive strength of a sample from 11.0 meter depth is 47.0 MPa. The unconfined compressive strength estimated from point load testing varies from 127 to 174 MPa. The laboratory test results are summarized in Table 3-2.

Table 3-2

SUMMARY OF LABORATORY TEST RESULTS

Test Hole	Depth (m)	Bulk Density (kg/cu. m)	Classification	UCS (MPa)[1][2]	UCS (MPa)[2]
THB-8	9.60		Gneiss	174	
THB-8	11.00	2945	Gneiss		47
THB-8	11.60		Gneiss	127	
THB-11	3.10		Sandstone	27	
THB-11	4.00		Sandstone	20	
THB-11	5.20	2568	Sandstone		31
THB-30	2.50	2598	Sandstone		101
THB-31	5.00	2527	Sandstone		46

(1) Values determined from point load testing of core (ASTM D571), as described on data sheets in Appendix D.
(2) UCS = Unconfined Compressive Strength (ASTM D2938), as described on data sheets in Appendix D.

Little Bear Creek Bridge Number 2

Based on THB-11, THB-30 and THB-31 the subsurface conditions at Little Bear Creek Bridge No. 2 consist of 2.0 to 3.0 meters of medium dense sand with few gravels and cobbles. Boulders were not encountered, but some boulders are evident on the nearby ground surface and in the stream channel. The presence of gravel and cobbles may have impacted the SPT results, causing them to be higher than the density would indicate. Recovery in the core barrel was only 5 to 15 percent in the overburden.

Water was encountered in the hole at a depth of 2.0 to 3.3 meters. This appears to be 0 to 2 meters below the channel bottom, based on the centerline elevation shown on Figure 3-3.

Bedrock consists of moderately strong, iron stained, medium to coarse grained sandstone, with some thin clay seams. Recovery was 50 to 100 percent and the RQD is 50 to 56. The unconfined compressive strength of three samples ranged from 31.1 to 101 MPa. The unconfined compressive strength estimated from point load testing varies from 20 to 27 MPa.

3.2 INTERPRETATION AND ANALYSIS

Observations and data on soil and bedrock have been interpreted and analyzed to develop geotechnical recommendations. At this site the soil overburden has been evaluated for lateral earth pressure and the bedrock has been evaluated for the bridge foundation.

The bedrock quality has been evaluated based on the unconfined compressive strength of intact rock, the RQD, and the Rock Mass Rating (RMR). Table 3-3 presents the interpretation of bedrock quality and estimated ranges of engineering parameters based on these methods. In general, these characterizations show that the bedrock quality is very poor to fair. The rock mass Young's modulus (E_m), and the cohesive (c) and frictional (ϕ) strength parameters, are based on published correlations to the RMR. They are presented here to assist in characterizing the relative quality of the rock mass. These correlated values are part of the information used to develop the geotechnical recommendations for design presented in Section 3.3.

Table 3-3

INTERPRETATION OF BEDROCK QUALITY
LITTLE BEAR CREEK BRIDGES

Location	Typical RQD	RQD Based Rock Quality[1]	RMR[2] Range	RMR Class[2]	Em (GPa)[3]	C (kPa)[2]	ϕ (deg)[2]
Bridge No. 1 (West Abutment)	15	Very Poor	50-58	III (Fair)	10-16	250-300	30-35
Bridge No. 2 (East Abutment)	35	Poor	40-60	III (Fair)	6-18	200-300	25-35

Notes:

(1) Based on RQD, Deere (1964). Classification for RQD <25 = very poor, 25 < 50 = poor, 50 < 75 = fair, 75 < 90 = good, 90 < 100 = excellent

(2) Rock Mass Rating, Bieniawski (1989), classification for RMR < 20 = V (very poor), 21 to 40 = IV (poor), 41 to 60 = III (fair), 61 to 80 = II (good), 81 to 100 = I (very good). Cohesion and friction ranges are based on RMR class. For Class V: ϕ < 15°, c < 100 kPa; for Class IV: ϕ = 15-25°, c = 100-200 kPa; for Class III: ϕ = 25-35°, c = 200-300 kPa, for Class II: ϕ = 35-45°, c = 300-400 kPa; for Class I: ϕ > 45, c > 400 kPa.

(3) Young's Modulus of Rock Mass based on RMR, $E_m = 10^{(RMR-10)/40}$, Serafin and Pereira (1983)

3.3 RECOMMENDATIONS

3.3.1 Foundations

The Little Bear Creek Bridge Sites No. 1 and No. 2 appear suitable for the proposed construction from a geotechnical engineering point of view.

The following foundation systems were evaluated for bridge support at the site:

- driven end-bearing pile (H-pile) foundation systems; and
- straight shaft piers drilled into the bedrock.

Driven H-piles are a more suitable foundation system for these sites due to the presence of gravel and cobbles. Driven piles should be installed in accordance with the Project Specifications.

Driven Piles

Steel H-piles driven into the bedrock formation and to virtual refusal may be designed using a working stress of 82.8 MPa. Virtual refusal is defined in Section 551.06 of the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-96 (1996).

Bedrock elevations and pile penetration into bedrock to attain virtual refusal have been estimated and are presented below. Note that the bedrock surface varies, so the presented values should be considered as typical.

Location	Typical Bedrock Elevation (meters)	Estimated Bedrock Penetration (meters)
Little Bear Creek Bridge No. 1		
Abutment 1	2,830	2
Abutment 2	2,830	2
Little Bear Creek Bridge No. 2		
Abutment 1	2,856	1.5
Abutment 2	2,855	1.5

Individual pile settlement should be 15 mm or less when designed according to the criteria presented herein.

Groups of piles required to support concentrated loads will require appropriate reductions of the axial, uplift and lateral capacities based on the effective envelope of the pile group. This reduction can be avoided by spacing piles at a minimum distance of at least three diameters center to center. Piles spaced less than three diameters center to center should be evaluated on an individual basis to determine appropriate reductions in axial, uplift and lateral capacities.

The contractor should select a driving hammer and cushion combination which is capable of installing the selected piling without overstressing the pile material. We recommend that pile capacities be evaluated during pile installation using the Pile Driving Analyzer (PDA).

The pile hammer should be operated at the manufacturer's recommended stroke when measuring penetration resistance. Piles should be provided with driving shoes to protect the pile tips from damage when penetrating dense granular soils or cobbles. Pile driving operations should be observed under the direction of a qualified geotechnical engineer. Each pile should be observed and checked for buckling, crimping and alignment in addition to recording penetration resistance, depth of embedment, and general pile driving operations. No specific minimum loading is required, and it is not necessary to consider downdrag in the embankment.

Lateral resistance to horizontal forces can be provided by the bending resistance of piles. Lateral resistance can also be provided by battered piles. The vertical and horizontal components of the load will depend on the batter inclinations. Pile batters typically should be limited not to exceed 4:1 (vertical:horizontal).

We understand that resistance to lateral load will be evaluated by the L-Pile or FLPier computer programs. Soil properties for lateral capacity analysis are presented as follows:

Material	Soil Type*	Subgrade Modulus (GPa/m)	ϕ (degrees)	c (kPa)	ε_{50}	Effective Unit Weight (kN/m^3)
Compacted Embankment Fill	4	41	35	0	---	21.2
Silty Sand with Gravel	4	27	35	0	---	11.8
Bedrock	2	543	0	239	0.007	11.8

*Soil Type 4 is sand

*Soil Type 2 is stiff clay below the water table

3.3.2 Abutment and Retaining Walls

The use of free draining granular soils for backfilling behind bridge abutments and retaining walls is recommended. Granular soils result in lower lateral earth pressures and provide better subsurface drainage. Abutments and retaining walls should be provided with an underdrain system consisting of a front drainage zone and an underdrain pipe at the base of the wall. The front drainage zone may consist of a vertical layer of either a granular soil layer meeting FP-96 Section 210 or a geocomposite drain meeting FP-96 Section 605.05. The underdrain pipe should consist of a minimum 100 mm PVC pipe encased in a geotextile wrapped granular layer or a geocomposite sheet drain. The pipe should be sloped to daylight at a minimum slope of 2 percent.

Abutment walls and retaining walls which can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 5.9 kN/m^3. This pressure assumes a free draining backfill. Retaining structures should be designed for appropriate surcharge pressures such as traffic, construction equipment and upward sloping backfill.

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-1(10) BEARTOOTH HIGHWAY	3-1	

LITTLE BEAR CREEK BRIDGE NO. 1
PLAN AND PROFILE

"THE ALIGNMENT AND GRADE AS SHOWN HEREON ARE SUBJECT TO ADJUSTMENT"

NOTES:

1. See Figure 2-1 for legend and notes.

20 0 20 40
SCALE IN METERS
(APPROXIMATE)

N

THB-8
THB-25
THB-24
PC 45+083.363
PT 45+269.954
PC 45+322.875
PT 45+483.730
BC 45+548.274
EC 45+908.284
S 88° 41' 23" E
S 36° 42' 32" W
CS 45+023.752
ST 45+063.752
UNPAVED
2845.69

THB-24
THB-8
2838.8
THB-25
45+180
2,840.600
45+420
2,839.000
K = 253
200 M VC
K = 70
250 M VC
0.1250%
0.6667%
0.6667%
-2.885%
PROPOSED GRADE
EXISTING GROUND

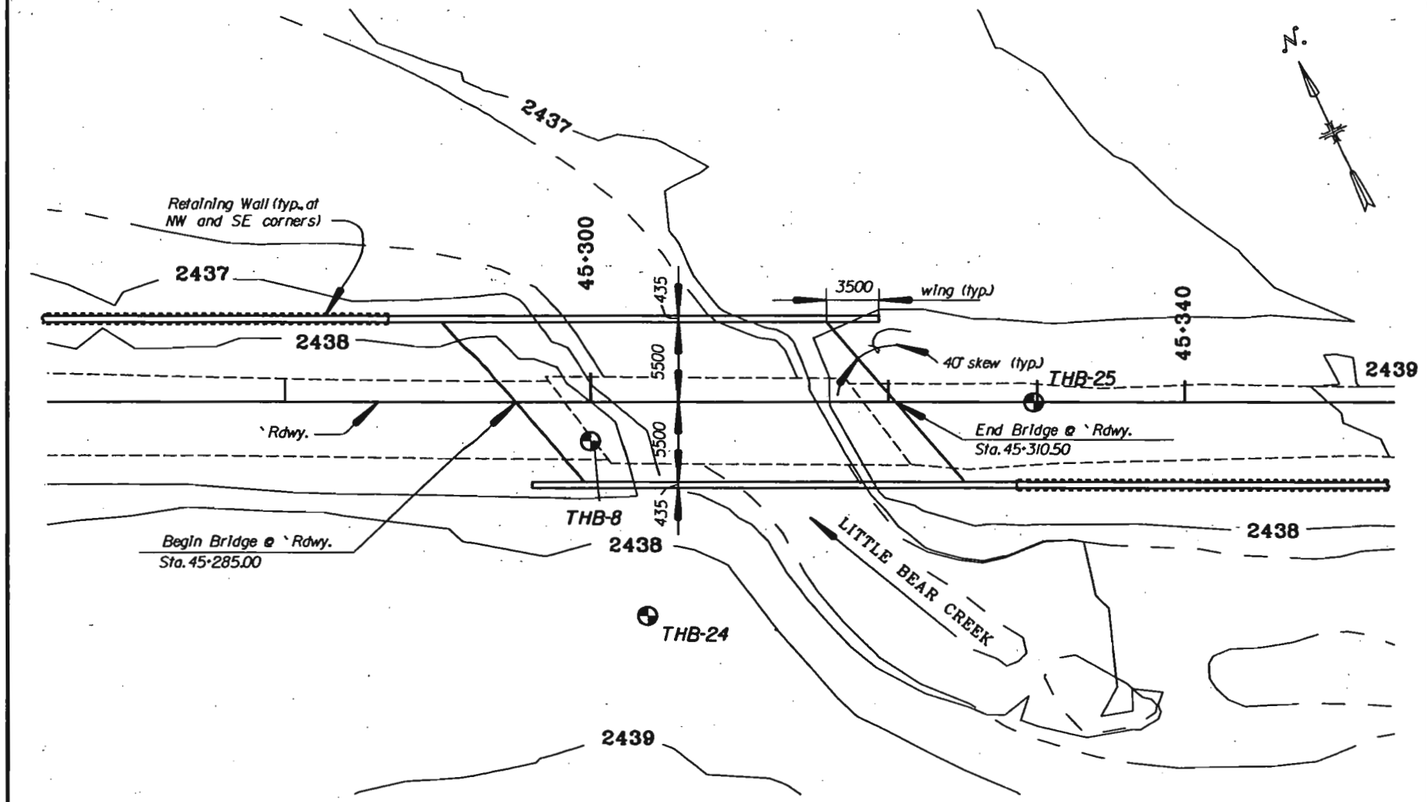
40.NA 37.NA 58
60.0 13
20.NA 31.NA
7 12
40.0 57.NA 28
28
80.20 18.NA 55
39
80.32 66.NA
54
80.40 67.NA
80.00
80.20
70.10

2848 2846 2844 2842 2840 2838 2836 2834 2832 2830 2828 2826

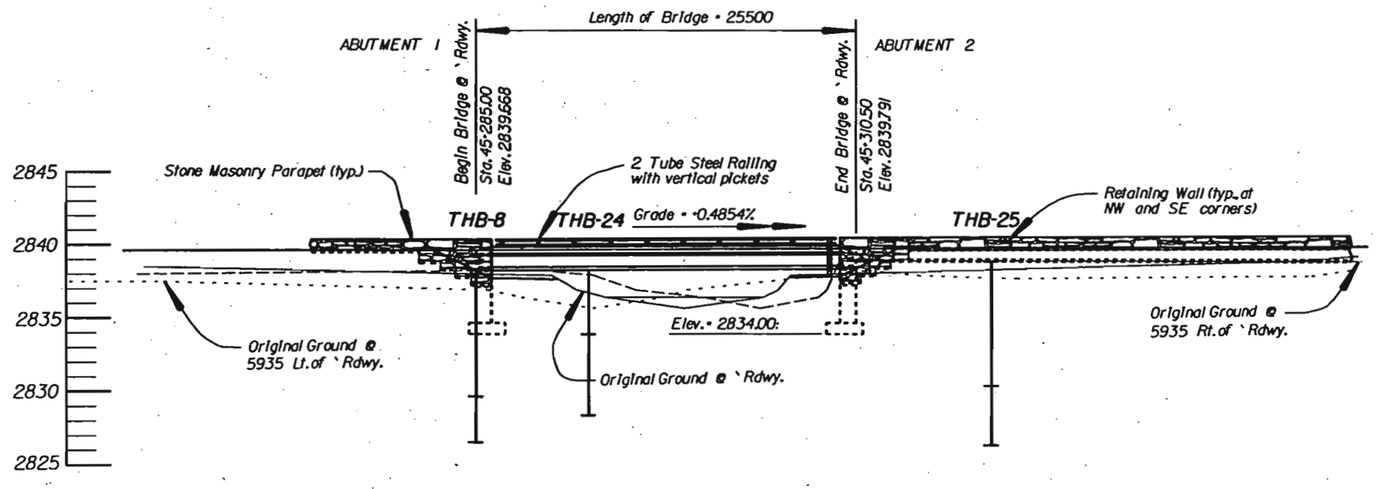
45+000 45+100 45+200 45+300 45+400 45+500 45+600 45+700

BRTH300_3-1.DGN

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-K(0) BEARTOOTH HIGHWAY	3-2	
LITTLE BEAR CREEK BRIDGE NO. 1				



PLAN
Scale : 400:1



ELEVATION
Scale : 400:1

BRTH300_3-2.DGN

NOTES:

1. *Summary test hole log is shown on Figure 3-1.*
2. *See Figure 6-4 for legend and notes.*
3. *Intermediate tick on test hole stick logs indicates interpreted top of bedrock.*

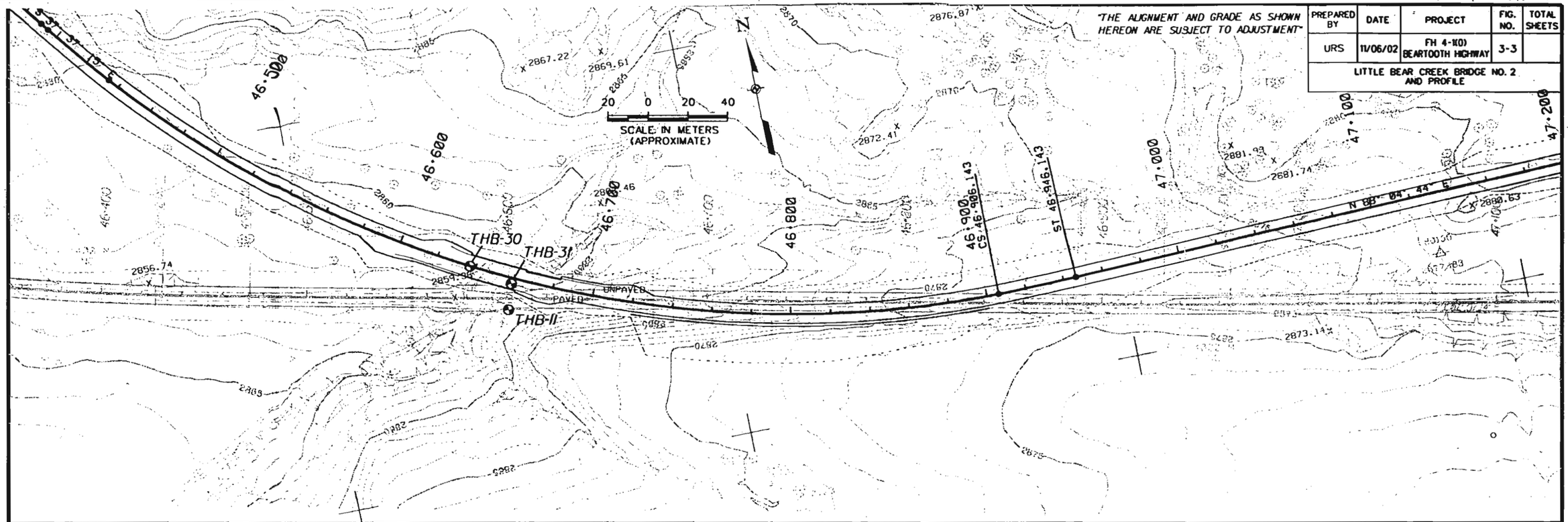
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION, DENVER, COLORADO

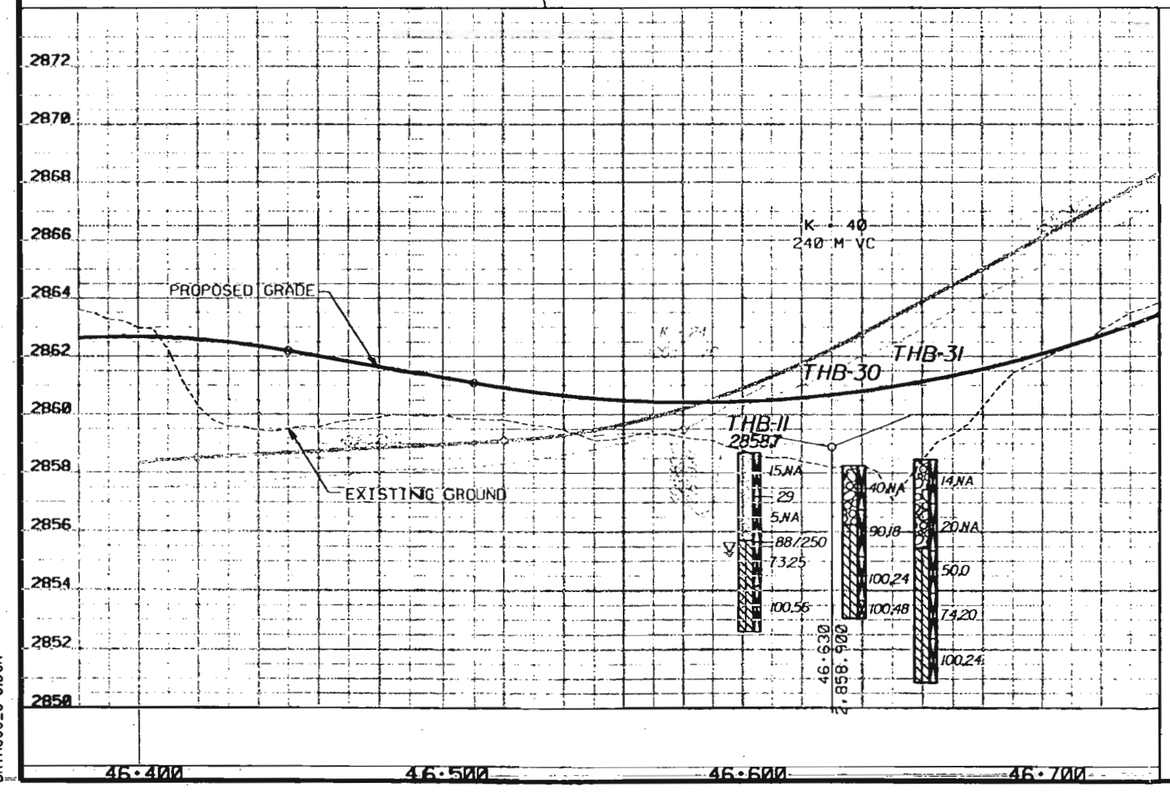
PRELIMINARY LAYOUT

BRIDGE NAME *Little Bear Creek Bridge No.1* STREAM NAME *Little Bear Creek*
ROUTE NAME AND NUMBER *Beartooth Highway, WY FS 4-1(0)*
PREPARED BY *FHWA (Base Drawing Only)*
SCALE: *As Shown* DATE: *October 16, 2000*

"THE ALIGNMENT AND GRADE AS SHOWN HEREON ARE SUBJECT TO ADJUSTMENT"

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-1(0) BEARTOOTH HIGHWAY	3-3	
LITTLE BEAR CREEK BRIDGE NO. 2 AND PROFILE				





BRTH300_3-3.DGN

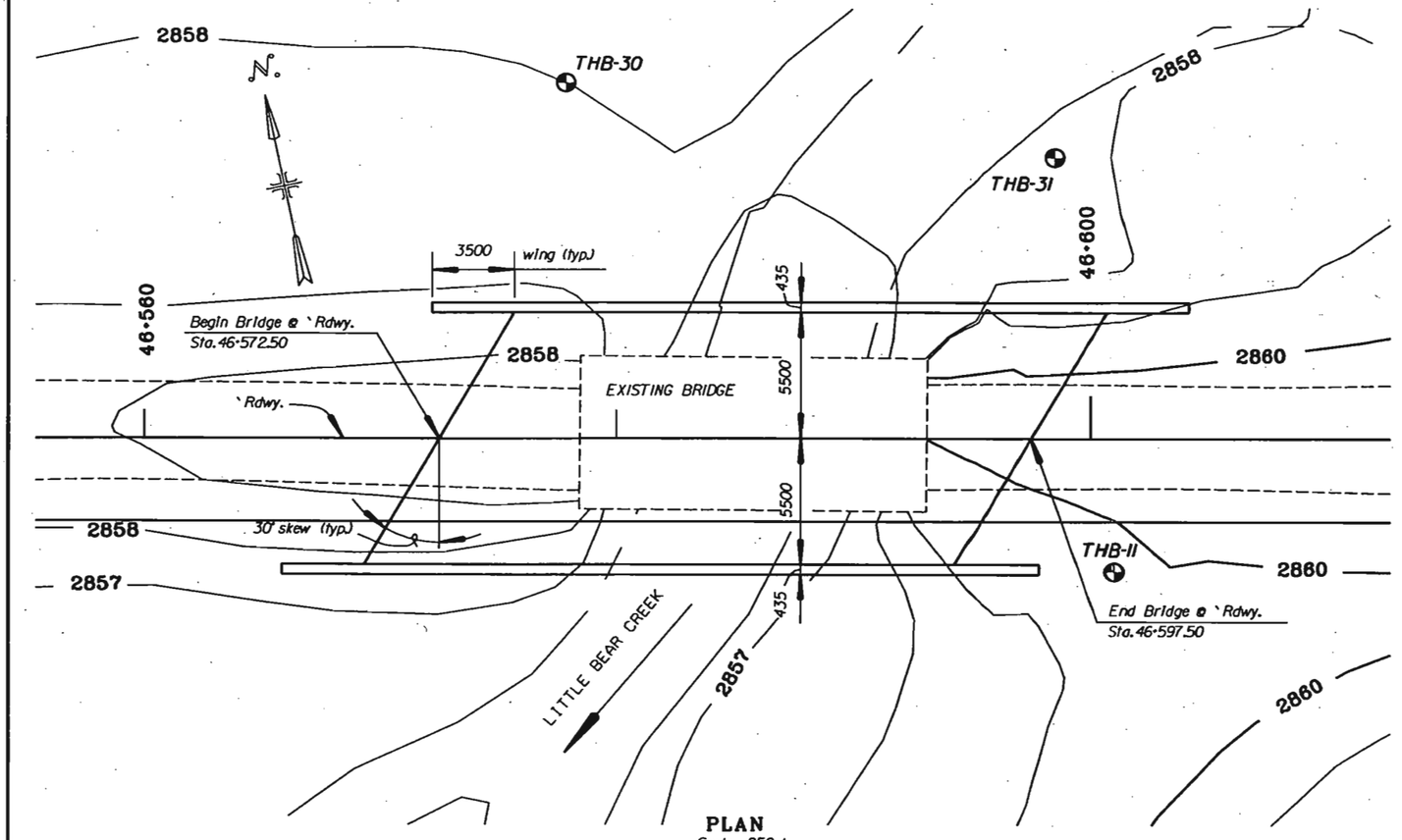
LEGEND FOR LITTLE BEAR CREEK BRIDGE NO. 1 AND NO. 2

- ASPHALT AND BASE COURSE PAVEMENT SECTION
- SAND, SW, MEDIUM DENSE, BROWN, SOME SILTY AND CLAYEY, SM, SC, GRAY, SOME GRAVEL AND COBBLES
- GRAVEL, COBBLE AND BOULDERS, LOOSE TO VERY DENSE (BASED ON BLOWCOUNTS), BROWN, REDDISH-BROWN, SILTY TO CLAYEY SAND MATRIX
- SANDSTONE, MODERATELY STRONG, GRAY, RED-BROWN, FINE TO COARSE GRAINED IRON STAINED, THIN LENSES OF CLAY
- GNEISS, MODERATELY STRONG TO VERY STRONG, GRAY, SLIGHTLY WEATHERED
- THB-II — TEST HOLE LOCATION
- — 12 — INDICATES TOP OF INTERVAL FOR STANDARD PENETRATION TEST (SPT), INDICATES THE BLOWCOUNT (N-VALUE) FOR THE FINAL 300 MM OF 450 MM TOTAL PENETRATION IS 12. THE SPT CONSISTS OF RECORDING BLOWS OF A 63.5 KG HAMMER FALLING 760 MM TO DRIVE A 50 MM O.D. SPLIT SPOON SAMPLER. WHERE TWO VALUES ARE SHOWN SEPARATED BY A SLASH, REFUSAL WAS MET BEFORE 450 MM PENETRATION. THE FIRST NUMBER IS THE BLOWCOUNT, THE SECOND NUMBER IS THE PENETRATION DEPTH.
- 90.30 — INDICATES SPLIT TRIPLE-TUBE CORE BARREL WAS USED TO ADVANCE HOLE. 90.30 INDICATES 90% RECOVERY FOR INTERVAL INDICATED AND A ROCK QUALITY DESIGNATION (RQD) OF 30. RQD IS 100 TIMES THE TOTAL LENGTH OF SOUND CORE OVER 100 MM (40 IN.) LONG DIVIDED BY THE LENGTH OF RUN INDICATED. WHERE SPT INTERVALS PRECEDE CORE INTERVALS, THE SPT INTERVAL IS SUBSEQUENTLY OVER-CORED. RECOVERY AND RUN ARE BASED ON A CORE RUN LENGTH THAT INCLUDES THE OVER-CORED LENGTH.
- NA — NOT APPLICABLE
- ▽ — INDICATES WATER LEVEL AT TIME OF DRILLING

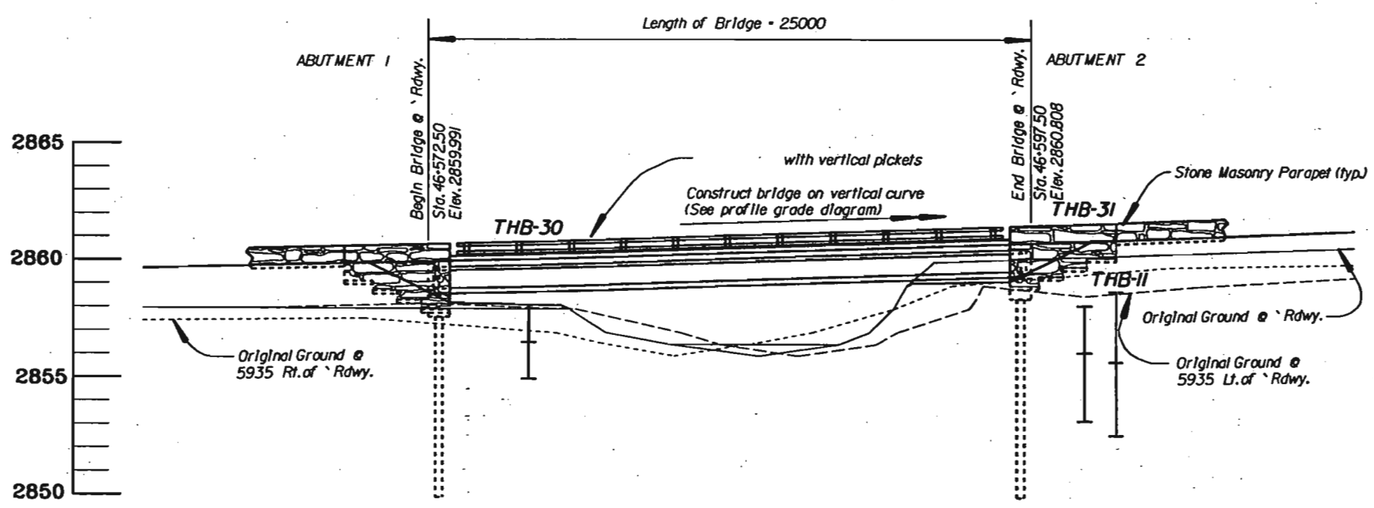
NOTES:

1. TEST HOLE THB-II WAS DRILLED ON 8/17/00 THROUGH 9/15/00 BY HAZTECH DRILLING, INC., USING A BK-81 (TRUCK MOUNT) RIG AND AN HQ SPLIT TRIPLE-TUBE CORE BARREL. TEST HOLES THB-30 AND THB-31 WERE DRILLED ON 5/23/02.
2. BASE MAPS OBTAINED FROM DESIGN FIGURES PROVIDED BY THE FHWA.
3. TEST HOLE LOCATIONS ARE APPROXIMATE AND WERE LOCATED BY TAPE MEASUREMENT ON OR BESIDE THE EXISTING ROAD AT DESIGNATED STATIONS. MEASUREMENTS WERE REFERENCED TO MARKINGS AND STAKES PLACED ALONG THE EXISTING ROAD BY THE FHWA.
4. TEST HOLE LOGS IN THIS REPORT ARE SUBJECT TO LIMITATIONS, EXPLANATIONS, AND CONCLUSIONS OF THIS REPORT. SEE INDIVIDUAL LOGS IN APPENDICES FOR MATERIAL DESCRIPTIONS AT EACH TEST HOLE.

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-1(0) BEARTOOTH HIGHWAY	3-4	
LITTLE BEAR CREEK BRIDGE NO. 2				



PLAN
Scale : 250:1



ELEVATION
Scale : 250:1

BRTH300_3-4.DGN

NOTES:

1. Summary test hole log is shown on Figure 3-3.
2. See Figure 2-1 for legend and notes.
3. Intermediate tick on test hole stick logs indicates interpreted top of bedrock.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION, DENVER, COLORADO

PRELIMINARY LAYOUT

BRIDGE NAME Little Bear Creek Bridge No.2 STREAM NAME Little Bear Creek
ROUTE NAME AND NUMBER Beartooth Highway, WY FS 4-1(0)
PREPARED BY FHWA (Base Drawing Only)
SCALE: As Shown DATE: October 16, 2000

4.1 INVESTIGATION

Three test holes, THB-19, THB-20 and THB-28 were drilled at the bridge. The holes were drilled using an H-size and N-size core barrels and SPT split spoon samples were generally collected at the end of each 1.5 meter core run unless the run ended on a boulder or in bedrock. The test hole locations and results are summarized in Table 4-1. The test hole locations are shown on Figures 4-1 and 4-2, summary logs are shown on Figure 4-2 and individual logs and photos are provided in Appendix A.

Table 4-1

TEST HOLE SUMMARY, LONG LAKE OUTLET BRIDGE

Test Hole Number	Stationing	Offset (m)	Elevation (m)	Depth to Bedrock (m)	Depth to Water[1] (m)	Test Hole Depth (m)
THB-19	50+262	7.6 L	2940.9	1.7	1.3	6.0
THB-20	50+285	6.7 L	2941.0	3.9	1.3	7.0
THB-28	50+340	0	2941.0	3.1	1.0	6.1

Notes: (1) Encountered in test hole at time of drilling. N.E. = Not Encountered

4.1.1 Site Characteristics

The Long Lake Outlet Bridge has one span of 19.5 meters, as shown on Figure 8-1. The bridge deck will be about 1.2 to 2.2 meters above the ground surface. The bridge spans Little Bear Creek, which is the outlet for Long Lake, located in a high alpine environment. We understand a retaining wall of less than approximately 2.5 meter height and 18 meter length is planned on the left side of the road, adjacent to Long Lake, east of the bridge.

4.1.2 Subsurface Characteristics

This section summarizes the abutment and pier foundation subsurface investigation results. The individual test hole logs are presented in Appendix A and the laboratory test results are presented in Appendix C.

THB-19 was drilled at the west abutment of the bridge. Slightly weathered granite bedrock was encountered approximately 1.7 meters below the road surface. The overburden consists of gravel, cobbles and boulders in a sand matrix. The longest length of cobble cored was 0.23 meters. Percent recovery in the core barrel of this overburden material was 40 percent. The bedrock was cored with an H-size core barrel and core recovery was generally 100 percent below 3 meters depth, and less at shallower depth. The rock quality designation (RQD) varies from 0 to 20. Groundwater was encountered at approximately 1.3 meter depth. The unconfined compressive strength of a sample from 3.5 meter depth is 42 MPa. The unconfined compressive strength estimated from point load testing varies from 119 to 125 MPa. The laboratory test results are summarized in Table 8-2.

Table 4-2

SUMMARY OF LABORATORY TEST RESULTS
LONG LAKE OUTLET BRIDGE

Test Hole	Depth (m)	Bulk Density (kg/cu. m)	Classification	UCS[1][2] (MPa)	UCS[2] (MPa)
THB-19	3.40	2765	Granite		42
THB-19	4.90		Granite	125	
THB-19	5.80		Granite	119	
THB-20	5.60	2623	Granite	200	118
THB-20	6.10		Granite	143	
THB-20	6.90		Granite	160	

(1) Values determined from point load testing of core (ASTM D5731), as described on data sheets in Appendix D.

(2) UCS = Unconfined Compressive Strength (ASTM D2938), as described on data sheets in Appendix D.

THB-20 was drilled at the east abutment of the bridge. Slightly weathered granite bedrock was encountered approximately 3.9 meters below the road surface. The overburden is gravel, cobbles and boulders in a sand matrix. The longest length of cobble cored was 0.2 meters. Standard Penetration Tests (SPT's) were generally conducted at the end of each 1.5 meter core run. N-values range from 17 to 24. The considerable presence of gravel, cobbles, and boulders has probably impacted some SPT results, especially the higher values. The summary logs show recovery for core runs in the overburden, as well as the SPT results. Core intervals include overcoring (reaming) the interval of the hole sampled with the SPT split spoon sampler. Despite coring through this disturbed material, recovery varied from 32 to 35.

THB-28 was drilled 30 meters east of the east abutment in proposed retaining wall area. The overburden is gravel, cobbles and boulders to a depth of 3.1 meters. The granite bedrock encountered was more fractured than the bedrock in THB-19 and THB-20.

Bedrock was cored with H-size and N-size core barrels and recovery was 14 to 100 percent. The rock quality designation (RQD) varies from 0 to 78. Groundwater was encountered at approximately 1.0 to 1.3 meters below the ground surface. The unconfined compressive strength of a sample from 5.6 meters depth is 118 MPa. The unconfined compressive strength estimated from point load testing varies from 143 to 200 MPa.

4.2 INTERPRETATION AND ANALYSIS

Observations and data on soil and bedrock have been interpreted and analyzed to develop geotechnical recommendations. At this site the soil overburden has been evaluated primarily for temporary excavation slopes and lateral earth pressure. The bedrock has been evaluated for the bridge foundation.

The bedrock quality has been evaluated based on the unconfined compressive strength of intact rock, the Rock Quality Designation (RQD), and the Rock Mass Rating (RMR). Table 4-3 presents the interpretation of bedrock quality and estimated ranges of engineering parameters based on these methods. In general, these characterizations show that the bedrock quality varies

from very poor to good. The bedrock quality appears to be slightly better at the east abutment than at the west abutment, but this difference is not significant enough to impact foundation recommendations.

The values of Young's modulus for the rock mass (E_m), and for the cohesive (c) and frictional (ϕ) strength parameters, are based on published correlations to the RMR. They are presented here to assist in characterizing the relative quality of the rock mass. These correlated values are part of the information used to develop the geotechnical recommendations for design presented in Section 4.3.

Table 4-3

INTERPRETATION OF BEDROCK QUALITY
LONG LAKE OUTLET BRIDGE

Location	Typical RQD	RQD Based Rock Quality[1]	RMR[2] Range	RMR Class [2]	Em (GPa)[3]	c (kPa)[2]	ϕ (deg)[2]
West Abutment (No. 1)	10	Very Poor	40-48	III (Fair)	6-9	200-250	25-30
East Abutment (No. 2)	40	Poor	48-66	III (Fair) II (Good)	9-25	250-350	30-40

Notes:

(1) Based on RQD, Deere (1964). Classification for RQD <25 = very poor, 25 < 50 = poor, 50 < 75 = fair, 75 < 90 = good, 90 < 100 = excellent

(2) Rock Mass Rating, Bieniawski (1989), classification for RMR < 20 = V (very poor), 21 to 40 = IV (poor), 41 to 60 = III (fair), 61 to 80 = II (good), 81 to 100 = I (very good). Cohesion and friction ranges are based on RMR class. For Class V: ϕ < 15°, c < 100 kPa; for Class IV: ϕ = 15-25°, c = 100-200 kPa; for Class III: ϕ = 25-35°, c = 200-300 kPa, for Class II: ϕ = 35-45°, c = 300-400 kPa; for Class I: ϕ > 45, c > 400 kPa.

(3) Young's Modulus of Rock Mass based on RMR, $E_m = {}^{10\,(RMR-10)/40}$, Serafin and Pereira (1983)

4.3 RECOMMENDATIONS

4.3.1 Foundations

The Long Lake Outlet Bridge site appears suitable for the proposed construction from a geotechnical engineering point of view.

Driven end-bearing pile (H-pile) foundation systems were evaluated for bridge support at the site. Driven H-piles are a suitable foundation system for this site due to the presence of gravel and cobbles. Driven piles should be installed in accordance with the Project Specifications.

Driven Piles

Steel H-piles driven into the bedrock formation and to virtual refusal may be designed using a working stress of 82.8 MPa. Virtual refusal is defined in Section 551.06 of the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-96 (1996).

Bedrock elevations and pile penetration into bedrock to attain virtual refusal have been estimated and are presented below. Note that the bedrock surface varies, so the presented values should be considered as typical.

Location	Typical Bedrock Elevation (meters)	Estimated Bedrock Penetration (meters)
Abutment 1	2939	1.5
Abutment 2	2937	1

Individual pile settlement should be 15 mm or less when designed according to the criteria presented herein.

Groups of piles required to support concentrated loads will require appropriate reductions of the axial, uplift and lateral capacities based on the effective envelope of the pile group. This reduction can be avoided by spacing piles at a minimum distance of at least three diameters center to center. Piles spaced less than three diameters center to center should be evaluated on an individual basis to determine appropriate reductions in axial, uplift and lateral capacities.

The contractor should select a driving hammer and cushion combination which is capable of installing the selected piling without overstressing the pile material. Pile capacities should be evaluated during pile installation using the Pile Driving Analyzer (PDA).

The pile hammer should be operated at the manufacturer's recommended stroke when measuring penetration resistance. Pile should be provided with driving shoes to protect the pile tips from damage when penetrating dense granular soils or cobbles. Pile driving operations should be observed under the direction of a qualified geotechnical engineer. Each pile should be observed and checked for buckling, crimping and alignment in addition to recording penetration resistance, depth of embedment, and general pile driving operations. No specific minimum loading is required, and it is not necessary to consider downdrag in the embankment.

Lateral resistance to horizontal forces can be provided by the bending resistance of piles. Lateral resistance can also be provided by battered piles. The vertical and horizontal components of the load will depend on the batter inclinations. Pile batters typically should be limited not to exceed 4:1 (vertical: horizontal).

We understand that resistance to lateral load will be evaluated by the L-Pile or FLPier computer programs. Soil properties for lateral capacity analysis are presented as follows:

Material	Soil Type*	Subgrade Modulus (MPa/M)	ϕ (degrees)	c (kPa)	ε_{50}	Effective Unit Weight (kN/m^3)
Compacted Embankment Fill	4	41	35	0	---	21.2
Silty Sand with Gravel	4	27	35	0	---	11.8
Bedrock	2	543	0	239	0.007	11.8

*Soil Type 4 is sand

*Soil Type 2 is stiff clay below the water table

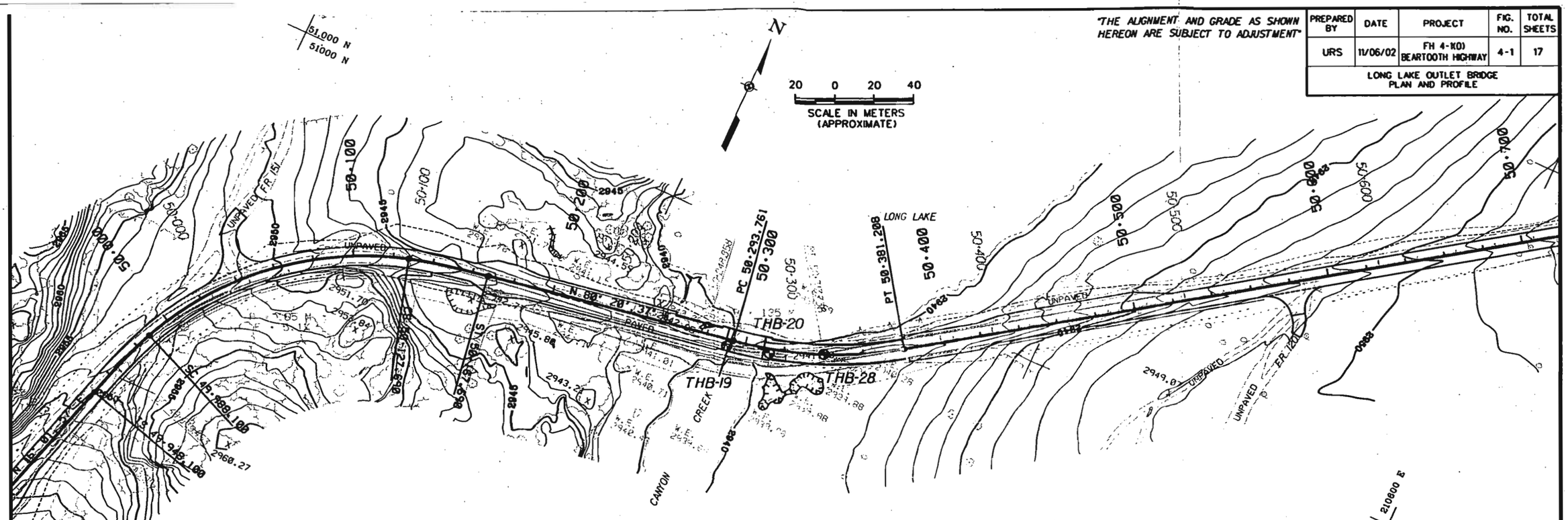
4.3.2 Abutment and Retaining Walls

The use of free draining granular soils for backfilling behind bridge abutments and retaining walls is recommended. Granular soils result in lower lateral earth pressures and provide better subsurface drainage. Abutments and retaining walls should be provided with an underdrain system consisting of a front drainage zone and an underdrain pipe at the base of the wall. The front drainage zone may consist of a vertical layer of either a granular soil layer meeting FP-96 Section 210 or a geocomposite drain meeting FP-96 Section 605.05. The underdrain pipe should consist of a minimum 100 mm PVC pipe encased in a geotextile wrapped granular layer or a geocomposite sheet drain. The pipe should be sloped to daylight at a minimum slope of 2 percent.

Abutment walls and retaining walls which can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 5.9 kN/m^3. This pressure assumes a free draining backfill. Retaining structures should be designed for appropriate surcharge pressures such as traffic, construction equipment and upward sloping backfill.

"THE ALIGNMENT AND GRADE AS SHOWN HEREON ARE SUBJECT TO ADJUSTMENT"

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-1(0) BEARTOOTH HIGHWAY	4-1	17
LONG LAKE OUTLET BRIDGE PLAN AND PROFILE				

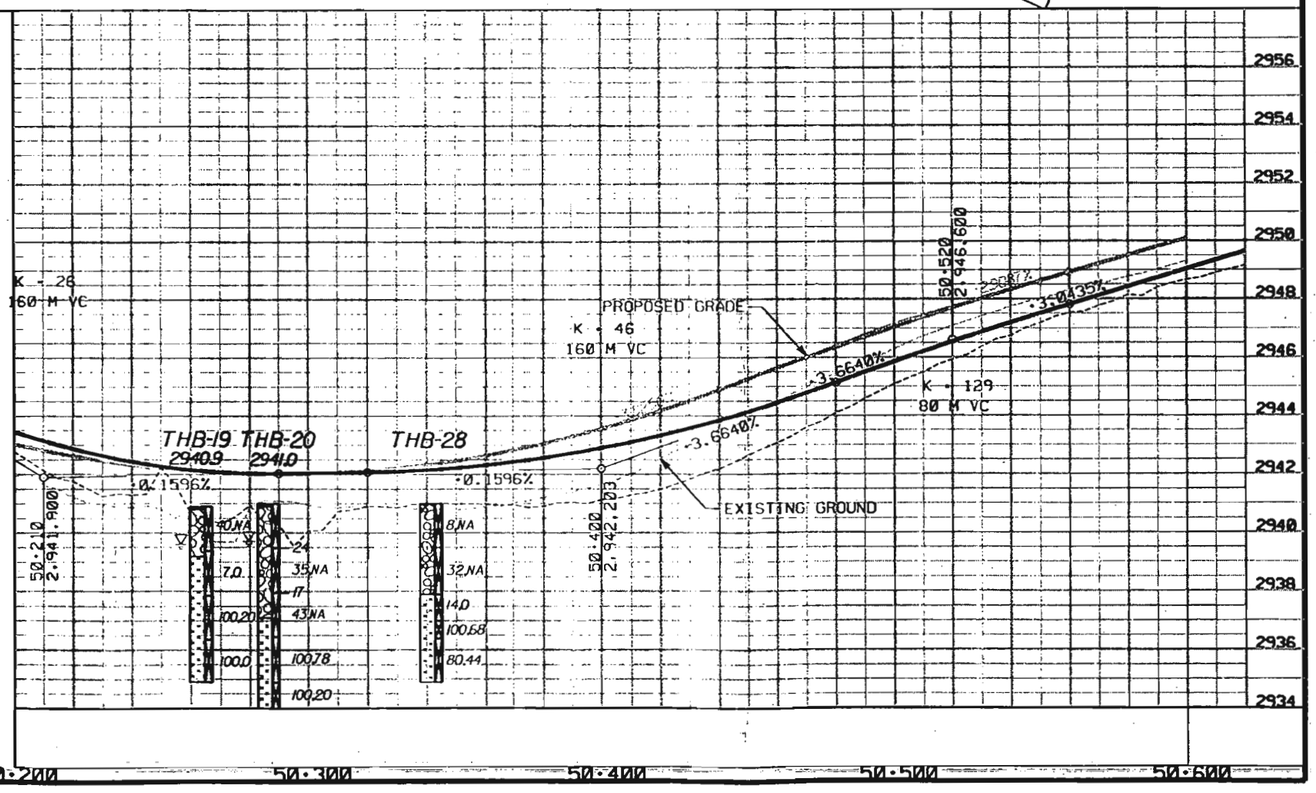


LEGEND FOR LONG LAKE OUTLET BRIDGE

- ASPHALT AND BASE COARSE PAVEMENT SECTION
- GRAVEL, COBBLE, AND BOULDERS, MEDIUM DENSE, (BASED ON BLOWCOUNTS), BROWN, SANDY TO GRAVELLY MATRIX,
- GRANITE, MODERATELY STRONG TO VERY STRONG, PINK, BLACK TO PINK, COARSE GRAINED, SLIGHTLY WEATHERED
- THB-19 — TEST HOLE LOCATION
- — 12 — INDICATES TOP OF INTERVAL FOR STANDARD PENETRATION TEST (SPT). INDICATES THE BLOWCOUNT (N-VALUE) FOR THE FINAL 300 MM OF 450 MM TOTAL PENETRATION IS 12. THE SPT CONSISTS OF RECORDING BLOWS OF A 63.5 KG HAMMER FALLING 760 MM TO DRIVE A 50 MM O.D. SPLIT SPOON SAMPLER. WHERE TWO VALUES ARE SHOWN SEPARATED BY A SLASH, REFUSAL WAS MET BEFORE 450 MM PENETRATION. THE FIRST NUMBER IS THE BLOWCOUNT. THE SECOND NUMBER IS THE PENETRATION DEPTH.
- 90.30 — INDICATES SPLIT TRIPLE-TUBE CORE BARREL WAS USED TO ADVANCE HOLE. 90.30 INDICATES 90% RECOVERY FOR INTERVAL INDICATED AND A ROCK QUALITY DESIGNATION (RQD) OF 30. RQD IS 100 TIMES THE TOTAL LENGTH OF SOUND CORE OVER 100 MM (40 IN.) LONG DIVIDED BY THE LENGTH OF RUN INDICATED. WHERE SPT INTERVALS PRECEDE CORE INTERVALS, THE SPT INTERVAL IS SUBSEQUENTLY OVER-CORED. RECOVERY AND RUN ARE BASED ON A CORE RUN LENGTH THAT INCLUDES THE OVER-CORED LENGTH.
- NA — NOT APPLICABLE
- INDICATES WATER LEVEL AT TIME OF DRILLING

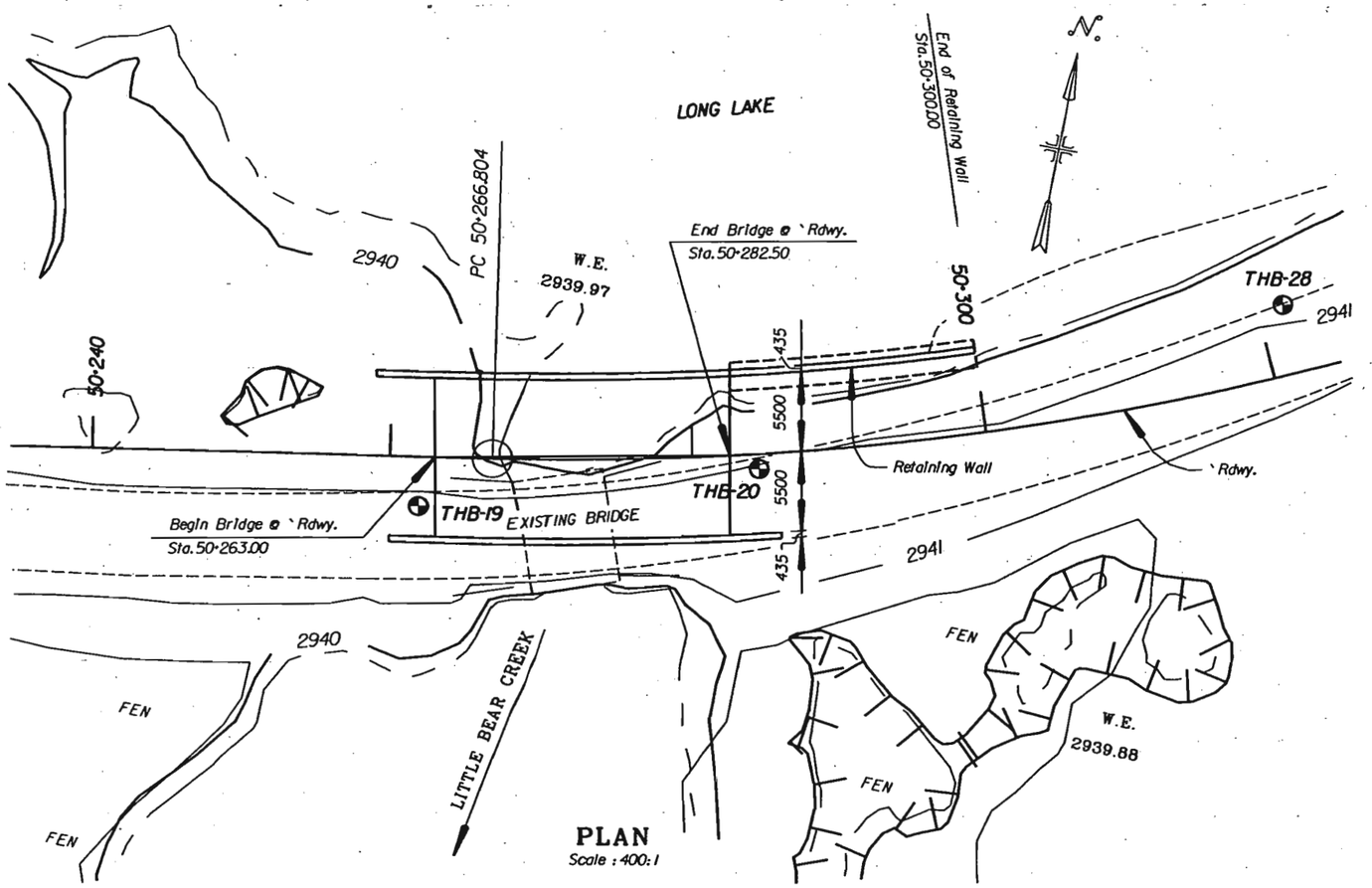
NOTES:

1. TEST HOLES WERE DRILLED ON 8/17/00 THROUGH 9/15/00 BY HAZTECH DRILLING, INC., USING A BK-81 (TRUCK MOUNT) RIG AND AN HQ SPLIT TRIPLE-TUBE CORE BARREL.
2. BASE MAPS OBTAINED FROM DESIGN FIGURES PROVIDED BY THE FHWA.
3. TEST HOLE LOCATIONS ARE APPROXIMATE AND WERE LOCATED BY TAPE MEASUREMENT ON OR BESIDE THE EXISTING ROAD AT DESIGNATED STATIONS. MEASUREMENTS WERE REFERENCED TO MARKINGS AND STAKES PLACED ALONG THE EXISTING ROAD BY THE FHWA.
4. TEST HOLE LOGS IN THIS REPORT ARE SUBJECT TO LIMITATIONS, EXPLANATIONS, AND CONCLUSIONS OF THIS REPORT. SEE INDIVIDUAL LOGS IN APPENDICES FOR MATERIAL DESCRIPTIONS AT EACH TEST HOLE.

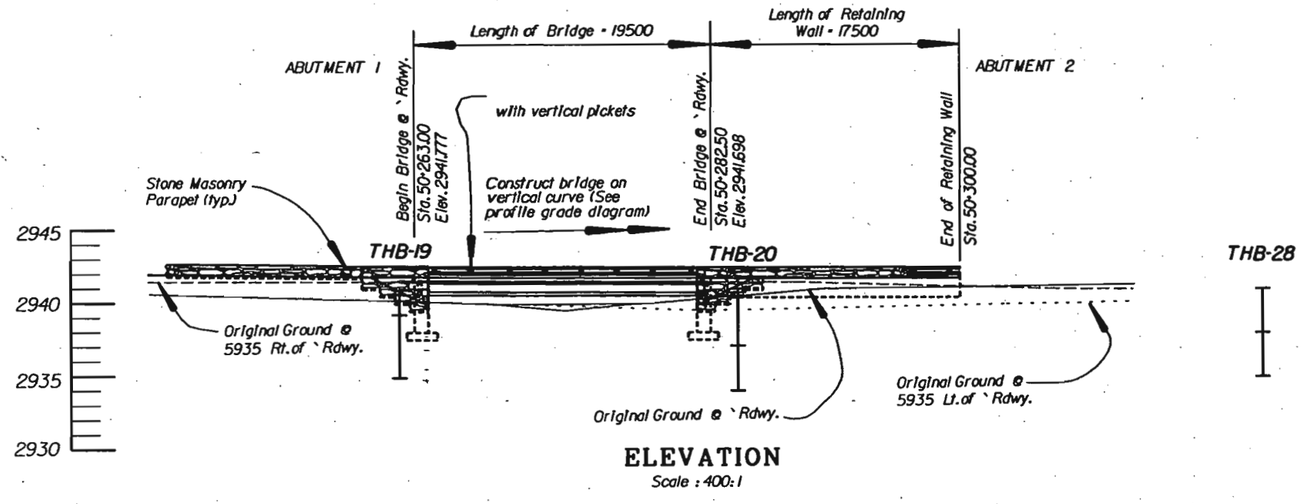


BRTH300_4-1.DGN

PREPARED BY	DATE	PROJECT	FIG. NO.	TOTAL SHEETS
URS	11/06/02	FH 4-1(0) BEARTOOTH HIGHWAY	4-2	
LONG LAKE OUTLET BRIDGE PLAN AND ELEVATION				



PLAN
Scale : 400:1



ELEVATION
Scale : 400:1

NOTES:

1. Summary test hole logs are shown on Figure 4-1.
2. See Figure 4-1 for legend and notes.
3. Intermediate ticks on test hole stick logs indicate interpreted top of bedrock.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
CENTRAL FEDERAL LANDS HIGHWAY DIVISION, DENVER, COLORADO

PRELIMINARY LAYOUT

BRIDGE NAME Long Lake Outlet Bridge STREAM NAME Little Bear Creek
ROUTE NAME AND NUMBER Beartooth Highway, WY FS 4-1(0)
PREPARED BY FHWA (Base Drawing Only)
SCALE: As Shown DATE: October 16, 2000 (Includes wall)

BRTH3009_4-2.dgn

5.1 LIMITATIONS

The analyses, interpretations and recommendations included in this report were prepared based on data obtained partly by URS and partly by others. The data obtained by others includes: topographic map, bridge drawings, stationing and seismic tomography, including a GPS survey.

The accuracy of the information provided by or obtained from reports or documents by others, relied on for the preparation of this report, could not be verified. URS assumes no responsibility for the accuracy of the data contained in those reports and documents.

URS warrants that our services are performed within the limits prescribed by our Clients, with the usual thoroughness and competence of the engineering profession. No other warranty or representation, either expressed or implied, is included or intended in our proposals, contracts or reports.

5.2 CREDITS

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Appendix A
Boring Logs

Appendix A
Boring Logs

Project: Beartooth Highway
Project Location: Four Bridges
Project Number: 68FHAT0027.00

Key to Log of Test Hole

Sheet 1 of 2

Elevation, meters	Depth, meters	ROCK CORE: Run No.	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: Fractures per 300 mm	ROCK CORE: R Q D, %	ROCK CORE: Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	SOIL SAMPLES: Number	SOIL SAMPLES: Blows per 150 mm	SOIL SAMPLES: Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in meters referenced to mean sea level (MSL).

2 **Depth:** Distance in meters below the collar of the borehole.

3 **Run No.:** Number of the individual coring interval.

4 **Box No.:** Number of the core box which contains core from the corresponding run.

5 **Recovery:** Amount (in percent) of core recovered from the coring interval; calculated as length of core recovered divided by length of run.

6 **Fractures per 300 mm:** (Fracture Frequency) The number of naturally occurring fractures in each 300 mm of core; does not include mechanical breaks (induced by drilling) or healed fractures. "NA" indicates not applicable due to lack of core recovery.

7 **R Q D:** (Rock Quality Designation) Percentage of intact core (pieces of sound core longer than 102 mm) in each coring interval; calculated as the sum of lengths of intact core divided by length of core run.

8 **Fracture Drawing:** Sketch of the naturally occurring fractures and mechanical breaks, showing the angle of the fractures relative to the cross-sectional axis of the core. "NR" indicates no recovery.

9 **Fracture Number:** Location of each naturally occurring fracture (numbered) and mechanical break (labeled "M"). Naturally occurring fractures are described in Column 11 (keyed by number) using descriptive terms defined on Sheet 2 (Items a through g).

10 **Lithology:** A graphic log of material encountered using symbols to represent differing soil and types; graphic symbols are explained below.

11 **Description:** Lithologic description of soil (may include USCS, density/consistency, color, grain size) or rock (may include strength, color, grain size, weathering, other features). Selected descriptive terms are defined on Sheet 2. Also, abbreviated description of fractures numbered in Column 9 using terms defined on Sheet 2.

12 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

13 **Sample Number:** Sample identification number.

14 **Blows per 150 mm:** Number of blows to advance driven sampler each 150-mm drive interval, or distance noted, using a 63.5-kg hammer with a 762-mm drop.

15 **Recovery:** Actual soil recovery in driven sampler as a percentage of the sampler penetration.

16 **Drill Time:** Time in 24-hour clock at start and finish of each sampling interval.

17 **Field Notes and Lab Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel. Lab tests are indicated using abbreviations explained below.

TYPICAL MATERIAL GRAPHIC SYMBOLS

SAND (SP/SW)
SILT (ML)
CLAY (CL)
GRAVEL (GP/GW)
Gravelly SAND (SP/SW)
Silty SAND (SM)
Clayey SAND (SC)
COBBLES and BOULDERS
GRANITE
GNEISS
GABBRO
SANDSTONE

TYPICAL SAMPLER GRAPHIC SYMBOLS

50-mm-OD split spoon sampler (SPT)
76-mm-OD split spoon sampler (California)

OTHER GRAPHIC SYMBOLS

First water encountered at time of drilling (ATD)
Change in material properties within a stratum

Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

LABORATORY TEST ABBREVIATIONS

Cc	Compression Index
LL	Liquid Limit
PI	Plastic Limit
PLI	Point Load Index
CS	Compression Strength [MPa] evaluated from point load test
UCS	Unconfined Compressive Strength [MPa]
*	Indicates L/D<2.0 correction factor from ASTM D2938 used

BLOW COUNT DENSITY AND CONSISTENCY RELATIONSHIPS

COARSE-GRAINED SOILS:

Apparent Density	SPT Blow Count
Very loose	0 to 4
Loose	>4 to 10
Medium dense	>10 to 30
Dense	>30 to 50
Very dense	>50

FINE-GRAINED SOILS:

Consistency	SPT Blow Count
Very soft	0 to 2
Soft	>2 to 4
Medium stiff	>4 to 8
Stiff	>8 to 15
Very stiff	>15 to 30
Hard	>30

Report: GEO_CORE+SOIL_17_METDENV_KEY; File: BTOOTHWY.GPJ; 1/14/2001 keycore

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Project: Beartooth Highway Project Location: Four Bridges Project Number: 68FHAT0027.00	Key to Log of Test Hole Sheet 2 of 2

KEY TO DESCRIPTIVE TERMS USED ON CORE LOGS

DISCONTINUITY DESCRIPTORS

a Dip of discontinuity, measured relative to a plane normal to the core axis.

b **Discontinuity Type:**

- F - Fault
- J - Joint
- Sh - Shear
- Fo - Foliation
- V - Vein
- B - Bedding

c **Aperture (mm):**

- W - Wide (13-51)
- MW - Moderately Wide (2.5-13)
- N - Narrow (1.3-2.5)
- VN - Very Narrow (<1.3)
- T - Tight (0)

d **Type of Infilling:**

- Cl - Clay
- Ca - Calcite
- Ch - Chlorite
- Fe - Iron Oxide
- Gy - Gypsum
- H - Healed
- Mn - Manganese Oxide
- No - None
- Py - Pyrite
- Qz - Quartz
- Sd - Sand

e **Amount of Infilling:**

- Su - Surface Stain
- Sp - Spotty
- Pa - Partially Filled
- Fi - Filled
- No - None

f **Surface Shape of Joint:**

- Pl - Planar
- Wa - Wavy
- St - Stepped
- Ir - Irregular

g **Roughness of Surface:**

- Slk - Slickensided [surface has smooth, glassy finish with visual evidence of striations]
- S - Smooth [surface appears smooth and feels so to the touch]
- SR - Slightly Rough [asperities on the discontinuity surfaces are distinguishable and can be felt]
- R - Rough [some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive]
- VR - Very Rough [near-vertical steps and ridges occur on the discontinuity surface]

ROCK WEATHERING / ALTERATION

Description	Recognition
Residual Soil	Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand
Completely Weathered/Altered	Original minerals of rock have been almost entirely decomposed to secondary minerals, although original fabric may be intact; material can be granulated by hand
Highly Weathered/Altered	More than half of the rock is decomposed; rock is weakened so that a minimum 50-mm-diameter sample can be broken readily by hand across rock fabric
Moderately Weathered/Altered	Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 50-mm-diameter sample cannot be broken readily by hand across rock fabric
Slightly Weathered/Altered	Rock is slightly discolored, but not noticeably lower in strength than fresh rock
Fresh/Unweathered	Rock shows no discoloration, loss of strength, or other effect of weathering/alteration

ROCK STRENGTH

Description	Recognition
Extremely Weak Rock	Can be indented by thumbnail
Very Weak Rock	Can be peeled by pocket knife
Weak Rock	Can be peeled with difficulty by pocket knife
Moderately Strong Rock	Can be indented 5 mm with sharp end of pick
Strong Rock	Requires one hammer blow to fracture
Very Strong Rock	Requires many hammer blows to fracture
Extremely Strong Rock	Can only be chipped with hammer blows

Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-6

Sheet 1 of 5

Date(s) Drilled	9/13/00 and 9/15/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	23.35 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2715.1 m MSL
Groundwater Level	~2.3 m bgs ATD	Location	Station 42+238, centerline	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
0 / 2715		1						Asphalt pavement					0850	
								SAND (SW), medium dense, brown to gray, well-graded, some gravel and cobbles, occasional boulder up to to 0.3 m cored length						
	1		29		NA									
1 / 2714														
											5		0902	
									SPT-1		9	94		N = 26
											17		0908	
2 / 2713								Boulder about 300 mm diameter						
	2		40		NA									Water encountered at approx. 2.3 m.
3 / 2712													0916	
													0925	SPT-2 not taken; in boulder.
	3		9		NA									
4														

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 1/14/2001 18THB-06

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-6

Sheet 2 of 5

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
4		1						SAND (SW), medium dense, brown to gray, well-graded, some gravel and cobbles, occasional boulder up to to 0.3 m cored length (continued)					
2711	3		9		NA								
								← Becomes loose		6		0930	
									SPT-3	3	0		N = 8
5										5		0944	
2710								SAND (SP), loose to medium dense, medium- to coarse-grained, no fines, no cohesion					
	4		0		NA								Heaving sand.
6													
2709										6		0948	
									SPT-4	6	100		N = 13
										7		0957	
	5		0		NA								
7													
2708													
										1		1004	
									SPT-5	2	89		N = 9
8										7		1010	
2707	6		0		NA								
9													

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-6

Sheet 3 of 5

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
9	6	1	0		NA			SAND (SW), medium dense, fine- to coarse-grained, few gravel or cobbles, no cohesion					
2706									SPT-6	7 7 6	22	1017 1045	Heaving sand. N = 13
10	7		0		NA								
2705									SPT-7	8 7 11	18	1049 1101	N = 18
11												1121	Heaving sand.
2704	8		3		NA			SILT (ML), medium dense, gray, clayey					
12													
2703									SPT-8	6 6 10	78	1126 1138	N = 16
13	9		0		NA								
2702													
14	10		0		NA				SPT-9	9 7	89	1144	N = 14

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-6

Sheet 4 of 5

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R.Q.D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
14 / 2701		1						SILT (ML), medium dense, gray, some sand and clay		SPT-9	7	89		Rig broke down; stopped for 9/13/00.
													0925	Resumed drilling on 9/15/00 after 1-1/2 days of no drilling due to inoperable rig.
	10		0		NA									
15 / 2700														
											4		0930	
										SPT-10	7	22		N = 15
											8		0938	
16 / 2699	11		0		NA									
											5		0945	LL = 23, PI = 5
17 / 2698										SPT-11	5	89		N = 16
											11		0954	
	12		12		NA									
18 / 2697														
											4		0959	
										SPT-12	7	89		N = 15
	13		11		NA						8		1015	
19													1032	Heaving sand.

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-6

Sheet 5 of 5

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
19 / 2696		1						SILT (ML), medium dense, gray, some sand and clay (continued)					
	13		11		NA								
										5		1037	
20 / 2695									SPT-13	6	89		N = 13
										7		1050	
	14		9		NA								
21 / 2694													
										4		1058	
									SPT-14	5	89		N = 12
										7		1106	
22 / 2693	15		27		NA								
										3		1111	Cc = 38.0
23 / 2692									SPT-15	4	89		N = 10
										6		1121	
24								Bottom of hole at 23.35 m					

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-7

Sheet 1 of 7

Date(s) Drilled	8/28/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	32.45 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2716.1 m MSL
Groundwater Level	~3 m bgs ATD	Location	Station 42+378, offset 0.6 R	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug and cuttings capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
2716	0		1						GRAVEL, COBBLES, and BOULDERS, medium dense, brown, slightly weathered to unweathered clasts up to 0.15 m cored length					0755	
		1		40		NA									
2715	1														
		2		33		NA									
2714	2														
												6		0820	
										SPT-1		7	11		N = 13
												6		0830	
2713	3														Water encountered at approx. 3.0 m.
												7		0845	
										SPT-2		14	13		N = 26
		3		16		NA						12		0850	
	4														

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-7

Sheet 1 of 7

Date(s) Drilled	8/28/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	32.45 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2716.1 m MSL
Groundwater Level	~3 m bgs ATD	Location	Station 42+278	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug and cuttings capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
0 / 2716		1						GRAVEL, COBBLES, and BOULDERS, medium dense, brown, slightly weathered to unweathered clasts up to 0.15 m cored length					0755	
	1		40		NA									
1 / 2715														
										SPT-1	6 7 6	11	0820 0830	N = 13
2 / 2714	2		33		NA									
3 / 2713										SPT-2	7 14 12	13	0845 0850	Water encountered at approx. 3.0 m. N = 26
	3		16		NA									
4														

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Project: Beartooth Highway
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Log of Test Hole THB-7

Sheet 2 of 7

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
4								GRAVEL, COBBLES, and BOULDERS, medium dense, brown, slightly weathered to unweathered clasts up to 0.15 m cored length (continued)					
2712	3	1	16		NA								
									SPT-3	4 3 4	11	0859 0904	N = 7
5													
2711	4		20		NA			SAND (SM/SC), brown, medium-grained, silty to clayey					
								GRAVEL, COBBLES, and BOULDERS, medium dense, brown, slightly weathered to unweathered clasts					
6													
2710									SPT-4	5 5 5	2	0918 0930	N = 10
								SAND (SP), loose to medium dense, light brown, coarse-grained, some rounded gravel and cobbles					
	5		22		NA								
7													
2709													
		2											
									SPT-5	6 3 3	0	0940 0946	N = 6
8													
2708	6		28		NA								
9													

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-7

Sheet 3 of 7

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	RQD, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
9 / 2707	6	2	28		NA			SAND (SP), medium dense, light brown, coarse-grained, some rounded gravel and cobbles					
									SPT-6	6 6 7	11	1002 1030	N = 13
10 / 2706	7		7		NA								Heaving sands; had to flush hole repeatedly.
								SILT (ML), medium dense, brown and gray, clayey					
									SPT-7	7 14 12	89	1120 1140	N = 26
11 / 2705	8		8		NA								
12 / 2704									SPT-8	3 5 5	0	1205 1210	N = 10
13 / 2703	9		3		NA								
14	10		23		NA				SPT-9	5	100	1217	

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-07

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Project: Beartooth Highway
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Log of Test Hole THB-7

Sheet 4 of 7

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
14 / 2702		2						SILT (ML), medium dense, gray, clayey	SPT-9	6 7	100	1225	N = 13
15 / 2701	10		23		NA								
									SPT-10	6 10 9	100	1230 1245	N = 19
16 / 2700	11		27		NA								
									SPT-11	9 10 12	100	1250 1303	N = 22
17 / 2699	12		38		NA								
18 / 2698		3							SPT-12	6 11 11	100	1350 1400	N = 22
	13		35		NA								
19													

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-07

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Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-7

Sheet 5 of 7

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
19								SILT (ML), medium dense, gray, clayey (continued)						
2697		3												
	13		35		NA									
													1520	SPT not taken.
20														
2696														
	14		43		NA									
21														
2695														
											9		1530	
										SPT-13	11	100		N = 24
											13		1535	
22														
2694	15		29		NA									
													1545	SPT not taken.
23														
2693														
	16		24		NA									
24														

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-07

URS

Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-7

Sheet 6 of 7

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
2692	24	16	3	24		NA			SILT (ML), medium dense, gray, clayey (continued)						
												4		1555	
										SPT	14	4	100		N = 11
												7		1600	
2691	25	17	4	16		NA									
														1610	SPT not taken.
2690	26														
		18		77		NA									
2689	27														
												4		1620	
										SPT	15	10	100		N = 28
									SAND (SM), medium dense, brown, fine-grained, silty			18		1630	
2688	28	19		31		NA									
									GRAVEL, COBBLES, and BOULDERS, brown, fine-grained sand matrix, slightly weathered to unweathered clasts up to 0.13 m cored length						
	29														

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-07

URS

Project: Beartooth Highway
Project Location: Beartooth Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-7

Sheet 7 of 7

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
29		4						GRAVEL, COBBLES, and BOULDERS, brown, fine-grained sand matrix, slightly weathered to unweathered clasts up to 0.13 m cored length (continued)				1645	SPT not taken; in boulder.
2687	20		31		NA								
30												1710	SPT not taken; in boulder.
2686													
31	21		??		NA								
2685								SAND (SM/SC), dense, gray, fine-grained, silty to clayey					
32										7		1720	
2684									SPT-16	13	68		N = 34
										21		1750	
								Bottom of hole at 32.45 m					
33													
2683													
34													

URS

Project: Beartooth Highway
Project Location: Little Bear Creek Bridge 1
Project Number: 68FHAT0027.00

Log of Test Hole THB-8

Sheet 1 of 3

Date(s) Drilled	8/30/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	11.70 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2838.8 m MSL
Groundwater Level	~2.9 m bgs ATD	Location	Station 45+300, offset 2.7 R	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
0		1						Asphalt pavement					0825	
								SAND, brown, medium-grained [Road Base]						
								GRAVEL, COBBLES, and BOULDERS, loose to medium dense, brown-red, silty to clayey well-graded sand matrix, maximum 0.25 m cored length						
2838	1		37		NA									
1														
										SPT-1	50/0	0	0840 0845	Drove SPT on boulder.
2837														
2	2		31		NA									
2836									▽					Water encountered at approx. 2.9 m.
3											3		0900	
										SPT-2	2	100		N = 7
											5		0905	
	3		57		NA									
2835														
4														

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 1/14/2001 20THB-08

URS

Project: Beartooth Highway
Project Location: Little Bear Creek Bridge 1
Project Number: 68FHAT0027.00

Log of Test Hole THB-8

Sheet 2 of 3

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
4		1						GRAVEL, COBBLES, and BOULDERS, loose to medium dense, brown-red, silty to clayey well-graded sand matrix, maximum 0.2 m cored length (continued)					
	3		57		NA								
								←Becomes medium dense		10		0915	
2834									SPT-3	10	100		N = 28
										18		0920	
5													
	4		18		NA			SAND (SM/SC), gray, fine-grained, silty to clayey, some gravel and cobbles					
2833													
6								GRAVEL, COBBLES, and BOULDERS, dense to very dense, brown, silty to clayey well-graded sand matrix, maximum 0.2 m cored length					
		2								11		0930	
									SPT-4	15	100		N = 39
										24		0940	
2832	5		66		NA								
7													
										14		0950	
2831									SPT-5	24	67		
8										30		0959	
	6		67		NA								
								GNEISS, moderately strong to very strong, gray, medium-grained, slightly weathered [Bedrock]					
2830				2									
9						1		1: 75°, J, N, Cl, Pa, Pl, SR					

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 1/14/2001 20THB-08

URS

Project: Beartooth Highway
Project Location: Little Bear Creek Bridge 1
Project Number: 68FHAT0027.00

Log of Test Hole THB-8

Sheet 3 of 3

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
9	6	2	67	0	NA	1		GNEISS, moderately strong to very strong, gray, medium-grained, slightly weathered [Bedrock] (continued)				1120	
				2		2		1: 60°, J, N, Cl, Su, Pl, R					
				2		2		2: 30°, J, N, Cl, Su, Pl, SR					PLI = 930 CS = 174 MPa
2829	7	3	80	2	20	2							
10				2		2							
				1		1							
				0									
2828												1142	
				0		M							
11	8		70	1	10	M							UCS = 47.0 MPa
				1		1		1: 45°, J, N, Cl, Su, Pl, SR					
				1									PLI = 681 CS = 127 MPa
												1215	
2827								**Bottom of hole at 11.70 m**					
12													
2826													
13													
2825													
14													

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 1/14/2001 20THB-08

URS

Project: Beartooth Highway
Project Location: Little Bear Creek Bridge 2
Project Number: 68FHAT0027.00

Log of Test Hole THB-11

Sheet 1 of 2

Date(s) Drilled	9/12/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	6.10 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2858.7 m MSL
Groundwater Level	~3.4 m bgs ATD	Location	Station 46+601	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
0		1						SAND (SW), medium dense, brown, well-graded, few gravel and cobbles					1510	
2858	1		15		NA									
1														
2857										SPT-1	8 14 15	22	1520 1530	N = 29
2	2		5		NA									
2856														
3								SANDSTONE, moderately strong, gray, medium-grained, thin clay layers up to 10 mm thick spaced about 0.2 m apart [Bedrock]		SPT-2	38 50/100	11	1540 1545	PL Test N = >50
				2		1		1: 0°, J, MW, Cl, Pa, Wa, R						
	3		73	2	25	1			▽					Water encountered at approx. 3.4 m.
2855				2		1								
4						1		Grades fine- to medium-grained						

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-11

URS

Project: Beartooth Highway
Project Location: Little Bear Creek Bridge 2
Project Number: 68FHAT0027.00

Log of Test Hole THB-11

Sheet 2 of 2

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
4		1		3		1		SANDSTONE, moderately strong, gray, fine- to medium-grained, thin clay layers up to 10 mm thick spaced about 0.2 m apart [Bedrock] (continued)						PL Test
	3		73	2	25	2 1 1		2: 80°, J, N, Fe, Su, Wa, R						
													1549	
2854				7				Soft, red-brown, iron oxide-stained, coarse-grained, no clay layers, highly fractured					1559	
5				2		1		1: 0°, J, MW, Cl, Pa, Wa, R						
	4		100	2	56	1								UCS Test
						1								
				6		1								
2853								SANDSTONE, moderately strong, red-brown, iron oxide-stained, coarse-grained [Bedrock]						
6				3									1615	
								Bottom of hole at 6.10 m						
2852														
7														
2851														
8														
2850														
9														

URS

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-11

Project: Beartooth Highway
Project Location: Long Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-19

Sheet 1 of 2

Date(s) Drilled	9/6/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	6.00 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2940.9 m MSL
Groundwater Level	~1.3 m bgs ATD	Location	Station 50+262	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number / Blows per 150 mm / Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
0		1						Asphalt pavement		1348	
								GRAVEL, COBBLES, and BOULDERS, light brown, sandy matrix, maximum 0.23 m cored length			
	1		40		NA						
2940 / 1								▽			Water encountered at approx. 1.3 m.
										1400	SPT not taken; on rock.
								GRANITE, strong, black and pink, coarse-grained, slightly weathered [Bedrock]			Top of bedrock based on depth at which drill rig began to core very slowly.
2939 / 2	2		7		0						Poor recovery due to core barrel problems.
2938 / 3				5				Highly fractured zone		1510	SPT not taken; on rock.
	3		100	7	20	1,1		1: 40°, J, N, Cl, Su, Pl, SR			UCS Test
				10		1		Highly fractured zone			
2937 / 4											

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-19

URS

Project: Beartooth Highway
Project Location: Long Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-19

Sheet 2 of 2

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
4		2		3		M		GRANITE, strong, black and pink, coarse-grained, slightly weathered [Bedrock] (continued0						
	3		100	0	20									
				3		1		Highly fractured zone; very high angle joints					1528	
2936				3		1		1: 70°, J, N, Fe, Pa, Pl, SR						PL Test
5						M 2		2: 65°, J, N, Fe, Su, Pl, SR						
	4		100	3	0	2								
				2		M 3		3: 50°, J, N, Fe, Su, Pl, SR						
2935				1										PL Test
6								**Bottom of hole at 6.00 m**					1616	
2934														
7														
2933														
8														
2932														
9														

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-19

URS

Project: Beartooth Highway
Project Location: Long Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-20

Sheet 1 of 2

Date(s) Drilled	9/6/00	Logged By	A. Burns	Reviewed By	D. Baures
Drilling Method	HQ Wireline Core	Drill Bit Size/Type	HQ diamond-impregnated	Total Depth of Test Hole	7.00 m
Drill Rig Type	BK-81 (truck-mount)	Drilling Contractor	Haztech	Approximate Surface Elevation	2941.0 m MSL
Groundwater Level	~1.3 m bgs ATD	Location	Station 50+285	Inclination from Horizontal/Bearing	90° (vertical)
Borehole Completion	Holeplug capped with concrete			Hammer Data	Pneumatic hammer; 63.5 kg / 762-mm drop

Elevation, meters	Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
2941	0		1						Asphalt pavement					0915	
									GRAVEL, COBBLES, and BOULDERS, medium dense, light brown, sandy matrix, maximum 0.2 m cored length						
		1		32		NA									Lost circulation.
2940	1									▽					Water encountered at approx. 1.3 m.
												5		0925	
											SPT-1	12	22		N = 24
												12		0930	
2939	2	2		35		0									
2938	3											5		0942	
											SPT-2	8	44		N = 17
		3		43		NA						9		1015	
2937	4								GRANITE [Bedrock] (see description next page)						

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-20

URS

Project: Beartooth Highway
Project Location: Long Lake Bridge
Project Number: 68FHAT0027.00

Log of Test Hole THB-20

Sheet 2 of 2

Elevation, meters / Depth, meters	ROCK CORE: Run No.	Box No.	Recovery, %	Fractures per 300 mm	R Q D, %	Fracture Drawing Number	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type / Number	Blows per 150 mm	Recovery, %	Drill Time, 24-hr clock	FIELD NOTES AND LAB TESTS
2937 / 4		1		5		1		GRANITE, strong, pink, coarse-grained, slightly weathered [Bedrock]					
	3		43	2	35	2 M		1: 45°, J, N, Fe, Su, Wa, R 2: 45°, J, N, Fe, Su, Pl, R					
						M							
				2		1		1: 75°, J, N, Cl, Pa, Wa, SR				1030	
		2				M							
2936 / 5				1		2		2: 45°, J, N, Fe, Su, Wa, R					PL Test
	4		100	0	78								
				2		3		3: 45°, J, N, Cl, Su, Pl, R					UCS Test
						3							
				0		4		4: 5°, J, N, Fe, Su, Pl, SR					
2935 / 6													
				2								1050	
				6									
	5		100		20								
				4		1		1: 80°, J, N, Cl, Fi, Wa, R					
						2		2: 50°, J, N, Cl, Su, Wa, SR					
2934 / 7						2						1105	PL Test
								Bottom of hole at 7.00 m					
2933 / 8													
2932 / 9													

Report: GEO_CORE+SOIL_17_METRIC; File: BTOOTHWY.GPJ; 11/10/2000 THB-20

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-23

Sheet 1 of 5

Date(s) Drilled	05-15-02 to 05-18-02	Logged By	DMB, ATB	Checked By	CJK
Drilling Method	Wireline core	Drill Bit Size/Type	6" HSA, NX core	Total Depth Drilled (m)	20.0
Drill Rig Type	CME-55 truck mount	Drilled By	Dakota Drilling	Hammer Weight/ Drop (Kg/m)	63.5/0.76
Groundwater Depth (m)	1.2			Approx. Surface Elevation (m)	2715
Comments	Beartooth Lake Outlet Bridge Site			Test Hole Backfill	Drill cuttings, cement cap

Depth (m)	Run Type	ROCK CORE: Box No.	Recovery, %	R Q D, %	Fractures per 30cm	Boulder Location	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	Blows per 152mm	Recovery, %	FIELD NOTES/ LAB DATA
0.0								Asphalt pavement 100mm thick				
								GRAVEL, COBBLES and BOULDERS in a matrix of sand, sand and gravel fine to coarse, medium dense, brown (fill)				
0.5	1	Bag	10	NA								
1.0								▽				
1.5									SPT 1	13 12 17	25	
2.0	2	Bag	5	NA								
2.5												
3.0								GRAVEL, COBBLES and BOULDERS in a matrix of sand, sand and gravel fine to coarse, medium dense, brown				
3.5	3	Bag	25	NA								
4.0												

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-23

Depth (m)	ROCK CORE: Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
4.0								GRAVEL, COBBLES and BOULDERS in a matrix of sand, sand and gravel fine to coarse, medium dense, brown				
	3	Bag	25	NA								
4.5												
5.0												
	4	Bag	20	NA								
5.5												
6.0												
6.5								GRAVEL (GP) and SAND (SP), interbedded, medium dense, some cobbles, thin beds of clay, limestone and granite clasts, brown				
	5	Bag	15	NA								
7.0												
7.5									SPT 2	8 8 8	100	
8.0												
	6	Bag	15	NA								
8.5												

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-23

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
9.0	6							GRAVEL (GP) and SAND (SP), interbedded, medium dense, some cobbles, thin beds of clay, limestone and granite clasts, brown				
									SPT 3	3 3 4	60	
9.5								SILT (ML), medium stiff, some fine grained sand, wet, brown				
	7											
10.0									ST 4		100	
10.5												
									CAL 5	2 3	100	
11.0												
	8											
11.5												
12.0												
									ST 6		100	
12.5												
	9											
13.0												
13.5								SILT (ML), medium to very stiff, wet, gray				

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-23

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
14.0								SILT (ML), medium to very stiff, wet, gray	CAL 7	5 4	100	
14.5	10							Some zones of gray clay				
15.0												
15.5									ST 8		100	
16.0	11											
16.5												
17.0									CAL 9	10 14	100	
17.5	12											
18.0												
18.5	13								ST 10		100	

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-23

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
								SILT (ML), stiff, wet, gray	ST. 10		100	
19.0	13											
19.5									CAL 11	4 5	100	
20.0								Bottom of test hole at 20.0m				
20.5												
21.0												
21.5												
22.0												
22.5												
23.0												

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-24

Date(s) Drilled	5-21-02	Logged By	ATB	Checked By	CJK
Drilling Method	Wireline core	Drill Bit Size/Type	NX No.10 diamond bit	Total Depth Drilled (m)	9.6
Drill Rig Type	Skid mount	Drilled By	Hell-Port Drilling	Hammer Weight/ Drop (Kg/m)	NA
Groundwater Depth (m)	1.2			Approx. Surface Elevation (m)	2839
Comments	Little Bear Creek Bridge No.1 Site	Test Hole Backfill	Drill cuttings		

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
0.5	1	1	40					GRAVEL, COBBLES and BOULDERS generally composed of granite, very strong, slightly weathered in a matrix of silty sand, fine to medium grained, brown, moist				
1.0												
1.5												
2.0	2	1	20					Strong zone.				
2.5												
3.0												
3.5	3	1	40	0								
4.0												

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-24

Depth (m)	ROCK CORE: Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
4.0												
	3	1	40	0	5			SANDSTONE, medium strong to strong, weathered, medium grained, green				
					7							
4.5												
	4	1	80	20	8							
5.0					3							
					3							
5.5					6							
6.0												
	5	1	100	32	3							
6.5					4							
		2			5							
7.0					3							
7.5												
	6	2	100	40	4							
8.0					4							
8.5					4							

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-24

Depth (m)	ROCK CORE: Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	SOIL SAMPLES: Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
9.0	6	2	100	40	4			SANDSTONE, medium strong to strong, weathered, medium grained, green					
					1								
	7	3	100	100	2								
9.5								Bottom of test hole at 9.6m					
10.0													
10.5													
11.0													
11.5													
12.0													
12.5													
13.0													
13.5													

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-25

Date(s) Drilled	05-17-02	Logged By	DMB	Checked By	CJK
Drilling Method	Rotary SFA and core	Drill Bit Size/Type	100mm SFA, NX core	Total Depth Drilled (m)	12.3
Drill Rig Type	CME-55 truck mount	Drilled By	Dakota Drilling	Hammer Weight/ Drop (Kg/m)	63.5/0.76
Groundwater Depth (m)	2.8			Approx. Surface Elevation (m)	2839
Comments	Little Bear Creek Bridge No.1 Site	Test Hole Backfill	Drill cuttings, cement cap		

Depth (m)	Run Type	ROCK CORE: Box No.	Recovery, %	R Q D, %	Fractures per 30cm	Boulder Location	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	Blows per 152mm	Recovery, %	FIELD NOTES/ LAB DATA
								Asphalt Pavement 100mm thick				
0.5								FILL-CLAYEY SAND (SC), very dense, trace gravel and cobbles, moist, brown	SPT 1	18 32 24	45	
1.0								CLAYEY SAND (SC), medium dense, traces gravel, cobbles and boulders, moist to wet, brown	SPT 2	15 8 5	29	
1.5								- Thin beds of clean sand				
2.0												
2.5								▽				
3.0									SPT 3	10 7 5	18	
3.5									ST 4			
4.0									SPT 5	12 14 14	27	

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-25

Depth (m)	ROCK CORE: Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
4.0								CLAYEY SAND (SC), medium dense, traces gravel, cobbles and boulders, moist to wet, brown	SPT 5	12 14 14	27	
4.5												
5.0								- Cobbles and boulders from 4.8 to 5.3m				
5.5												
6.0									SPT 6	15 25 30	16	
								CLAYEY SAND (SC), very dense, some gravel, moist, green				
6.5								SANDY CLAY (CL), hard, some gravel, moist, green				
7.0	1	1	18	NA								
7.5												
8.0	2	1	0	NA								
8.5												
	2	1	80	25	0							

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-25

Sheet 3 of 3

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
9.0	2	1	80	25	0			GNEISS, weak to strong, highly weathered to weathered, medium to coarse grained, decomposed, gray				
9.5												
10.0					3		1	1: 5,J, UN, CL, Fi, Wa, S				
					7		1	2: 60, J-Sh, W, CL, Fi, PL-Wa, SLK				
10.5	3	1	76	17	2		2					
11.0					2		1					
					3			GNEISS, strong, slightly weathered, fine to coarse grained, gray				
11.5					1							
					2							
12.0		2			4							
								Bottom of test hole at 12.3m				
12.5												
13.0												
13.5												

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-28

Sheet 1 of 2

Date(s) Drilled	5-22-02	Logged By	ATB	Checked By	CJK
Drilling Method	Wireline core	Drill Bit Size/Type	NX No.8 diamond bit	Total Depth Drilled (m)	6.1
Drill Rig Type	CME-55 truck mount	Drilled By	Dakota Drilling	Hammer Weight/ Drop (Kg/m)	NA
Groundwater Depth (m)	1.0			Approx. Surface Elevation (m)	2941
Comments	Long Lake Site	Test Hole Backfill	Drill cuttings		

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
0.5	1	1	8					GRAVEL, COBBLES and BOULDERS in a matrix of silty sand, sand and gravel fine to coarse, wet, brown (fill)				
1.0								GRAVEL, COBBLES and BOULDERS in a matrix of silty sand, sand and gravel fine to coarse, wet, brown				
1.5												
2.0	2	1	32									
2.5												
3.0												
3.5	3	1	14	0	4			GRANITE, strong, slightly weathered, medium grained, pink				
4.0					1							

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-28

Depth (m)	ROCK CORE: Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
4.0					1			GRANITE, strong, slightly weathered, medium grained, pink				
	4	1	100	68	5							
4.5					3							
5.0					2							
	5	2	80	44	6							
5.5					0							
6.0					3							
								Bottom of test hole at 6.1m				
6.5												
7.0												
7.5												
8.0												
8.5												

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-30

Sheet 1 of 2

Date(s) Drilled	5-23-02	Logged By	ATB	Checked By	CJK
Drilling Method	Wireline core	Drill Bit Size/Type	NX No.10 diamond bit	Total Depth Drilled (m)	5.2
Drill Rig Type	Skid mount	Drilled By	Hell-Port Drilling	Hammer Weight/ Drop (Kg/m)	NA
Groundwater Depth (m)	2.0			Approx. Surface Elevation (m)	2858
Comments	Little Bear Creek Bridge No.2 Site	Test Hole Backfill	Drill cuttings		

Depth (m)	Run Type	ROCK CORE: Box No.	Recovery, %	R Q D, %	Fractures per 30cm	Boulder Location	Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	Number	Blows per 152mm	Recovery, %	FIELD NOTES/ LAB DATA
0.5	1	1	40					GRAVEL, COBBLES and BOULDERS in a matrix of sand, sand and gravel fine to coarse, brown, maximum cored length of boulders 170 mm.					
1.0													
1.5													
2.0	2	1	90	18	5			SANDSTONE, medium strong, highly weathered to weathered, medium to fine grained, gray to brown					
2.5					2								
3.0					4								
3.5	3	1	100	24	6								
		2			4								
4.0					1								
					2								

11/4/02 ROCK_CORE_METRIC B-TOOTH.GPJ

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-30

Depth (m)	ROCK CORE: Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type	SOIL SAMPLES: Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
4.0	3	2	100	24	1 0			SANDSTONE, medium strong, highly weathered to weathered, medium to fine grained, gray to brown					
4.5	4	2	100	48	2 4								
5.0								Bottom of test hole at 5.2m					
5.5													
6.0													
6.5													
7.0													
7.5													
8.0													
8.5													

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-31

Date(s) Drilled	5-23-02	Logged By	ATB	Checked By	CJK
Drilling Method	Wireline core	Drill Bit Size/Type	NX No.8 diamond bit	Total Depth Drilled (m)	7.6
Drill Rig Type	CME-55 truck mount	Drilled By	Dakota Drilling	Hammer Weight/ Drop (Kg/m)	NA
Groundwater Depth (m)	2.0			Approx. Surface Elevation (m)	2858.5
Comments	Little Bear Creek Bridge No.2 Site	Test Hole Backfill	Drill cuttings		

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
0.5	1	1	14					GRAVEL, COBBLES and BOULDERS in a matrix of sand, sand and gravel fine to coarse, brown, maximum cored length of boulders 170 mm.				
1.0												
1.5												
2.0	2	1	20									
2.5												
3.0								SANDSTONE, medium strong to strong, highly weathered to weathered, medium to fine grained, gray to brown				
3.5	3	1	50	0								
4.0												

URS

Project: Beartooth Highway
Project Location: Park County, Wyoming
Project Number: 68-FHAT0039.00

Test Hole Log THB-31

Sheet 2 of 2

Depth (m)	Run Type	ROCK CORE: Box No.	ROCK CORE: Recovery, %	ROCK CORE: R Q D, %	ROCK CORE: Fractures per 30cm	ROCK CORE: Boulder Location	ROCK CORE: Lithology	MATERIAL DESCRIPTION	SOIL SAMPLES: Type Number	SOIL SAMPLES: Blows per 152mm	SOIL SAMPLES: Recovery, %	FIELD NOTES/ LAB DATA
4.0	3	1	50	0				SANDSTONE, medium strong to strong, highly weathered to weathered, medium to fine grained, gray to brown				
4.5												
5.0	4	1	74	20								
5.5												
6.0												
6.5	5	2	100	24								
7.0												
7.5								Bottom of test hole at 7.6m				
8.0												
8.5												

URS

Appendix B
Site Photos

Appendix B
Site Photos

THB-6, STA 42+238

THB-7, STA 42+378

THB-8, STA 45+300

THB-11, STA 46+601

THB-19, STA 50+262

THB-20, STA 50+285

THB-23, STA 42+220

THB-24, STA 45+305

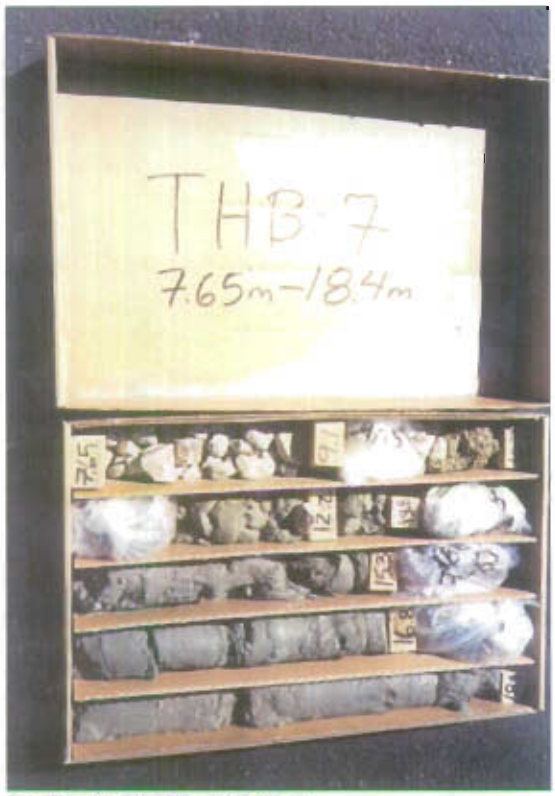
THB-25, STA 45+330

THB-28, STA 50+320

THB-30, STA 46+575

THB–6, 0 - 23.35 m

THB–7, 0 - 7.65 m



THB–7, 7.65 - 18.4 m

THB–7, 18.4 - 25.0 m

THB–7, 25.0 – 32.0 m

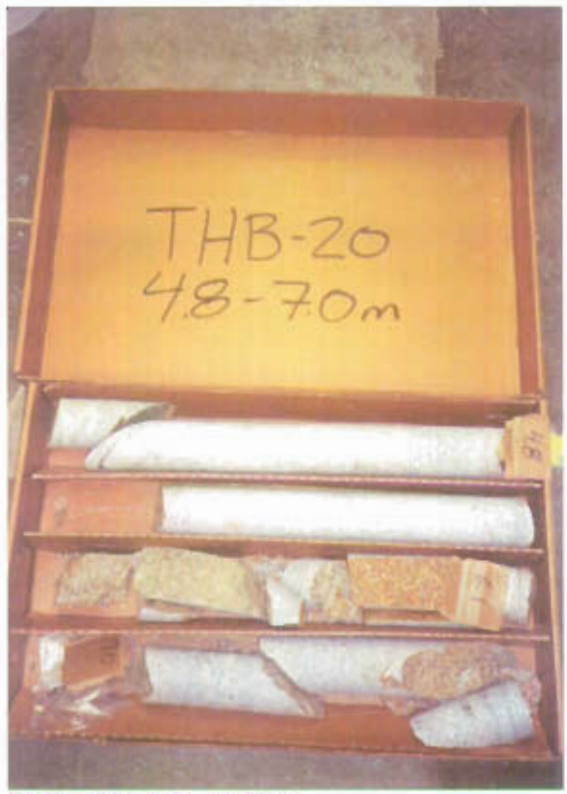
THB–8, 6.1 - 9.7 m

THB–8, 9.7 – 11.7 m

THB–19, 0 - 5.0 m

THB–19, 5.0 - 6.0 m

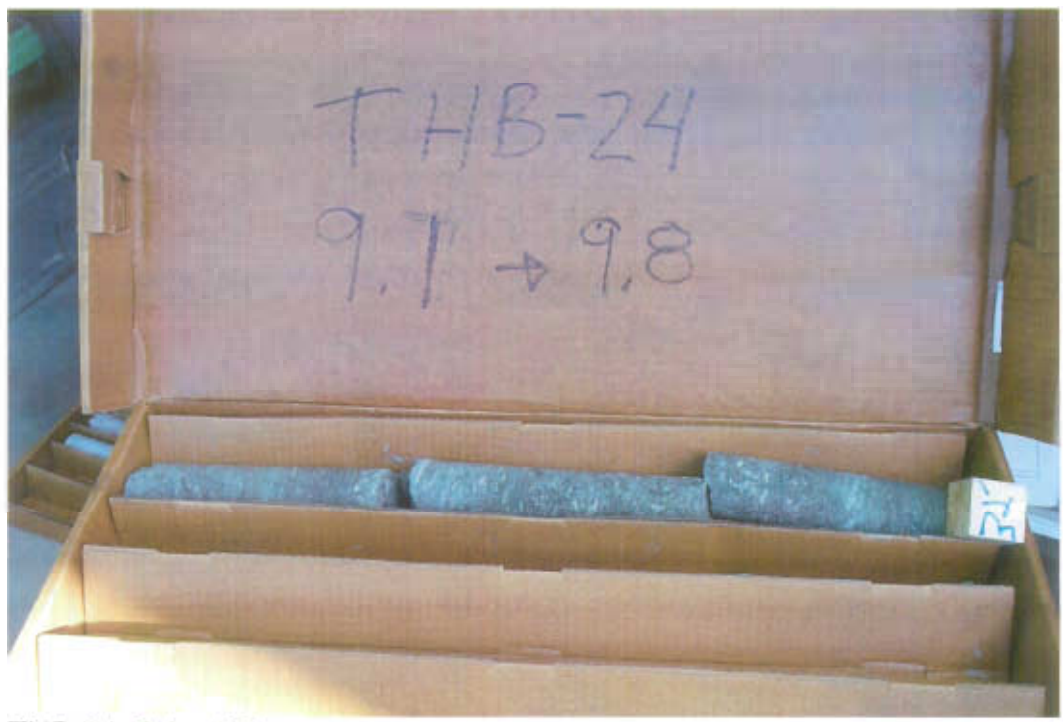
THB–20, 0 - 4.8 m



THB–20, 4.8 - 7.0 m

THB-24, 0 - 6.7

THB-24, 6.7 - 9.1



THB-24, 9.1 – 9.8

THB-28, 0 – 6.1

THB-28, 6.1 – 7.6

THB-30, 0 – 3.7

THB-30, 3.4 – 5.2

THB-31, 0 – 6.1

THB-31, 6.1 – 7.6

Appendix C
Laboratory Test Results

Appendix C
Laboratory Test Results

Table C-1
SUMMARY OF LABORATORY TEST RESULTS

Site	Test Hole	Depth (m)	Bulk Density (kg/cu. m) [1]	Dry Density (kg/cu. m) [1]	Moisture Content (%) [1]	Classification [2]	% Gravel [3]	% Sand [4]	% Fines [5]	Plasticity Index [6]	Liquid Limit [6]	UCS [7] (MPa)	UCS [8] (MPa)
Beartooth Lake Bridge	THB-6	12.50				CL-ML		20	80				
Beartooth Lake Bridge	THB-6	17.00				CL-ML	3	8	89	5	23		
Beartooth Lake Bridge	THB-6	23.10		1539	27.7	CL							
Beartooth Lake Bridge	THB-7	11.00				ML		13	87				
Beartooth Lake Bridge	THB-7	14.00				ML		13	87	3	21		
Beartooth Lake Bridge	THB-23	10.00		1913	16.4	ML							
Beartooth Lake Bridge	THB-23	12.50		1678	23.4	ML			80	NP			
Beartooth Lake Bridge	THB-23	15.00		1645	24.6	ML			91	34	15		
Little Bear Creek Br. 1	THB-8	9.60				Gneiss						174	
Little Bear Creek Br. 1	THB-8	11.00	2945			Gneiss							47
Little Bear Creek Br. 1	THB-8	11.60				Gneiss						127	
Little Bear Creek Br. 2	THB-11	3.10				Sandstone						27	
Little Bear Creek Br. 2	THB-11	4.00				Sandstone						20	
Little Bear Creek Br. 2	THB-11	5.20	2568			Sandstone							31
Little Bear Creek Br. 2	THB-30	2.50	2598			Sandstone							101
Little Bear Creek Br. 2	THB-31	5.00	2527			Sandstone							46
Long Lake Bridge	THB-19	3.40	2765			Granite							42
Long Lake Bridge	THB-19	4.90				Granite						125	
Long Lake Bridge	THB-19	5.80				Granite						119	
Long Lake Bridge	THB-20	5.60	2623			Granite						200	118
Long Lake Bridge	THB-20	6.10				Granite						143	
Long Lake Bridge	THB-20	6.90				Granite						160	

[1] Dry unit weight test performed in general accordance with ASTM D 2216

[2] USCS = Unified Soil Classification System, based on visual observation when grain size data and plasticity data not available Grain size distribution performed in general accordance with ASTM D422. Visual classification performed in general accordance with ASTM D 2488

[3] Percent greater than the No. 4 sieve size.

[4] Percent finer than the No. 4 sieve size and coarser than the No 200 sieve size.

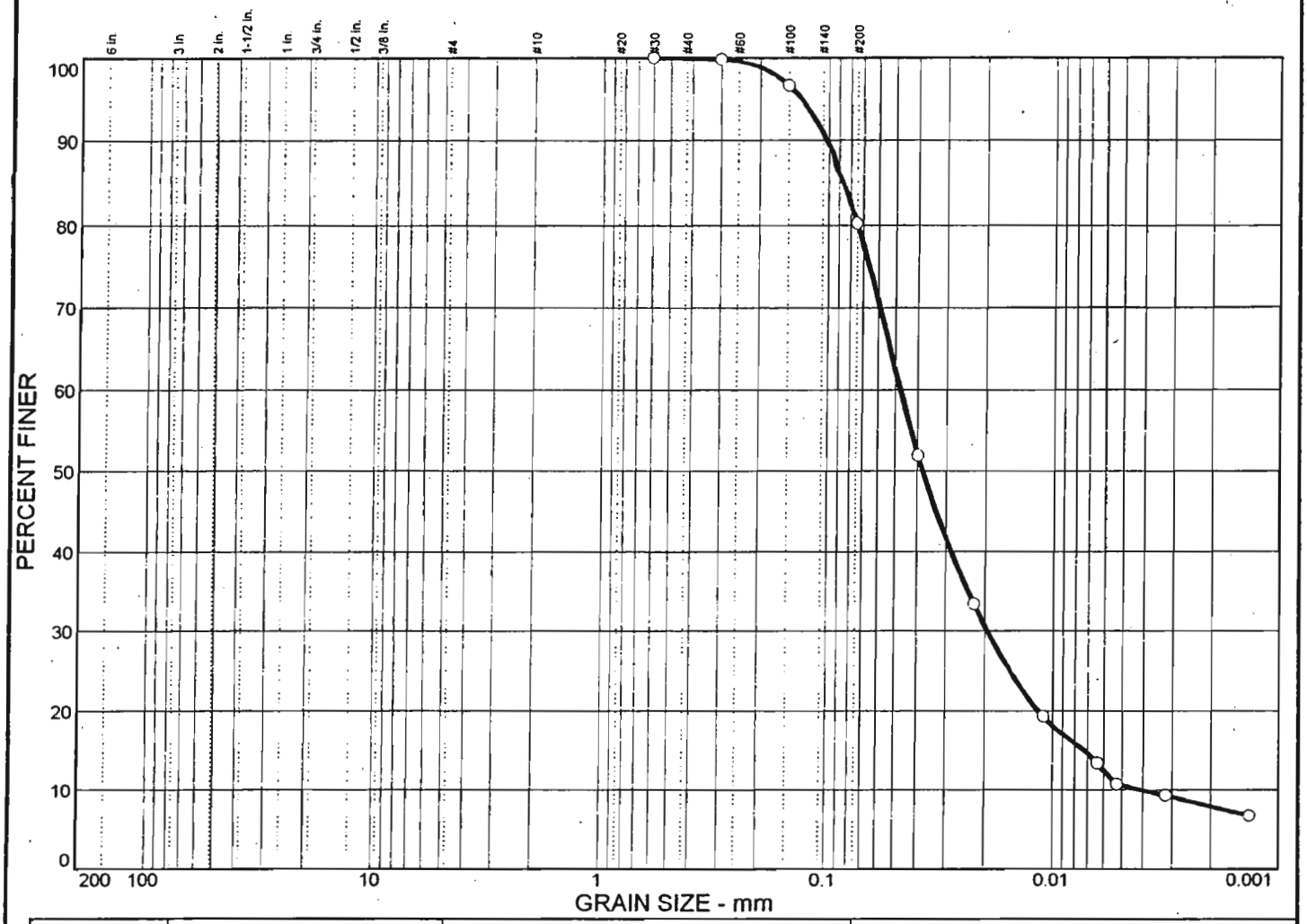
[5] Percent finer than the No. 200 sieve size. Includes silt and clay sizes.

[6] Atterberg limits performed in general accordance with ASTM D 4318.

[7] Values determined from point load testing and the point load index.

[8] UCS = Unconfined Compressive Strength from Unconfined Compressive Strength Test

PARTICLE-SIZE DISTRIBUTION REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.0	19.7	69.8	10.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0858	0.0477	0.0378	0.0195	0.0073	0.0041	1.95	11.64

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silty clay with sand	CL-ML	

Project No. 68FHAT0027 **Client:**

Project: BEAR TOOTH HIGHWAY

○ **Source:** THB-6 **Sample No.:** SPT-8 **Elev./Depth:** 12.5m

Remarks:

○

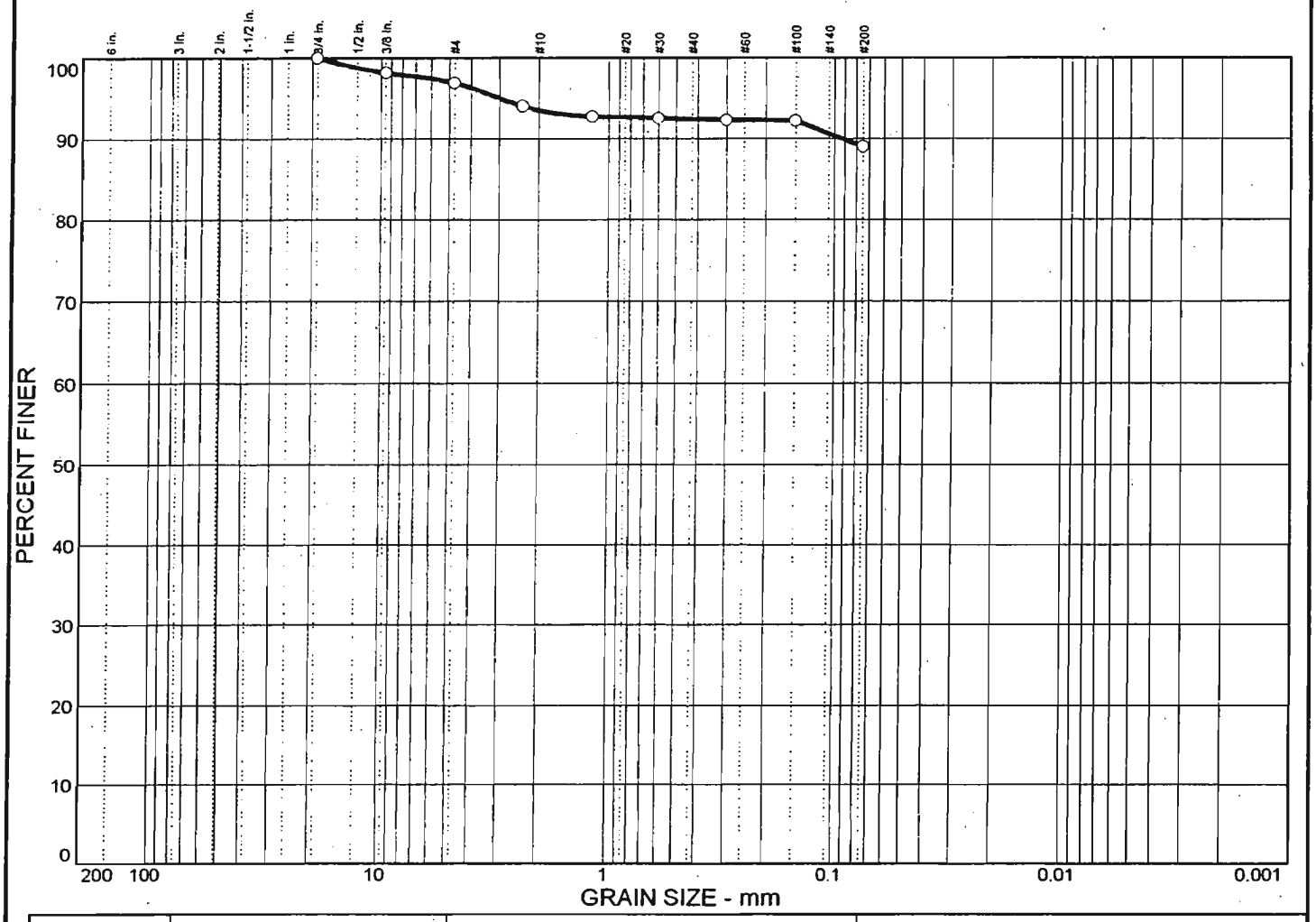
PARTICLE-SIZE DISTRIBUTION REPORT

URS GREINER WOODWARD CLYDE

D-10

Fig.

PARTICLE-SIZE DISTRIBUTION REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	3.1	3.4	1.1	3.4	89.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	23	5								

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silty clay	CL-ML	

Project No. 68FHAT00270 **Client:**

Project: BEAR TOOTH HIGHWAY

Remarks:

○

○ **Source:** THB-6 **Sample No.:** SPT-11 **Elev./Depth:** 17.0m

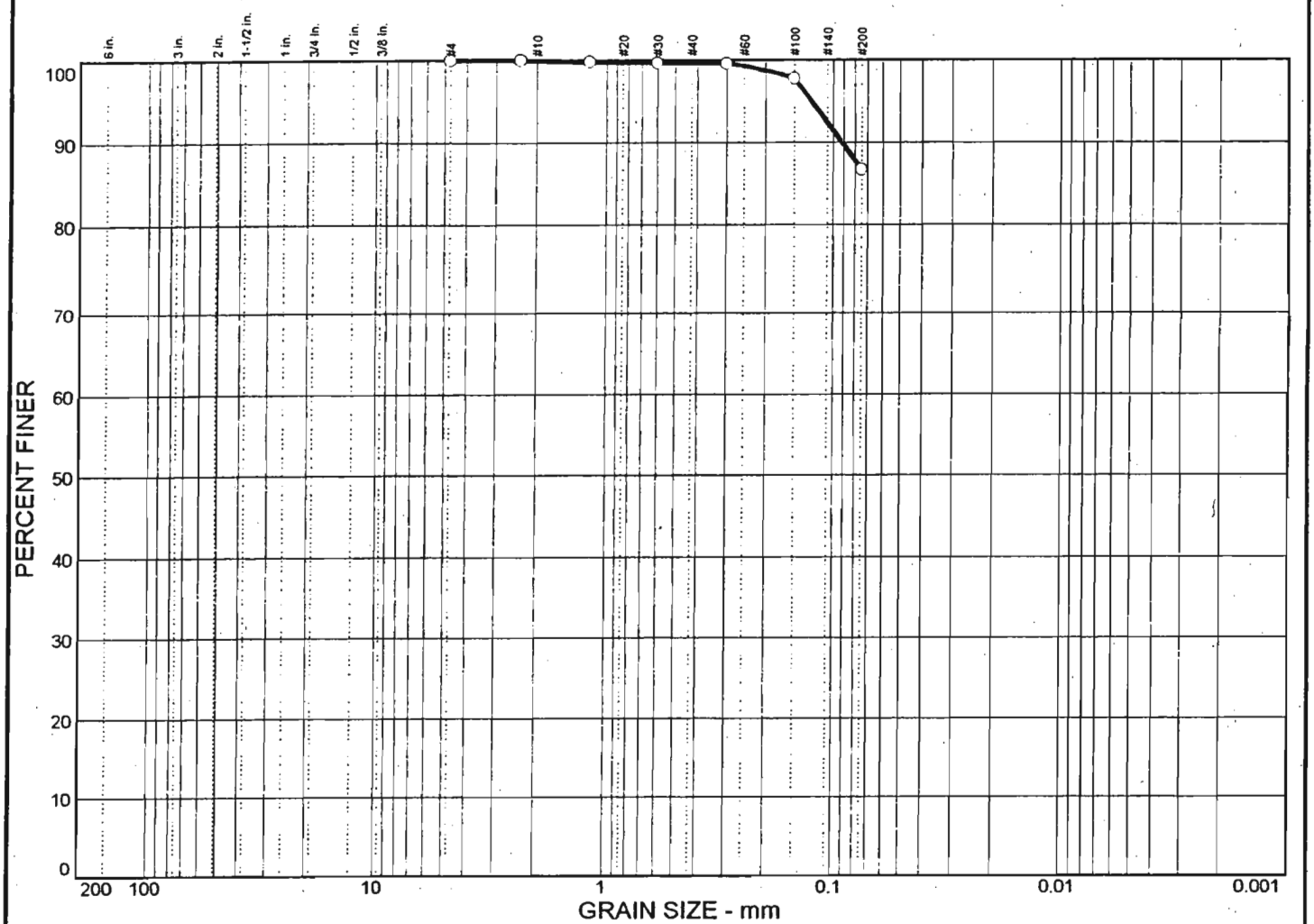
PARTICLE-SIZE DISTRIBUTION REPORT

URS GREINER WOODWARD CLYDE

D-11

Fig.

PARTICLE-SIZE DISTRIBUTION REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.1	0.3	12.9	86.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○		NONPLASTIC								

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silt	ML	

Project No. 68FHAT0027 **Client:**

Project: BEAR TOOTH HIGHWAY

○ **Source:** THB-7 **Sample No.:** STP-7 **Elev./Depth:** 11.0m

Remarks:

○

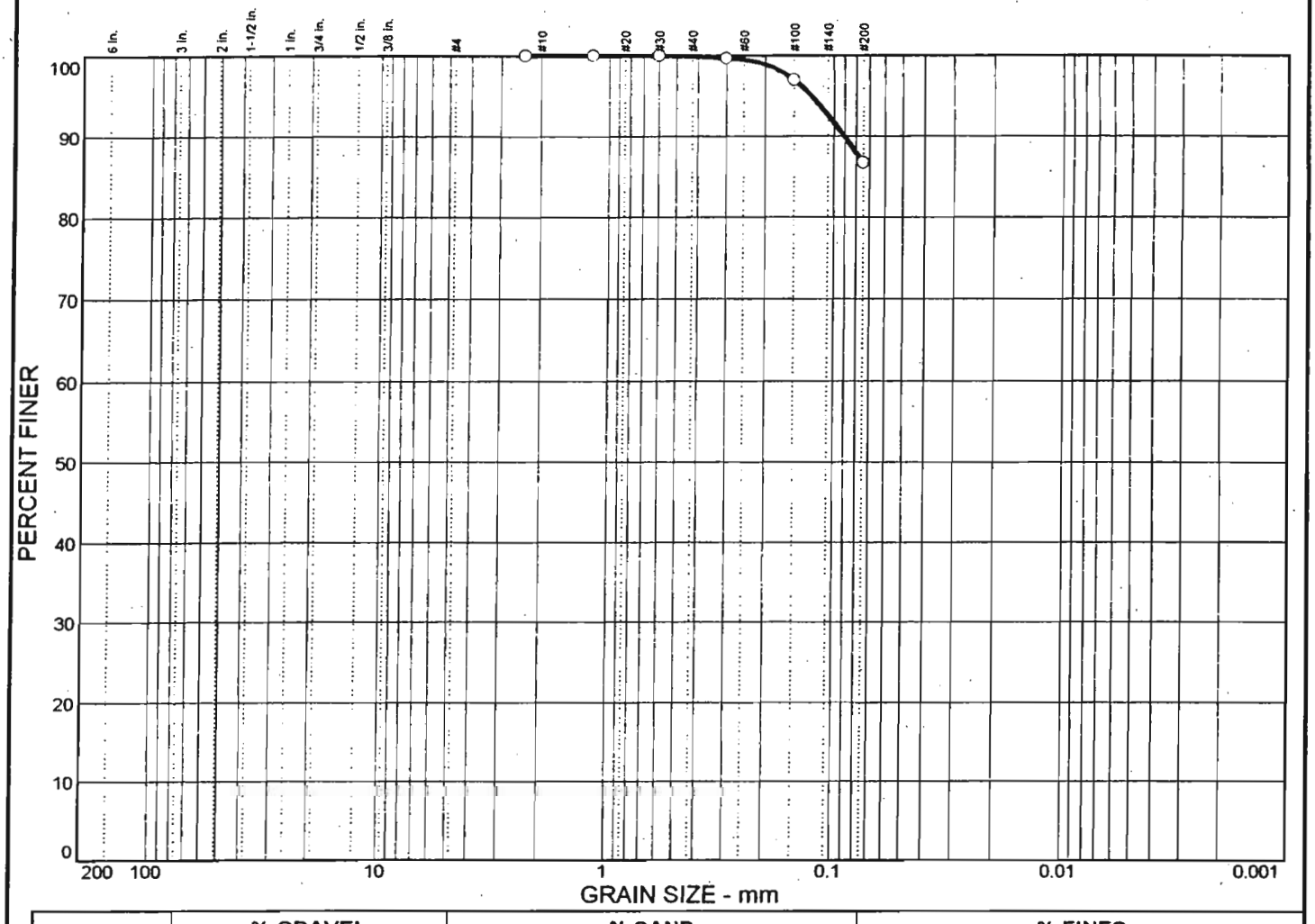
PARTICLE-SIZE DISTRIBUTION REPORT

URS GREINER WOODWARD CLYDE

D-12

Fig.

PARTICLE-SIZE DISTRIBUTION REPORT



	% + 3"	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.1	13.2	86.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	21	3								

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silt	ML	

Project No. 68FHAT0027 **Client:**
Project: BEAR TOOTH HIGHWAY

○ **Source:** THB-7 **Sample No.:** SPT-9 **Elev./Depth:** 14.0m

Remarks:
○

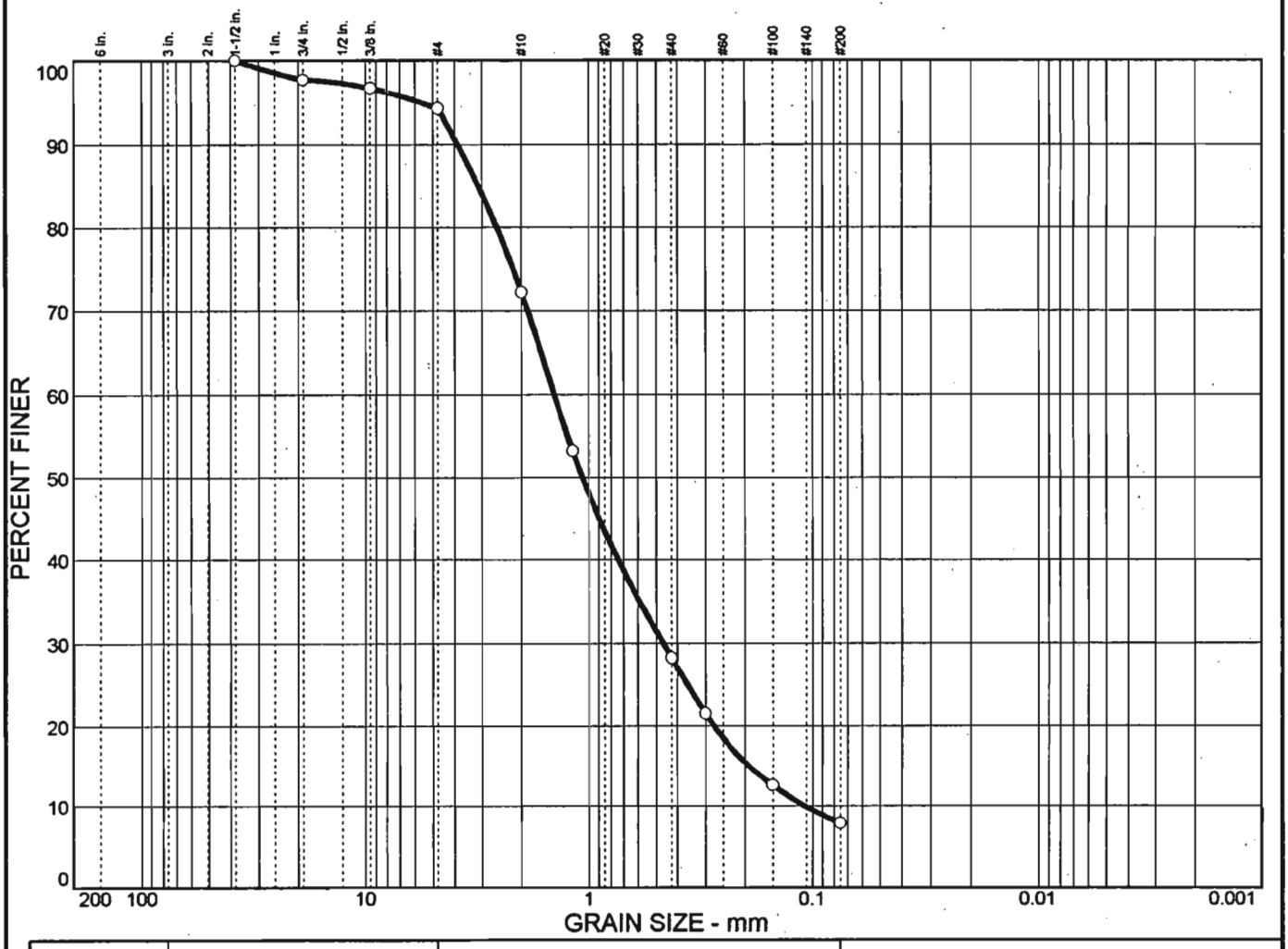
PARTICLE-SIZE DISTRIBUTION REPORT

URS GREINER WOODWARD CLYDE

D-13

Fig.

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	2.3	3.4	22.1	44.0	20.3	7.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			3.13	1.43	1.07	0.465	0.191	0.108	1.40	13.26

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No. 68FHAT0039.01 **Client:**
Project: BEARTOOTH HIGHWAY

○ **Source:** THB-26 **Elev./Depth:** 1.5-2 m

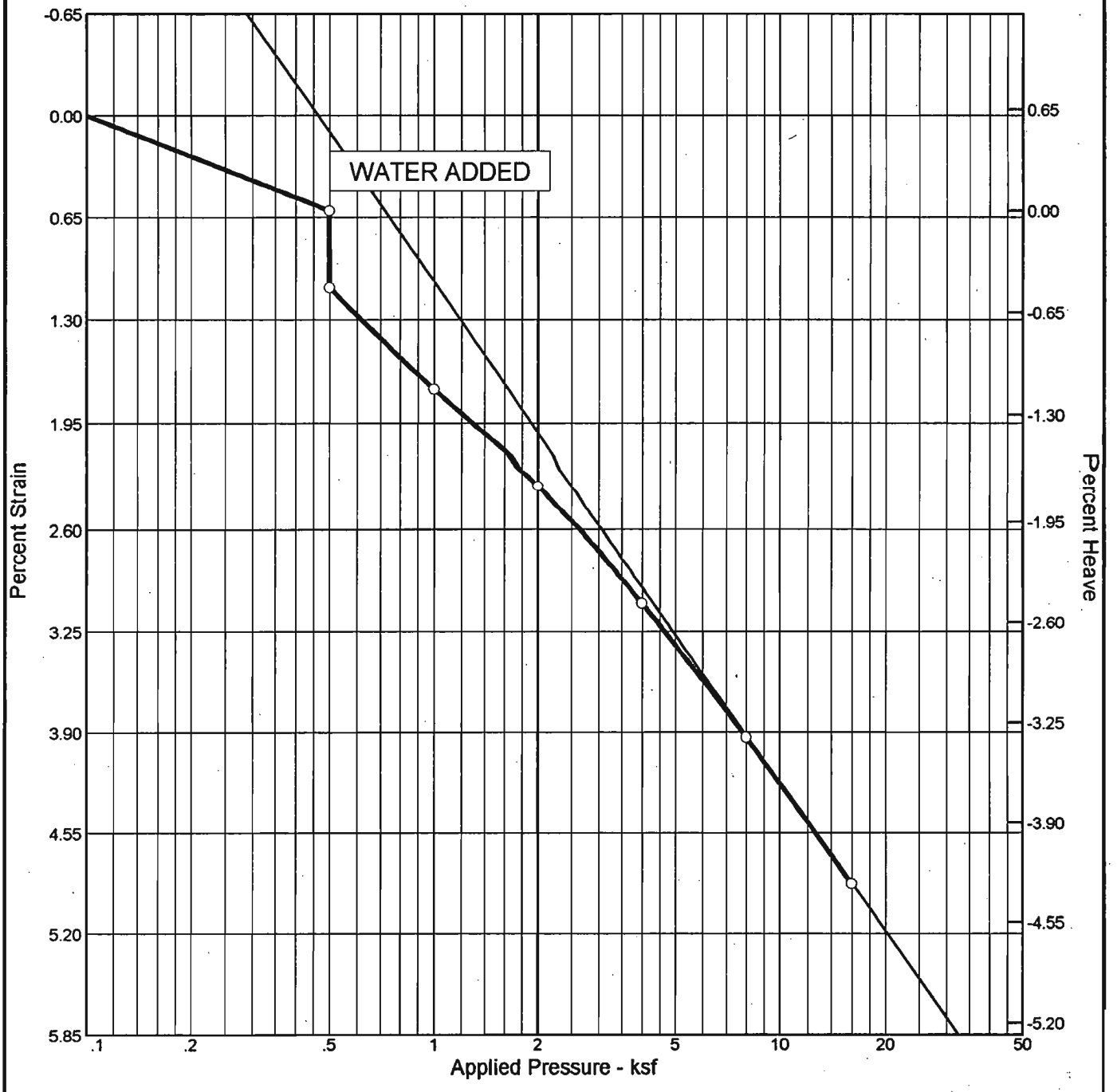
Remarks:
○

Particle Size Distribution Report

URS CORPORATION

Fig.

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
	23.4 %	104.6	N/P	N/P		ML		

MATERIAL DESCRIPTION

Silt with sand

Project No. 68FHAT0039.00 **Client:**

Project: BEARTOOTH HIGHWAY

Source: THB-23 **Sample No.:** ST-2 **Elev./Depth:** 12.5 m

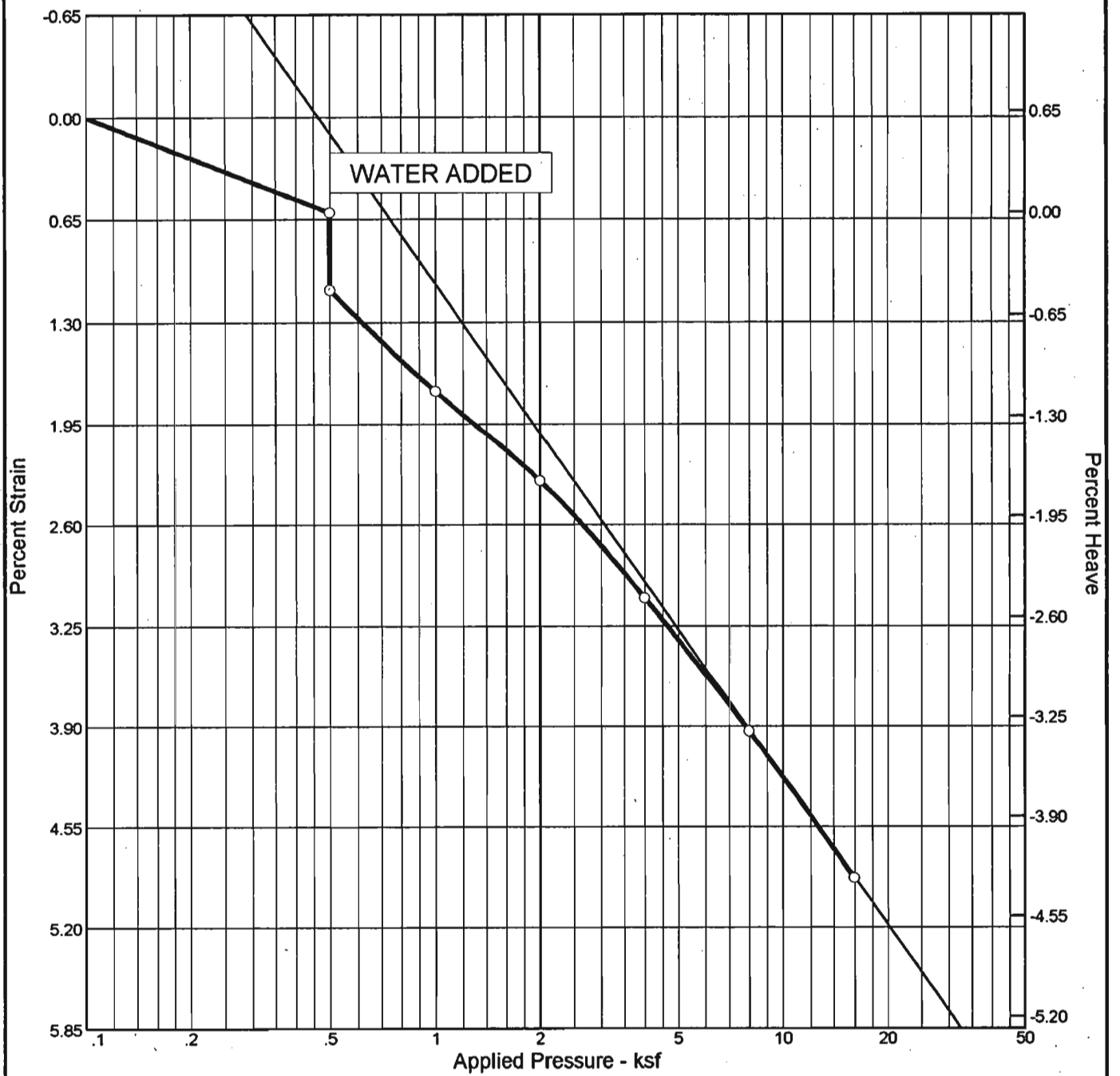
Remarks:

CONSOLIDATION TEST REPORT

URS CORPORATION

Fig.

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
	23.4 %	104.6	N/P	N/P		ML		

MATERIAL DESCRIPTION

Silt with sand

Project No. 68FHAT0039.00 **Client:**

Project: BEARTOOTH HIGHWAY

Source: THB-23 **Sample No.:** ST-2 **Elev./Depth:** 12.5 m

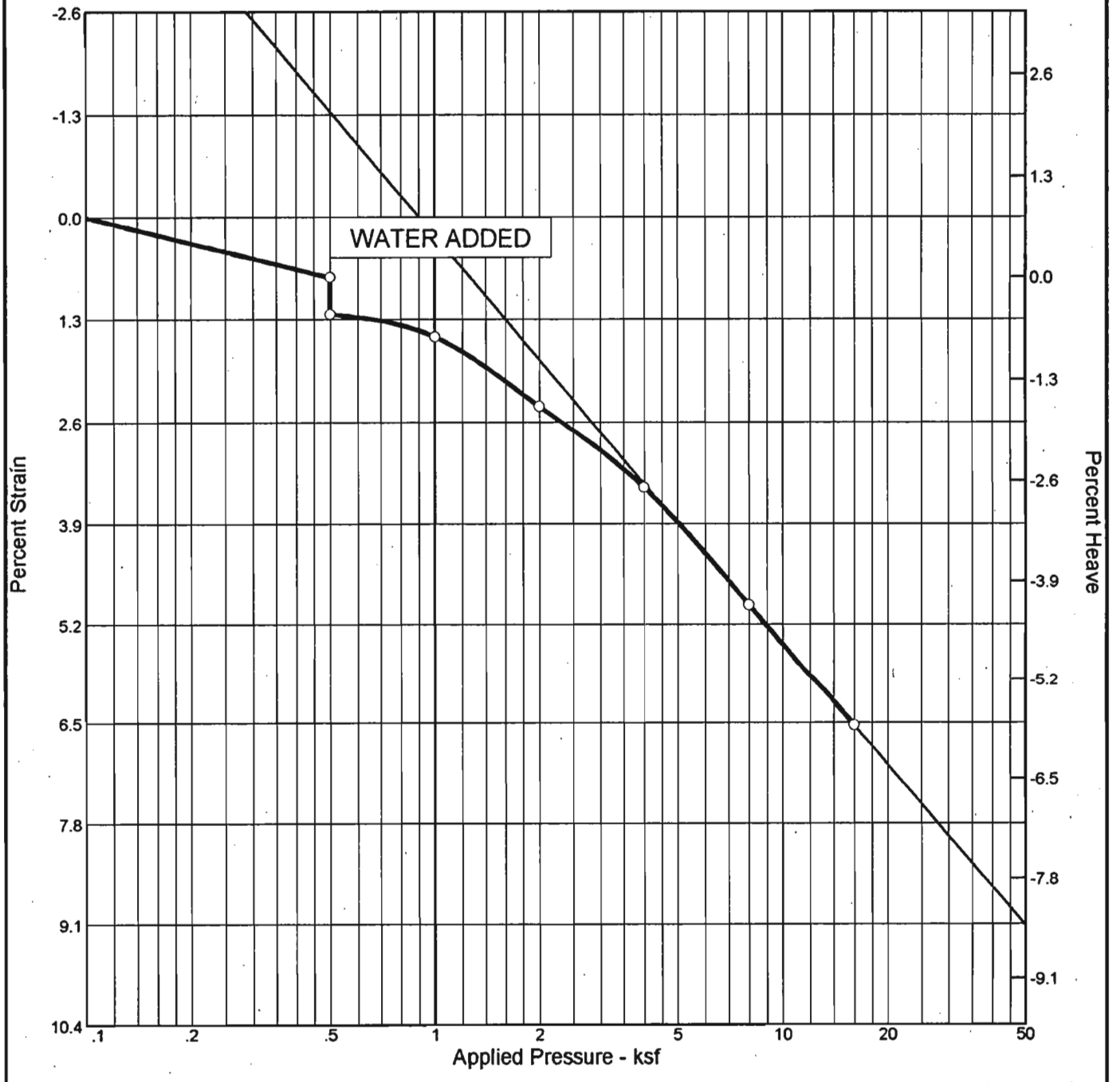
CONSOLIDATION TEST REPORT

URS CORPORATION

Remarks:

Fig.

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
	24.6 %	102.5	34	15		CL		

MATERIAL DESCRIPTION

Lean clay

Project No. 68FHAT0039.00 **Client:**

Project: BEARTOOTH HIGHWAY

Source: THB-23 **Sample No.:** ST-3 **Elev./Depth:** 15 m

CONSOLIDATION TEST REPORT

URS CORPORATION

Remarks:

Fig.