FINAL REPORT

UPPER PLATTE AND BEAVER / DEUEL AND SNYDER FEASIBILITY STUDY

PRELIMINARY DESIGN REPORT

Prepared for:

The Upper Platte & Beaver Canal Company
P.O. Box 205
Brush, Colorado 80723

In cooperation with the Colorado Water Conservation Board

July 12, 2016

TZA Water Engineers
a Lamp Rynearson Company

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ASTM	American Society for Testing and Materials
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
DEM	digital elevation model
DGPS	Differential Global Positioning System
DOR	depth of refusal
GIS	geographic information system
HEC-RAS	Hydrologic Engineering Center (USACE) River Analysis System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWP	Nationwide Permit
OSHA	Occupational Safety and Health Administration
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RCC	roller-compacted concrete
RQD	rock quality designation
SCS	Soil Conservation Service
SDF	Spillway Design Flood
SPT	Standard Penetration Test
SSURGO	Soil Survey Geographic Database
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WOUS	Waters of the United States
WQC	Water Quality Certification

Acknowledgements

TZA gratefully acknowledges the assistance of Everett Matheny, Dam Operator, Steve Griffith, President, Upper Platte & Beaver Canal Company (UP&B) and Dan Kendrick, President, Deuel & Snyder Canal Company (D&S) during the preparation of this report.

PROJECT BACKGROUND

The Upper Platte and Beaver (UP&B) / Deuel &Snyder (D&S) diversion dam spans the South Platte River and allows diversion of irrigation water for 16,600 acres. The original structure was constructed over 80 years ago and recent investigations have found problem areas where the bedrock has been undermined resulting in structural damage that must be addressed so that the diversion structure does not catastrophically fail. TZA and its subconsultants investigated site conditions and prepared preliminary engineering designs, cost estimates, and schedules for two alternatives, Alternative 1 – Rehabilitate the Existing Dam and Alternative 2 – New Diversion Dam. The study will provide the UP&B and D&S with the data necessary to move forward on a course of action to repair or replace the dam. The design and construction phase that will follow will be planned to provide an efficient, safe, diversion structure that will provide benefits for the next 80 plus years.

SITE SURVEY

TZA coordinated with the Lamp Rynearson, Inc. (LRA) office in Fort Collins, Colorado to perform a topographic field survey of the project site including the existing diversion dam and extending 200 feet downstream of the structure. The survey included the dam abutments, dam crest, upstream toe, downstream toe, buttresses location, size and sill elevation of gates, and adequate spot elevations to define the structure. A river cross section of the entire floodplain was surveyed at the location of the new diversion structure (Alternative 2). The cross section was also for verifying the accuracy of the FEMA hydraulic model.

VISUAL INSPECTION

A visual inspection of the existing diversion dam was conducted on December 9, 2015. The visual inspection found that the South Dam, Diagonal Dam and North Dam were in poor to unsatisfactory condition. The inspection found that the canal headworks, flood gates and sluice gate were in satisfactory condition and appear to meet diversion requirements. The primary deficiencies identified in the South dam, Diagonal Dam and North Dam are described below.

- Seepage under the structure has eroded the foundation and undermined the slab.
- Erosion from overtopping has undermined the toe of the downstream base slab and has exposed the shear keys beneath the slab.
- Significant concrete deterioration has occurred in the buttresses and concrete base slabs. The deterioration has led to corrosion of reinforcement steel, and likely reduced the kinematic stability of the structure.

Repair of the concrete base slab is considered important to restore the kinematic stability of the dam. The concrete base slab should be repaired so as to provide protection against foundation erosion, and should include a cutoff wall at the upstream and downstream toe to provide protection against undermining erosion. In addition, the concrete buttresses, slab sections that are not replaced and appurtenances such as the concrete walkway bridge should be repaired

GEOTECHNICAL INVESTIGATION

TZA retained Olson Engineering to conduct a geophysical seismic survey to provide a river wide profile of the bedrock surface and general formation thickness and retained RJH Consultants (RJH) to conduct test borings to calibrate the seismic data, define the formation characteristics and determine specific soil/rock properties.

Geophysical Survey

The geophysical seismic survey determined the thickness of unconsolidated alluvial sediments overlying the shale bedrock, and the lateral and vertical variability of stiffness in the overburden and the shale bedrock. The results of the seismic survey indicated the surface of the bedrock was relatively uniform across the river floodplain and ranged in elevation from 4262 to 4270. The seismic results also indicated relative consistency of the bedrock formation with depth. A plot of the river cross section was developed showing the results of the survey.

Test Borings, Sampling and Laboratory Testing

The subsurface conditions at the Site were evaluated by drilling boreholes, collecting samples, and performing laboratory testing on selected samples. RJH advanced a total of five boreholes for this exploration program: Two boreholes were located along the existing structure and three were located along an alignment for a proposed new structure, which is generally upstream of the existing structure. RJH also collected alluvium samples at three locations along the River upstream of the structure.

The geologic units identified at the Site consisted of colluvium, alluvium, and bedrock of the Upper Transition Member of the Pierre Shale (Pierre Shale). RJH engaged Elite Drilling Services (Elite) of Denver, Colorado to advance five boreholes between December 21 and 29, 2015.

RJH conducted the laboratory tests on samples obtained during the subsurface investigation. Index tests included moisture content, dry density, grainsize analyses and Atterberg limits tests to classify the material and determine basic material characteristics. The engineering properties were determined by consolidation testing, unconfined compressive strength tests, consolidated undrained triaxial shear strength tests and corrosivity tests.

Pierre Shale was identified below alluvium in all borings or was present at the ground surface. The approximate elevation of the top of bedrock was generally between El. 4269.0 and El.

4270.3. Rock types identified within the Pierre Shale are described in two groups, hard sandstone and soft rock. Hard sandstone was identified at the top of bedrock and generally was about one to two feet thick. The second rock type within the Pierre Shale consisted of soft sandy claystone, clayey sandstone, and silty sandstone and is referred to as soft rock. Soft rock was identified below the hard sandstone in most of the borings. The degree of weathering of the soft rock ranged from fresh to intensely weathered and the degree of fracturing ranged from slightly to moderately fractured. The hardness ranged from soft to very soft. In general, a 2- to 4-foot-thick weathered zone existed at the top of the soft rock. Weathered soft rock was commonly poorly cemented and slightly to intensely weathered. The soft rock below the weathered zone was better cemented and the degree of weathering ranged from fresh to slightly weathered.

ENVIRONMENTAL EVALUATION

TZA retained ERO Resources Corporation (ERO) to determine the environmental regulatory permitting requirements for the proposed alternatives identified in the feasibility study. The natural resource/environmental agencies with regulatory authority over the potential improvements were investigated and the permitting requirements, costs, and timing for regulatory approval identified. Wetlands identification and mapping at the location of the proposed alternatives was not included at this time since it has been determined that a Section 404 permit will not be required. The sections below summarize the evaluation of ERO regarding natural resources in the study area, the potential effects each alternative may have on natural resources, Endangered Species Act and/or Historic Preservation Act compliance and the Clean Water Act Section 404 regulations.

Regulatory Requirements for Proposed Alternatives

The Federal regulation 33 USC 1344, Part 323.4 (a)(3) includes an exemption that states construction of diversion structures that are considered functionally related to irrigation ditches are exempt from Clean Water Act permitting requirements.

ERO contacted the Corps after the concept design of the alternatives was completed to discuss the applicability of 33 USC 1344, Part 323.4 (a)(3). The Corps has indicated that both alternatives would fall under this exemption if the Upper Platte & Beaver Irrigation Company and the Deuel & Snyder Irrigation Company can demonstrate that at least 50% of the water in the irrigation ditches are for agricultural use. Therefore, a Section 404 permit for the proposed project would not be required. Once an alternative is chosen, ERO recommends submitting a letter to the Corps to verify the proposed activities would fall under the exemption and a Section 404 permit would not be required.

Federally Threatened and Endangered Species

ERO completed a desktop analysis for suitable habitat for federally listed threatened and endangered species protected under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA). Several species are listed as potentially occurring in Morgan County, Colorado (Table 1).

Table 1. Federally threatened, endangered, and candidate species potentially found in Morgan County or potentially affected by projects in Morgan County.

Common Name	Scientific Name	Status[*]	Habitat	Potential Habitat Present or Effects Anticipated?
Mammals				
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	T	Shrub riparian/wet meadows	Yes
Birds				
Interior least tern[**]	*Sterna antillarum athalassos*	E	Sandy/pebble beaches on lakes, reservoirs, and rivers	Yes
Piping plover[**]	*Charadrius melodus*	T	Sandy lakeshore beaches and river sandbars	Yes
Whooping crane[**]	*Grus americana*	E	Mudflats around reservoirs and in agricultural areas	Yes
Fish				
Pallid sturgeon[**]	*Scaphirhynchus albus*	E	Large, turbid, free-flowing rivers with a strong current and gravel or sandy substrate	Yes
Plants				
Ute ladies'-tresses orchid	*Spiranthes diluvialis*	T	Moist to wet alluvial meadows, floodplains of perennial streams, and around springs and lakes below 6,500 feet in elevation	Yes
Western prairie fringed orchid[**]	*Platanthera praeclara*	T	Moist to wet prairies and meadows	Yes

[*] T = Federally Threatened Species, E = Federally Endangered Species.

[**] Water depletions in the South Platte River may affect the species and/or critical habitat in downstream reaches in other counties or states.

Source: Service 2016.

Recommendations and Permitting Requirements

ERO recommends completing a habitat assessment for the Preble's meadow jumping mouse (Preble's) and the Ute ladies'-tresses orchid (ULTO) if any activities are proposed within the wetland/riparian areas in the project area. The interior least tern, piping plover, whooping crane, pallid sturgeon, and western prairie fringed orchid are species that are affected by continued or ongoing water depletions to the Platte River system. Consultation regarding these species would not be necessary because the project would fall under the agricultural exemption and a Section 404 permit would not be required,

Cultural and Historic Resources

Cultural and historic resources are protected under Section 106 of the National Historic Preservation Act (NHPA) when any project has a federal nexus. Because the project would fall under the agricultural exemption and is unlikely to have a federal nexus such as a Section 404 permit, consultation regarding cultural and historic resources would not be required.

HYDRAULIC MODELING

TZA reviewed water rights for the UP&B and D&S, streamflow conditions in the South Platte and developed a hydraulic model of the South Platte River using an existing FEMA HECRAS model for Morgan County Colorado dated January 2010.

Water Rights

The table below lists the irrigated acres and water rights information for the UP&B and D&S.

Description	**UP&B**	**D&S**
Decreed Absolute Water Right (cfs)	468.34	136.40
Decreed Conditional Water Right (cfs)	234.17	31.60
Maximum Day Diversion (cfs)	270	69
Date of maximum	5-27-2002	4-26-2007
Acres Irrigated	14,000	2,600

Historic Floods

Numerous significant flood events have been documented on the South Platte River at Fort Morgan. Significant floods are listed below:

- The flood of May 30-31, 1935 (Cherry Creek Storm) resulted from 24 inches of precipitation centered in the Cherry Creek watershed and had a discharge of 84,300 cubic feet per second at Fort Morgan. The flood resulted in the relocation of the UP&B headworks to the present site and the construction of South Diversion Dam and the North Diversion Dam in 1936.
- The flood of June 16-17, 1965 resulted from 18.1 inches centered on the Plum Creek and Bijou Creek watersheds and is known as the Plum Creek Storm. The flood elevation of the South Platte River at Highway 52 was 4272.6 feet. The 1965 flood washed out the island between the South Diversion Dam and the North Diversion Dam and allowed the river to bypass the diversion structures. The Diagonal Dam was constructed 1965 to connect the north and south sections of the diversion dam.
- The flood of September 2013 had a discharge of 60,000 cfs at Fort Morgan.

The flood frequencies and discharges for the South Platte at Fort Morgan as determined by the U.S. Army Corps of Engineers are listed below.

Flood Event	Peak Discharge (cfs)
2YR	4,800
10YR	24,000
50YR	73,000
100YR	114,000
500YR	300,000

Hydraulic Design Criteria

The hydraulic design criteria for the diversion dam was selected to meet the irrigation demands of the UP&B and D&S Canal Companies, provide redundancy for operation and maintenance, minimize damage during flood events and maintain a stable channel environment. The design criteria is summarized below.

- Flood condition: Safely pass the 100-Year Flood without overtopping for the non-overflow sections of the dam.
- High flow condition: River discharge taken as mean monthly flow for June. The diversion requirement is equal to the decreed absolute water right for UP&B and D&S.
- Average flow conditions: River discharge taken as the mean monthly flow for August. The diversion requirement is equal to the historic maximum flow for the UP&B and D&S.
- Low flow conditions: River discharge taken as the 80 percent exceedance flow. The diversion requirement is equal to the historic average diversion for the UP&B and D&S for the month of August.

Hydraulic Model Results

The peak discharges for the 2-year through 500-year floods were modeled using HECRAS with the flood gate open. The results of the modeling are summarized in the following table.

Storm Event	**Flood Discharge (cfs)**	**Alt. No. 1 (Existing) Flood Elevation (feet)**	**Alt. No.2 flood Elevation (feet)**
2YR	4,800	4279.2	4276.6
10YR	24,000	4282.4	4282.8
2013 Flood	60,000	4287.8	4287.4
50YR	73,000	4289.1	4288.7
100YR	114,000	4292.4	4291.7
500YR	300,000	4302.1	4300.9

Diversion Simulation

The hydraulic performance of the diversion gates for the design flow conditions is summarized in the table below. A single 15’ wide headgate was assumed to be operating for the UP&B and the existing 10’ wide headgate was assumed to be operating for the D&S. The flood gates and sluice gates were assumed to be closed for the calculations

Description	High Flow Condition	Average Flow Condition	Low Flow Condition
River Discharge (cfs)	2100	577	167
River Water Surface Elevation (ft)	4280.5	4278.2	4276.7
Diversion Requirement UP&B/D&S (cfs)	468 / 136	270 / 69	97 / 11
Canal Water Surface (UP&B)(ft)	4277.05	4276.22	4275.24
Gate Position UP&B (percent open)	72%	93%	93%
Gate Position D&S (percent open)	37%	66%	74%

ALTERNATIVE 1 – REHABILITATE THE EXISTING DAM

Alternative 1 consists of rehabilitating the existing diversion structure to prevent catastrophic failure and permit continued efficient operation of the irrigation systems. The Alternative 1 improvements primarily address the structural components of the dams. Repair of the concrete base slab is considered important to restore the kinematic stability of the section. The concrete base slab should be repaired so as to provide protection against foundation erosion, and should include a cutoff wall at the upstream and downstream toe to provide protection against undermining erosion. In addition, the concrete buttresses, slab sections that are not replaced and appurtenances such as the concrete walkway bridge should be repaired. The completed improvements will address the observed deficiencies and are expected to provide reasonable service in the future. However, unknown problems in the existing structures may result in necessity for future maintenance and corrective actions. The secondary goal of channelization of the South Platte River to minimize flood impacts and improve sediment transport is not economically feasible by modifying the existing diversion. This would require the installation of a large bladder gate in the diagonal dam which would not be efficiently oriented for channelization and sediment transport.

Description of Improvements

Alternative 1 will consist of the following improvements.

- Upstream Cut-Off Wall: The upstream cut-off wall will consist of a barrier to seepage and will confine and protect the claystone bedrock. The cut-off wall will extend at least 10 feet below the surface of the bedrock. A new upstream slab will be extended to connect to the existing structure foundation.
- Repair of Downstream Slab: The downstream slab is cracked and broken at many locations where it extends past the end of the buttresses. The existing slab will be saw

cut at the end of the buttresses and removed. The voids und the structure will be filled with concrete backfill. Voids extending a significant distance under the structure will be grouted by drilling through the slab. A new slab extending 10 feet downstream of the buttress terminating in a cut-off wall will be constructed. The slab will be structurally connected to the existing slab. The constructability of the repairs to the existing slab may be difficult due to unknowns in the condition of the slab and foundation.

- Downstream Cut-Off Wall: The downstream cut-off wall will be extended a minimum of 10 feet below the surface of the bedrock similarly to the upstream cut-off wall.
- Downstream Scour Protection: A concrete scour pad will be constructed to extend 20 feet from the downstream cut-off wall. The scour pad will terminate in a key extending 5 feet below the bedrock surface. The length of the scour protection is sufficient to contain the hydraulic jump downstream of the weir for the 2-Year and 5-Year Floods. Floods greater than the 5-Year Flood have high tailwater depth which reduces the potential for scour.
- Concrete Repair: The existing concrete structure including buttresses, slabs walkways and other appurtenances will be inspected for cracks, spalling, delamination and exposed rebar. Deficiencies will be corrected by removing concrete to expose a sound surface and provide sufficient depth for a structural repair.

Dewatering and Diversion

The construction of the upstream slab and cutoff wall will require diversion and dewatering of river flows. Adequate gates for diversion exist at the both the south and north ends of the dam. The river may be diverted to the south side or north side as needed to facilitate the construction. The timing of the diversion must be scheduled with irrigation diversion requirements. Dewatering of the cutoff wall trench will be required. Local river bed materials may be used to direct the flow and protect the construction areas.

Schedule

Based on the quantities the construction may take up to 6 months and can be completed in one season. Work should be avoided during the peak runoff periods of May and June although work on the downstream face of the existing dam may be possible depending on the snowmelt conditions. The low flow period of the river generally extends from August through December.

Project Cost

The engineer's opinion of project cost has been prepared to establish budgetary requirements and facilitate economic analysis. Construction pricing is in current dollars and intended to be for "contract" construction cost. Construction material is assumed to be sourced within a reasonable distance, not requiring an escalated cost to bring construction material to the site. This includes, but is not limited to, concrete material, reinforcing, fill, etc. A 30 percent contingency has been added to the subtotal to be in keeping with the level of the unknowns in the preliminary design. Costs for engineering and construction services are estimated in accordance with the guidelines from the American Society of Civil Engineers Manual of Practice No. 45. Estimated project cost does not include other owner costs such as legal, permits, land acquisition, procurement requirements, environmental mitigation and construction cost growth after contract. A summary of the cost is provided in following table.

Alternative 1 Project Cost Estimate at the 30 Percent Design Stage

Description	Values
Diversion and Dewatering	$225,000
Demolition and Temporary Access	$79,000
Earthwork (incl. riprap)	$310,000
Concrete Backfill and Grouting	$435,000
Reinforced Concrete (slab, cutoffs and scour pad)	$2,910,000
Concrete Repair	$105,000
Subtotal	**$4,064,000**
Contingency (30 percent)	$1,220,000
Engineering	$344,000
Construction Services	$291,000
Total Project Cost	**$5,919,000**

ALTERNATIVE 2 – NEW DIVERSION DAM

Alternative 2 consists of constructing a new diversion structure upstream along the alignment of the existing North Dam. The new diversion structure will have an expected operational life of 80 years or more and address all project goals to provide an efficient, safe, diversion structure. The new diversion structure will connect to the existing North Dam and extend across the river to the south bank. The total length of the dam will be reduced from 1410 feet for the existing dam to 1000 feet for the new diversion structure. Construction in the river bed will be limited to 500 feet and will include a concrete ogee section and a bladder dam. The south flood dike will be an earth embankment which will provide access to the gate structures and prevent floods from going around the south side of the structure. The UP&B canal will be extended upstream about 700 feet to the location of the new diversion structure. The new diversion location will require jurisdictional approval for a new point of diversion for the UP&B Canal. The canal headworks and river sluices are designed for 100 percent back-up so maintenance can be performed without impacting diversion. A vertical slot fish passage will be located on the left side of the Ogee dam at the connection with the existing North Dam.

Description of Improvements

- Concrete Ogee Dam: A concrete Ogee dam 280 feet in length will be located near the center of the South Platte River. The Ogee dam will direct flood flows toward the center of the river to help maintain the channel alignment in the center of the river. The design includes a cut-off wall extending at least 10 feet below the surface of the bedrock on the upstream and downstream sides of the structure. A concrete erosion scour pad will extend 20 feet downstream of the cut-off wall and terminate in a key with a depth of 5 feet into the bedrock. The length of the scour protection is sufficient to contain the hydraulic jump downstream of the dam for the 2-Year and 5-Year Floods. Floods greater than the 5-Year Flood have high tailwater depths which reduce the potential for scour.
- Bladder Flood Gate: The floodgate will allow release of normal river flows and will increase the capacity of the diversion structure during major floods. The fully open bladder gate will result in velocities which will scour sediment from the center of the river channel and help maintain the channel alignment in the floodplain. The bladder gate will be an Obermeyer type gate with a upstream steel face which is raised and lowered by pneumatically operated reinforced rubber bladders. The crest of the bladder flood gate will be set at elevation 4280.0 to match the existing dam. The length of the gate is 200 feet. The Ogee dam and floodgate will handle minor floods up to the 10-Year Flood. The Obermeyer gate will be mounted on a concrete slab founded on bedrock with upstream and downstream cut-off walls. A concrete scour pad will extend 20 feet downstream of the cutoff wall.
- River Sluices: River sluices will be located on the north side of the river and the south side to keep sediment from building up near the headworks for the UP&B and the D&S canals. The river sluices for both canals will consist of two radial gates 10 feet in width. The dual gates will allow one gate to remain in service during repair or maintenance of

the other gate. The sill of the sluice gates will be set 2 feet below the riverbed elevation of 4272 and 5 feet below the sill of the canal headgate for efficient removal of sediment.

- D&S Canal Headworks: The existing bladder headgate for the D&S Canal will continue to be used.
- The headworks for the UP&B Canal will consist of two bladder gates 15 feet in width. The gates will be Obermeyer type gates similar to the floodgate. The sills of the gates will be set to match the existing D&S gate at approximately elevation 4275. Each gate will have adequate capacity to meet diversion requirements. The dual gates will allow one gate to remain in service during maintenance or repair of the other gate. A gate house will be located adjacent to the gates to house the pneumatic operation and control equipment.
- Extension of UP&B Canal: The UP&B Canal will be extended approximately 700 feet to the new headworks structure for Alternative 2. The alignment of the canal will follow the existing south bank of the river. An earth embankment will protect the canal from normal river flows up to the 10-Year Flood level. The river side of the embankment will be armored with riprap.
- Fish Passage: A vertical slot fish passage will be located at the north end of the Ogee dam near the connection to the existing North Dam. The passage is designed to accommodate the Brassy Minnow based on guidelines in the report "Fish Barriers and Small Plains Fishes: Fishway Design Recommendations and the Impact Of Existing Instream Structures", Department of Fish, Wildlife, and Conservation Biology, Colorado State University, June 2007. The fish passage is 75 feet in length and consists of 25 pools three feet in length and 10 feet in width.
- South Flood Dike: The South Flood Dike will connect the canal headworks to the high ground on the south side of the river. The dike will prevent floods from by-passing the structure on the south side. The South Flood Dike will consist of an earth embankment with the crest above the 100-Year Flood. The upstream side of the dike will be armored with riprap.
- North Bank Protection: Bank stabilization and erosion protection will be constructed on the north bank of the South Platte River from the D&S headworks upstream about 600 feet. The bank protection will prevent the river from cutting a channel around the diversion structure, but will not reduce the capacity of the floodplain during major flood events.
- Repair of North Dam: The existing North Dam will be repaired as described for Alternative 1. A new concrete walkway will be constructed along the top of the buttresses to provide access to the River Sluice radial gates.

Dewatering and Diversion

The construction of the Ogee structure and floodgate will require diversion and dewatering of river flows. The river may be diverted to the south side or north side as needed to facilitate the construction. The timing of the diversion must be scheduled with irrigation diversion requirements. Dewatering of the cutoff wall trench will be required. Local river bed materials may be used to direct the flow and protect the construction areas. The diversion flow can be released through the river sluices once the sluice gates are constructed

Schedule

Based on the quantities the construction may take up to 8 months and can be completed in one season. Adequate lead time must be incorporated for manufacture of gates and bladder dam components. Work should be avoided during the peak runoff periods of May and June although work on the downstream face of the existing north dam may be possible depending on the snowmelt conditions. The low flow period of the river generally extends from August through December.

Project Cost

The engineer’s opinion of project cost has been prepared to establish budgetary requirements and facilitate economic analysis. Construction pricing is in current dollars and intended to be for “contract” construction cost. Construction material is assumed to be sourced within a reasonable distance, not requiring an escalated cost to bring construction material to the site. This includes, but is not limited to, concrete material, reinforcing, fill, etc. A 20 percent contingency has been added to the subtotal to be in keeping with the level of the unknowns in the preliminary design. Costs for engineering and construction services are estimated in accordance with the guidelines from the American Society of Civil Engineers Manual of Practice No. 45. Estimated project cost does not include other owner costs such as legal, permits, land acquisition, procurement requirements, environmental mitigation and construction cost growth after contract. A summary of the cost is provided in following table.

Alternative 2 Project Cost Estimate at the 30 Percent Design Stage

Description	**Values**
Diversion and Dewatering	$225,000
Demolition and Temporary Access	$25,000
Earthwork (incl. riprap and gravel surfacing)	$1,072,000
Reinforced Concrete (ogee dam, slabs, walls and scour pad)	$2,489,000
Bladder Dam	$800,000
River Sluice Radial Gates	$264,000
Bladder Headgates	$288,000
Gate House (incl. power service)	$80,000
Access Road Bridges	$270,000
Subtotal	**$5,514,000**
Contingency (20 percent)	$1,103,000
Engineering	$431,000
Construction Services	$364,000
Total Project Cost	**$7,412,000**

RECOMMENDATION

TZA recommends that the UP&B and D&S select Alternative 2 – New Diversion Structure. The preliminary plan should be advanced to final design with additional geotechnical and river mechanics analysis to confirm the design assumptions. This recommendation is based on the following considerations:

- Safeguard Diversion: The existing diversion structure is in danger of imminent structural failure. Loss of diversion would result in the inability to irrigate about 17,000 acres with severe economic consequences. Alternative 2 would provide the means to continue diversions and protect existing water rights.
- Useful service life: The project life of rehabilitating the dam is unknown given the current condition of the structure. The service life for the Alternative 2 diversion structure is approximately 80 years and has the potential to be greater with proper maintenance.
- Water quality and environmental enhancement: Alternative 2 would stabilize the river channel, protect streambanks from erosion and allow sediment to pass downstream restoring the natural sediment balance to the South Platte.
- Operational Safety: Alternative 2 would provide safe access for operation of diversion, sluice and flood gates.
- Fish passage: Alternative 2 would provide a vertical slot fish passage designed to provide a detour route for migrating native Colorado fish.

SECTION ONE: INTRODUCTION

1.1 AUTHORIZATION

The Upper Platte and Beaver Canal Company (UP&B) submitted an application on May 1, 2015 for a grant from the Colorado Water Conservation Board (CWCB) Water Reserve Account for the Upper Platte & Beaver / Deuel & Snyder Feasibility Study. The UP&B was awarded the grant by the CWCB for the feasibility study on September 17, 2015 The UP&B entered into a contract with TZA Water Engineers for the study on October 23, 2015.

1.2 PROJECT GOALS

The existing diversion dam spans the South Platte River and allows UP&B and Deuel & Snyder (D&S) to divert water into their intake structures. The original structure was constructed over 80 years ago and UP& B and D&S have modified and repaired the structure throughout its history to make it useable for both companies. Recent investigations have found problem areas where the shale bedrock has been undermined resulting in structural damage that must be addressed so that the diversion structure does not catastrophically fail, and so that UP&B and D&S can insure efficient operation of their irrigation systems. The work to be performed in this feasibility study consisted of an evaluation of the existing diversion structure and associated diversion components that are owned and operated by both UP&B and D&S. The feasibility study evaluated options to repair and/or upgrade the existing structures as well as options to replace the existing structure with a new diversion dam across the South Platte River.

The goal of this feasibility study is to evaluate the existing structures and determine if it is best to repair/modify the existing structure or if it is best to replace the dam. The design and construction phase that will follow will provide an efficient, safe, diversion structure that will provide benefits for the next 80 plus years. Additional benefits that have been identified for evaluation at this time include, but are not limited to the following:

- Channelization of the South Platte River to minimize flood impacts and ongoing erosion on the north and south banks of the South Platte River at and near the diversion structure
- Bank stabilization
- Protection of existing downstream infrastructure (Morgan County Quality Water, Morgan Heights, etc…)
- Safe operations
- Fish passage structure(s) designed to provide a detour route for migrating native Colorado fish including the Brassy Minnow and Sucker Mouth Minnow

1.3 SCOPE OF WORK

TZA and the UP&B and D&S in cooperation with the Colorado Water Conservation Board (CWCB) developed a detailed scope of services to meet the project goal. The tasks defined by the scope of services are listed below.

Task 1 – Site Survey

- Topographical survey and dam stationing
- River cross-sections
- Base mapping

Task 2 – Visual Inspection

- Site Visit by inspection team
- Report of findings

Task 3 – Geotechnical Investigation

- Drilling test borings
- River bed sampling
- Laboratory testing
- Report

Task 4 – Environmental Evaluation

- Regulatory Permitting Requirements

Task 5 – Hydraulic Modeling

- Hydraulic Model
- River Mechanics

Task 6 – Preliminary Design / Recommendations

- Preliminary Plans
- Cost Estimates
- Report

SECTION TWO: PROJECT BACKGROUND

2.1 LOCATION AND DESCRIPTION

The existing UP&B / D&S diversion dam spans the South Platte River about 2 miles upstream of the State Highway 52 Rainbow Arch Bridge in Morgan County, Colorado. The dam is located at latitude 40 16’ 31.2” N and Longitude 103 50’ 2.7” W in Section 26 and 35 of Township 4 North Range 58 West of the 6th Prime Meridian as shown in Figure 2.1. The dam can be accessed from the north end of Cedar Street near the Town of Log Lane Village. The headworks for the UP&B are located on the south abutment of the dam and the headworks for the D&S are located on the north abutment.

The UP&B / D&S diversion dam is a concrete slab and buttress structure with a height of about 8.8 feet and a length of 1,416 feet. The dam is composed of three sections. The south section is 348 feet in length with the dam axis oriented in a north/south direction. The south section includes a non-overflow section 93 feet in length and an overflow section 255 feet in length. The non-overflow section includes a radial gate 10 feet in width and two large steel flood gates 30 feet in width. There is bay for installation of an additional radial gate that is currently blocked with concrete. The operation deck for the flood gates has an elevation of 4290. The overflow section has a concrete crest elevation of 4278 and wood stop logs to elevation 4280. A concrete walkway spans the buttresses with a deck elevation of 4282. The south section has 20 bays with buttresses spaced approximately 12 feet on center. The north 4 bays have wood stop log gates which extend to the floor slab. The headworks for the UP&B connect to the south end of the south section. The headworks are oriented at an angle of about 135 degrees left of the dam axis and consist of 3 radial gates ten feet in width.

The diagonal section is 765 feet in length with the dam axis oriented northwest at an angle of 45 degrees from the south dam axis. The diagonal dam has an overflow crest elevation of 4280 and includes 48 bays (16 feet between buttress centerlines). There is no walkway and there are no stop log gates in the diagonal section.

The north section is 152 feet in length with the dam axis oriented in a north/south direction. The north section has an overflow crest elevation of 4280 and includes 8 bays with buttresses spaced approximately 16 feet on center and 3 bays with buttresses spaced 8 feet on center. The 3 bays have a concrete crest elevation of 4274.5 and stop logs extend to elevation 4280. There is no walkway in the north section.

The headgate for the D&S is connected to the north section of the diversion dam. The headgate consists of a bladder gate (Obermyer Gate) 10 feet in width.

2.2 DAM GEOMETRIC DATA

The dam geometric data based on NAVD 88 datum are listed below.

Dam	
Type	Concrete Slab and Buttress
Crest Elevation	4280 ft
Toe Elevation	4271.2 ft
Height	8.8 ft
Length	1416 ft
Structure width	18 – 26 ft
Primary Spillway	Two steel slide gates 30 feet in width, sill elevation 4271.2
Sluice Gate	Radial gate 10 feet in width, sill elevation 4271.2
Canal Headworks	
UP&B Structure	Three radial gates 10 feet in width, sill elevation 4274
D&S	Bladder gate (Obermyer) 10 feet in width.

2.3 PROJECT HISTORY

The UP&B has an appropriation date of 1868. A decree dated 1895 established the location of the headgate as follows: “The headgate of the Upper Platte and Beaver Canal is located on the south bank of the South Platte River at a point 4560 feet north, 29 degrees 23 minutes West from the Southeast corner of Section 27, Township 4 North, Range 58 West Morgan County Colorado, and the said Upper Plattes & Beaver Canal runs thence in an easterly direction, being 20 feet wide on the bottom with a grade of 2.11 feet per mile, slope of banks one to one, capable of carrying water three and a half feet in depth.” The remains of the old canal are visible on aerial photography. Debris from the old diversion structure is scattered in the river bed.

The north and south sections of the current diversion dam were constructed in 1936 after the flood of May 1935 (Cherry Creek Storm). The date of construction is imprinted in the south section of the dam. The north and south sections connected to an island located in the center of the river channels. A decree dated September 8, 1948 changed the point of diversion to the location of the new diversion dam and headgate described as follows: “Located at a point, whence the Southeast corner of Section 35, Township 4 North, range 58 West of the 6th Prime Meridian, Morgan County, Colorado, bears south 13 degrees 57 minutes East, 5020.2 feet, being approximately 7680 feet from the original decreed point of diversion”. The estimated location of the original point of diversion, the location of the canal and the current diversion structure are shown in Figure 2.2.

The flood of June 1965 (Plum Creek Storm) washed out the island and allowed the river to bypass the diversion structures. The diagonal section of the dam was designed by Cecil Osborne and constructed in September 1965 to connect the north and south sections of the diversion dam. Since 1965 maintenance activities have been conducted to reduce the seepage under the dam and protect the downstream toe from scour.

Figure 2.1 - Location Map

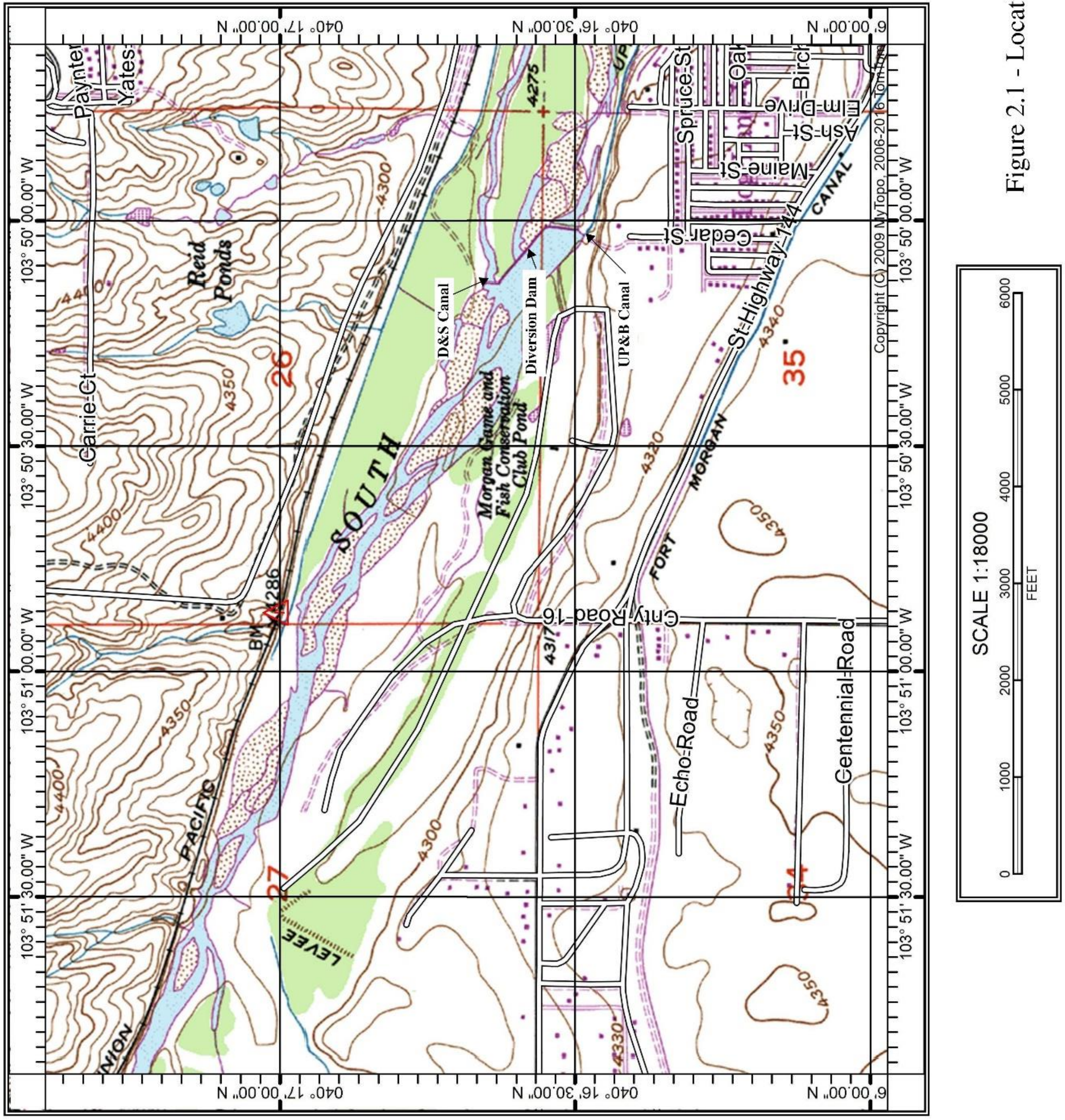


Figure 2.1: Upper Platte & Beaver / Deuel & Snyder Location Map

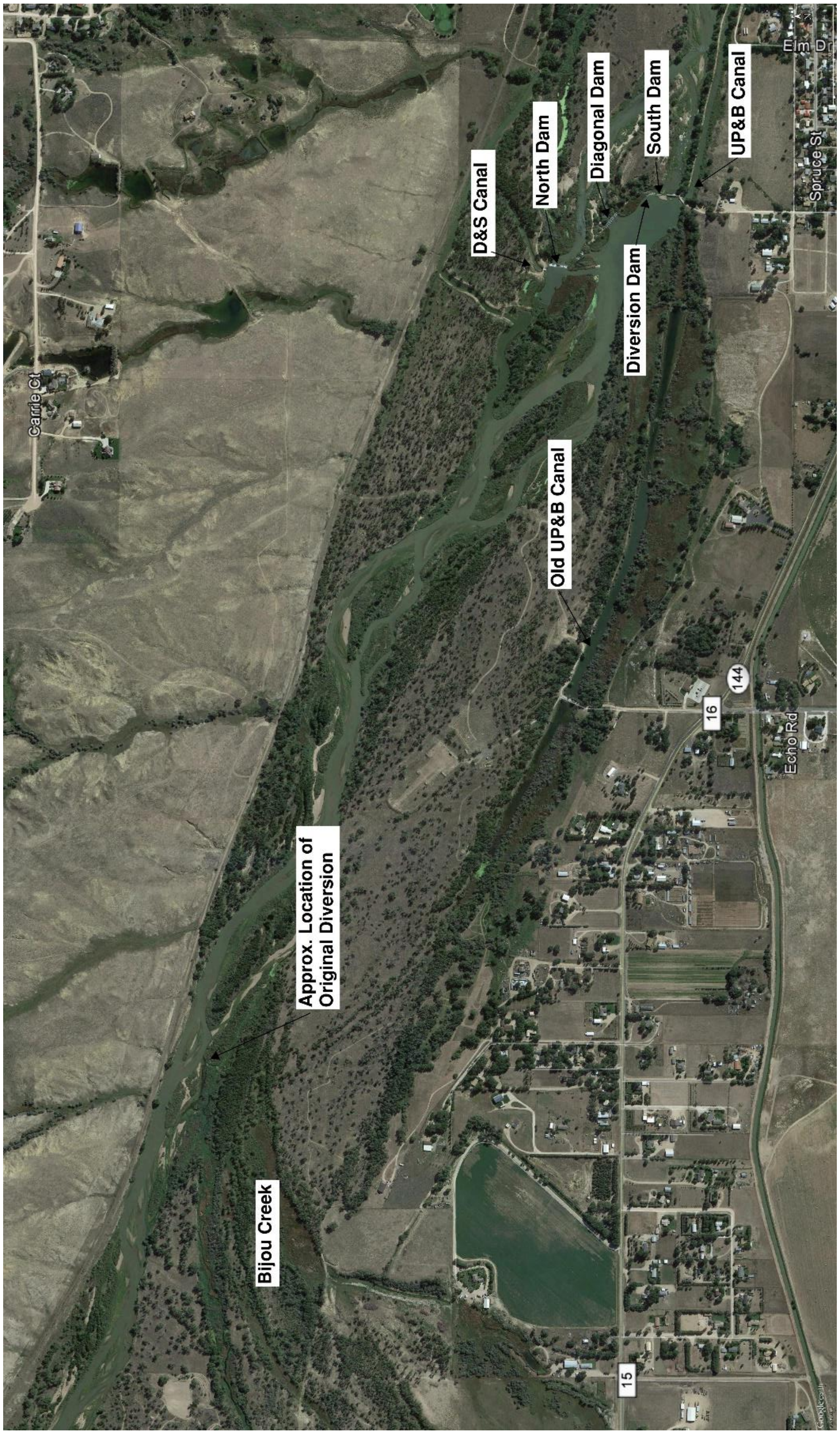


Figure 2.2: Upper Platte & Beaver Site Map

SECTION THREE: TOPOGRAPHIC SURVEY AND MAPPING

3.1 STRUCTURE SURVEY AND STATIONING

TZA coordinated with the Lamp Rynearson, Inc. (LRA) office in Fort Collins, Colorado to perform a topographic field survey of the project site including the existing diversion dam and extending 200 feet downstream of the structure. The survey included the dam abutments, dam crest, upstream toe, downstream toe, buttresses location, size and sill elevation of gates, and adequate spot elevations to define the structure. The dam was stationed from the south bank to the north bank and marked at intervals of 50 feet. The survey conforms to NAD83 horizontal datum (Colorado State Plane) and NAVD 88 vertical datum.

3.2 FLOODPLAIN AND CHANNEL SURVEYS

The original scope included a number of cross-sections of the floodplain for the purpose of HEC-RAS modeling. The cross-sections were not required because a recent HEC-RAS model dated 2010 was obtained from FEMA sources. The FEMA model covered the South Platte River through Morgan County and included cross-sections at intervals of about 2000 feet. The site survey for UP&B included one cross-section of the river channel at the location of the proposed dam for Alternative 2. This cross-section was used to verify the FEMA data and to provide construction quantity information for the new diversion dam.

3.3 BASE MAPPING

The survey was used to develop a base map for preparing the preliminary plans of the proposed alternatives. The base map includes a screened aerial photo, with one foot contours adjacent to the existing dam and spot elevations. The base mapping is included on the Preliminary Plan, sheets 1 through 5 in Appendix A.

SECTION FOUR: VISUAL INSPECTION

4.1 INSPECTION TEAM AND PROCEDURE

A visual inspection of the existing diversion dam was conducted on December 9, 2015. The purpose of the visual inspection was to document the structural and mechanical condition of the dam and appurtenances. The visual inspection team consisted of a civil engineer, structural engineer, geotechnical engineer and hydraulic engineer licensed in Colorado and experienced in dam engineering as well as representatives from the UP&B and D&S. TZA retained Gannett Fleming to provide structural engineering services. RJH Consultants was the subconsultant for geotechnical engineering services. Simons and Associates was the subconsultant for the hydraulics/river mechanics engineering. Prior to the inspection the team met with the UP&B and D&S staff to discuss operational procedures, maintenance practices, problem areas and the history of repairs to the dam. A health and safety plan was prepared for the inspection and a tailgate safety meeting was held to review safety procedures and address specific safety concerns prior to conducting the inspection. The inspection consisted of a visual examination of the components of the dam listed below.

- Abutment: The team examined the abutment sections for depressions, sinkholes, erosion, sloughs, seepage, and erosion protection.
- Concrete Structures: The team examined the crest, upstream face, and downstream face of the concrete structure for alignment, settlement, cracking, leakage spalling, exposed aggregate, exposed rebar, delamination, joints, undermining, and obvious voids as indicated by sounding. Deficiencies were photographed and located by the stationing.
- Mechanical water control equipment: The team examined the gates, stop logs and appurtenances, for wear, corrosion and operational function.
- River conditions: The river flow at the time of the inspection was recorded. River conditions upstream and downstream were observed in regard to sedimentation, scour and the formation of new channels.

4.2 SITE OBSERVATIONS

A letter report was prepared by Gannett Fleming to document the findings of the visual inspection and is included in Appendix B. The findings for each section of the dam are summarized below and proceed from the south end of the dam to the north end. During the inspection photographs were taken to illustrate deficiencies and are included in Appendix B. A field sketch is included in Appendix B to identify the location and orientation of the photographs.

River Conditions

The flow in the South Platte River on December 9, 2015 was 720 CFS as measured at the USGS gage at the State Highway 52 Bridge. Sediment deposition was observed along the upstream face of the dam in the vicinity of the north end of the diagonal section and the north section of the dam. Significant scour was evident downstream of the dam along the entire length of the dam. The scour undermined the concrete structure at many locations as noted below. The UP&B staff noted that a large seep exists under the slab on the north side of the large steel gates. The bedrock exposed below the dam was composed of hard sandstone 6 inches to 12 inches in thickness with soft claystone underneath.

Intake Structure (Headgate) for Upper Platte and Beaver Canal

The inspection of the intake structure to the Upper Platte and Beaver Canal was performed from crest of the structure and the downstream area adjacent to canal. Based on the visual observations during the site visit, the intake structure is considered to be in good condition. There were no significant deterioration or deficiencies noted. However, the canal was not operating, and so these observations do not reflect any issues that may develop due to operation.

Radial Gate and Steel Slide Gates

The inspection of the spillway radial gate and steel slide gates was performed from the crest of the structure, and the downstream river channel. The radial gate was recently installed and is in good condition. The steel slide gates appear to be in satisfactory condition. During the site visit, one gate was open (up position) and releasing water while the other gate was closed (down position).

South Buttress Section

The inspection of the south buttress section was performed from the crest of the structure and the downstream channel. Based on observations taken during the site visit the south buttress section is considered to be poor to unsatisfactory condition, due to the reasons listed below:

- Erosion has undermined the toe of the downstream base slab, as shown in Photo No. 22, and has exposed the shear keys beneath the slab (inset to Photo No. 22). The erosion has reduced the kinematic stability of the section and will need to be repaired.
- Significant concrete deterioration of the buttresses and concrete base slab, as shown in Photo No. 23. The deterioration has led to corrosion of reinforcement steel, and likely reduced the kinematic stability of the structure.
- Concrete deterioration of Walkway Bridge, as shown in Photo No. 24. Repair of the concrete base slab is considered important to restore the kinematic stability of the section. The concrete base slab should be repaired so as to provide protection against foundation erosion, and should include a cutoff wall at the downstream toe to provide protection against undermining erosion. In addition, the concrete buttresses and concrete walkway bridge should be repaired.

Transition to Diagonal Section

The inspection of the transition section was performed from the area downstream of the structure. Based on the visual observations from the site visit, the transition section is considered to be in satisfactory to poor condition. Although there are areas of concrete where deterioration has developed (i.e., along the top of the buttresses and vertical walls and base of the buttresses) it is not considered to be sufficient to reduce the structural capacity.   The poor condition rating is primarily due to the undermining erosion visible beneath the concrete base slab. The undermining needs to be repaired to restore the kinematic stability. The repair should include construction of a cutoff wall at the downstream toe of the base slab to provide protection against undermining erosion.

Diagonal Buttress Section

The inspection of the diagonal buttress section was performed from the downstream river channel, and the downstream concrete slab where accessible. The diagonal buttress section was considered to be unsatisfactory condition due to the following observations:

- There has been significant erosion that has undermined the toe of the concrete base slab. The loss of foundation material beneath the base slab has resulted in the structural failure of the slab is many areas. The failure of slab has likely reduced the kinematic stability of the structure.
- Deteriorated condition of reinforcing steel in concrete slab. The structural failure of the base slab, in conjunction with the undermining erosion, has resulted in significant deterioration of the reinforcement steel. Based on visual observations, it appears that the current condition of the reinforcement steel is inadequate for the base slab. The loss in capacity would result in reduced kinematic stability for the structure.
- Potential deterioration in wall slabs. There were several areas where seepage had developed through the wall slab. The seepage could result in corrosion of the reinforcement steel, which would potentially reduce the structural capacity of the wall slab. Repair of the concrete base slab is considered important to restore the kinematic stability of the section. Repairs to the concrete base slab should be sufficient to protect the foundation against erosion during high flow, or overtopping events. In addition, it is recommended that a cutoff wall be constructed at the downstream toe of the base slab to provide protection against undermining erosion.   Evaluations should be performed to assess the potential effects of reinforcement steel corrosion in the wall slab due to seepage. The evaluations should determine if a potential reduction in structural capacity of the wall slab is a concern for the diversion dam.

North Buttress Section

The inspection of the north buttress section was performed from the right abutment, and the downstream river channel. Based on the visual observations during the site visit, the structure is considered to be in poor condition primarily due to the following reasons:

- Erosion has undermined the toe of the downstream base slab. The undermining has reduced the kinematic (i.e., overturning or sliding) stability of the section, which is directly related to the condition of the concrete base slab on the foundation.
- Concrete deterioration of the downstream base slab. The deterioration may provide a path for water to flow to the foundation, and potentially contribute to the erosion. Repair of the concrete base slab is considered important to restore the kinematic stability of the section. The concrete base slab should be repaired so as to provide protection against foundation erosion. In addition, it is recommended that a cutoff wall be constructed at the downstream toe of the base slab to provide protection against undermining erosion.

Headgate Structure for Duel and Snyder Canal

The inspection of the headgate structure was performed from the crest of the structure. The intake has no visual signs of deterioration or deficiencies and was considered to be in good to satisfactory condition.

SECTION FIVE: GEOTECHNICAL INVESTIGATION

5.1 FIELD INVESTIGATIONS

TZA met with Olson Engineering and RJH Consultants (RJH) regarding the geotechnical investigation that would best evaluate the subsurface and foundation conditions. The approach selected was to perform a geophysical seismic survey to provide a river wide profile of the bedrock surface and general formation thickness. Test borings would be used to calibrate the seismic data, define the formation characteristics and determine specific soil/rock properties. The geophysical survey was performed on December 3, 4, 2015 near the alignment for the new diversion dam. The work was conducted prior to the visual inspection so that the preliminary results of the survey could be used to define the program for the drilling and testing. The locations for five test borings were selected based on the results of the geophysical survey. Three test borings were located along the alignment for the new dam and two borings were located downstream of the existing dam. Figure 3.1 shows the location of the geophysical survey and the borings. The procedure and findings for the investigations are summarized from the reports by the sub-consultants in the following sections. The complete reports are included in Appendix C and D.

5.2 GEOPHYSICAL SURVEY

TZA retained Olson Engineering, Inc. (Olson) to perform the geophysical seismic survey at the UP&B / Deuel &Snyder diversion dam. The objectives of the investigation were to determine the thickness of unconsolidated alluvial sediments overlying the shale bedrock, and to determine the lateral and vertical variability of the shale bedrock. A total of six seismic lines, totaling 1,860 linear feet of geophysical coverage, were collected. Field work was conducted December 3rd and 4th, 2015. The following sections presents results from the investigation and summarizes the site conditions, data acquisition, processing procedures, and interpretation approach.

Site Conditions

The site ranged from minimally- to heavily-vegetated. The terrain was generally mild/rolling except for the dam crossing between Lines 3 and 5. The South Platte River was being drained/diverted such that the river channel was flowing between Lines 1 and 6 at the time of the investigation. The recent lowering of the water level combined with recent precipitation made large portions of site very muddy and difficult to traverse. The general geologic composition at the site is overburden on bedrock. The overburden is comprised primarily of sandy alluvium. Bedrock at the site is generally flat-lying sandstone, claystone and/or siltstone.

Method

In a Seismic Refraction Tomography (SRT) survey, an impulse (shot) is imparted to the ground (e.g., via a sledge hammer) and the seismic waves generated by the impulse are detected along an array of receivers (geophones). The propagation of seismic waves is governed by the stiffness of the soils or the hardness of rock formations. The variability of the soil deposits can be mapped laterally, and depth to competent bedrock can be imaged, with a modeling process called tomographic inversion. For this project, P-wave energy was used for the analysis.

Data Acquisition

Seismic data were acquired using Geometrics Geode 24-channel seismographs with up to forty-eight 4.5 Hz vertical component geophones spaced at a 10 foot interval. Shot points were located every 30 feet. A sledge hammer impacting a plastic strike plate was used to generate seismic energy. The six seismic lines were positioned and oriented in the field based on recommendations of TZA personnel and accessibility/safety constraints.

Data Processing

The refraction data from this project were processed using Rayfract, version 3.33, by Intelligent Resources, Inc.

Results and Discussion

The 2D interpretive geophysical results for the SRT lines are presented in Figure 5.1 of this report. The velocity profiles are presented with ‘cool’ colors (e.g., blue) representing lower velocity values and ‘warm’ colors (e.g., red) representing higher velocity values. The horizontal (distance) and vertical (elevation) dimensions (as measured by GPS) are shown in feet, at 2x vertical exaggeration. In the lower left corner of the figure is a location map showing the seismic lines. Lithologic logs from the boreholes, provided to Olson by RJH, are overlain on the profiles at their approximate horizontally-projected positions along each line. Elevation data for the boreholes were provided by TZA. The results are interpreted based on velocity gradient analysis and correlation to the borehole logs. A high velocity gradient is indicated by a rapid change in seismic velocity over a short depth range. Velocity gradients are indicative of transitions to harder layers, although not necessarily indicative of geologically distinct layering. It is important to note that refraction tomography will always produce a gradient at a velocity transition or geologic/layer interface, no matter how sharp the interface is physically. The profiles have been annotated to highlight two interpretive velocity contours; the dashed line represents a velocity of approximately 4,000 feet per second (ft/s), and the solid line represents a velocity of approximately 6,000 ft/s. On the south side of the river the 4,000 ft/s contour correlates well with the top of the upper soft bedrock layer, and the 6,000 ft/s contour correlates with depth of the thin hard sandstone layer. On the north side of the river the 4,000 ft/s contour again correlates with the top of bedrock and the 6,000 ft/s contour does not appear to correlate to any geologic interfaces encountered by the boreholes.

5.3 TEST BORINGS, SAMPLING AND LABORATORY TESTING

TZA retained RJH Consultants (RJH) to perform the geotechnical subsurface investigation at the UP&B / D&S diversion dam. The subsurface conditions at the Site were evaluated by drilling boreholes, collecting shallow samples, and performing laboratory testing on selected samples. RJH advanced a total of five boreholes for this exploration program: Two boreholes were located along the existing structure and three were located along an alignment for a proposed new structure, which is generally upstream of the existing structure. RJH collected alluvium samples at three locations along the River upstream of the structure. The locations of the subsurface explorations are shown on Figure 5.2. The purpose of the investigation was to provide data for the preliminary design of Alternative 1 – Rehabilitate the Existing Diversion Dam and Alternative 2 – New Diversion Dam. The Geotechnical Data Report by RJH is attached as Appendix D. The following sections summarize the investigations and findings conducted by RJH.

Regional Geology

The Site is located within the Great Plains Physiographic Province, which is characterized by broad gently east sloping uplands dissected by generally east flowing streams that form broad, shallow, steep sided valleys (Hunt, 1967). Bedrock within the Great Plains province consists of relatively flat-lying Mesozoic and Cenozoic formations (less than 254 million years old). The Site is situated along the River, a major drainage within the Great Plains province. The geologic units identified at the Site consisted of colluvium, alluvium, and bedrock of the Upper Transition Member of the Pierre Shale (Pierre Shale). Colluvium and alluvium were Holocene-age (younger than approximately 10,000 years) and the Pierre Shale was Cretaceous age (between 145 million and 65 million years old).

Test Borings

RJH engaged Elite Drilling Services (Elite) of Denver, Colorado to advance five boreholes between December 21 and 29, 2015. Elite utilized a buggy-mounted drill rig and advanced boreholes through surficial soils and into the top of bedrock using hollow-stem augers. Within bedrock, boreholes were generally advanced with continuous wireline coring. A summary of the exploratory drilling program is provided in Table 5.1

Table 5.1: Summary of RJH Subsurface Investigations

Investigation Location	Northing(1) (ft)	Easting(1) (ft)	Ground Surface Elevation(2) (ft)	Depth to Bedrock (ft)	Depth to Groundwater (ft)	Total Depth (ft)
B-101	1347687.9(3)	3464904.9(3)	4274.8(3)	4.5	6.0	21.0
B-102	1347981.7(3)	3464497.0(3)	4269.7(3)	0.0	0.9	15.6
B-103	1348420.0(3)	3464402.3(3)	4286.0(3)	17.0	9.3	23.5
B-104	1347720(4)	3464390(4)	4277.5(3,5)	8.0	0.8	25.5
B-105	1347128.3(3)	3464394.0(3)	4293.8(3)	10.0	4.0	27.0
SS-101	1350810(4)	3457830(4)	4287(6)	N/E	0.0	1.0
SS-102	1349640(4)	3461090(4)	4285(6)	N/E	0.3	1.0
SS-103	1348800(4)	3463170(4)	4283(6)	N/E	0.3	1.0

Notes:

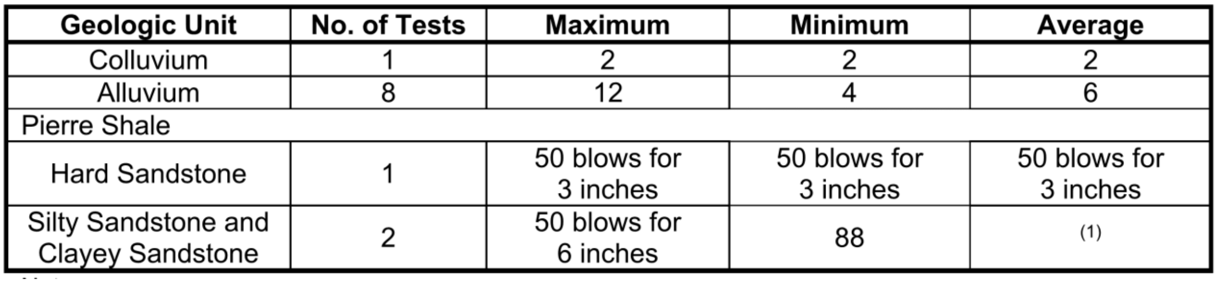
1. The horizontal coordinate system is Colorado Northern State Plan.
2. The vertical datum is NAVD 88.
3. Survey data provided by TZA.
4. Coordinates measured in the field by hand-held GPS unit accurate to about 10 feet.
5. Boring location was submerged at time of survey. The elevation was surveyed at the closest point on the bank.
6. Elevations estimated from River elevation in Google Earth Pro.
7. N/E signifies not encountered.

Samples of surficial soils were collected ahead of the augers at approximately 5.0-foot intervals. A sample was also collected at the top of bedrock. An RJH engineer observed drilling procedures, visually classified soil and rock samples, prepared a field log of each borehole, photographed recovered samples, and observed and recorded relevant drilling information. Collected soil samples were classified in the field in general accordance with ASTM D 2488 (visual-manual classification). Soil classifications and field borehole logs were reviewed by an experienced geotechnical engineer for quality control. Final logs are included in Appendix D. Photographs of selected samples and selected site photographs are provided in Appendix D.

Field Testing

Within the boreholes, Standard Penetration Tests (SPTs) were performed using the standard split-spoon sampler in general accordance with ASTM D 1586. The hammer blows required to advance the sampler 6 inches were recorded on the borehole logs and uncorrected N values were developed by summing the blows required to advance the sampler beyond the first 6-inch interval. A summary of the SPT results is presented in Table 5.2.

Table 5.2: Uncorrected N Values



Geologic Unit	No. of Tests	Maximum	Minimum	Average
Colluvium	1	2	2	2
Alluvium	8	12	4	6
Pierre Shale				
Hard Sandstone	1	50 blows for 3 inches	50 blows for 3 inches	50 blows for 3 inches
Silty Sandstone and Clayey Sandstone	2	50 blows for 6 inches	88	(1)

Note:

1. An average N-value is not applicable because one test reached refusal before the sampler was driven 18 inches

South Platte River Alluvium Samples

RJH collected shallow samples of alluvium at three locations as requested by Bob Simons of Simons and Associates (Figure 5.2). Three general sample locations were selected to be roughly equally spaced between the existing structure and the confluence between the River and Bijou Creek, which is about 1.5 miles upstream of the existing structure. Specific sample locations were generally selected on sandbars adjacent to the River channel. Generally, sandy material was selected; areas with fine grained deposits or areas with gravel armoring were not sampled. However, sample SS-101 was collected from alluvium submerged by less than 4 inches of water immediately downstream of a concrete foundation of an old diversion structure because no sand bars were accessible in that reach of the River on the day of sampling. Approximately 30 to 50 pounds of sample was collected from the top 1 foot of alluvium at each location using a hand shovel. Material descriptions were developed for each sample as described in the section on Test Borings.

Laboratory Testing

RJH conducted the following laboratory tests on samples obtained during the subsurface investigation. The results of the testing are summarized in Table 5.3. A complete description of the test method and results is included in Appendix D.

- Index Testing: Index tests were performed on samples of alluvium and bedrock. The moisture content tests were used to evaluate the in-situ water content of the soil or rock sample. Dry density tests were used to measure the in-situ density of the soil or rock sample. Grainsize analyses (including minus No. 200 sieve tests) provided data on the individual particle sizes of the soil or rock samples and the distribution of these particle sizes. Atterberg limits tests approximated the relationship between the moisture content of a soil or bedrock sample and its liquid and plastic behaviors. The results of all of the laboratory testing is included in Appendix D. The following index tests were performed:

  - Eleven moisture content tests (ASTM D 2216)
  - Eleven dry unit weight tests (ASTM D 2937)
  - Seven Atterberg limit 5 point tests (ASTM D 4318)
  - Five minus No. 200 sieve analysis (ASTM D 1140)
  - Four grain-size analysis (ASTM D 6913)

- Consolidation Testing: Two consolidation tests were performed on samples of bedrock in general accordance with Method B of ASTM D 4546. Consolidation testing was used to evaluate the potential for the foundation to swell or consolidate when saturated and loaded by the overlying structure.

- Strength Testing: Three unconfined compressive strength tests with stress-strain curves were performed on selected bedrock samples in general accordance with ASTM D 2166 (soft rock and soil) and one unconfined compressive strength test was performed in general accordance with ASTM D 7012, Method C (hard rock). Unconfined compressive strength tests were used to evaluate the compressive strength of a rock sample without the confining stresses that would be present in-situ. Three consolidated undrained triaxial shear strength tests were performed on samples of bedrock in general accordance with ASTM D 4767. Triaxial shear strength tests were used to evaluate the shear strength of a rock or soil sample with varying confining stresses.

- Corrosivity tests: A suite of soil corrosivity tests were performed on a sample of bedrock. Corrosivity tests can be used to evaluate the potential for corrosion of concrete or steel structures and components that would be in contact with the bedrock.

Table 5.3: Summary of Index, Consolidation, and Strength Laboratory Test Results

Boring/ Test Pit ID	Sample ID	Sample Depth Interval (ft)	General Material Description	Natural Moisture Content (%)	Dry Unit Weight (pcf)	Gradation			Atterberg Limits		Swell/Consolidation (-) = Collapse Consolidation (%)	Unconfined Compressive Strength (psf)	Effective Strength		Total Strength	
						% Gravel (>No. 4)	% Sand (No. 4 to No. 200)	% Fines (>No. 200)	Liquid Limit (%)	Plasticity Index (%)			φ' (deg)	c' (psf)	φ (deg)	c (psf)
Alluvium																
SS-101	Bu-1 A & B	0.0 - 1.0	Poorly Graded Sand			6.3	90.9	2.8								
SS-102	Bu-1 A & B	0.0 - 1.0	Poorly Graded Sand with Gravel			28.3	71.4	0.3								
SS-103	Bu-1 A & B	0.0 - 1.0	Poorly Graded Sand			4.4	95.1	0.5								
B-104	Bu-4	0.0 - 8.0	Poorly Graded Sand with Gravel			27.4	71.6	1.0								
Pierre Shale																
B-102	HQ-1	2.0 - 2.9	Sandy Claystone	16.3(2)	115.4(2)			52.7	40	25		61,573				
B-102	HQ-3	5.6-6.5	Sandy Claystone	16.9	115.4			68.6	37	19						
B-102	HQ-3	9.7-10.6	Sandy Claystone	16.2(1) 15.9(2)	114.8(1) 116.8(2)				38	23	0.00	73,607				
B-102	HQ-4	14.8-15.6	Sandy Claystone	16.3	116.5				41	26						
B-104	HQ-1	9.8 - 10.5	Sandstone	5.7	151.0							835,200				
B-104	HQ-4	18.5 - 19.1	Sandy Claystone	16.6(3)	114.8(3)								39	0	69	8,800
B-104	HQ-4	19.1 - 19.7	Sandy Claystone	16.2(3)	116.0(3)											
B-104	HQ-4	19.7 - 20.5	Sandy Claystone	17.0(3)	115.2(3)			79.3	38	22						
B-104	HQ-5	21.4-22.0	Sandy Claystone	16.6(1)	114.9(1)			74.3	41	26	-0.02					
B-105	HQ-2	17.2 - 17.9	Clayey Sandstone	17.5(2)	112.9(2)			42.7	35	17		35,956				

Notes:

1. Moisture and dry density values from swell/consolidation test results.
2. Moisture and dry density values from unconfined compressive strength test results.
3. Moisture and dry density values from triaxial shear test results.

5.4 SUBSURFACE CONDITIONS

The information in this section is based on the results of the subsurface investigations conducted by RJH, laboratory testing, and the geophysical investigation conducted by Olson. The stratigraphy generally consisted of alluvium overlying bedrock of the Pierre Shale. Colluvium was also identified on the slope south of the River.

Colluvium

Colluvium was identified at the ground surface on the slope south of the River in borehole B-105. The thickness was about 2.8 feet. Colluvium consisted of poorly graded sand with clay and the Unified Soil Classification System (USCS) group symbol was SP-SC. Sand content ranged from 85 to 95 percent and fines contents ranged from 5 to 15 percent. The plasticity ranged from low to medium plasticity. The density was very loose based on one SPT test, with an N-value of 2. The moisture content was moist. No laboratory testing was performed on samples of colluvium.

Alluvium

Alluvium was identified at the ground surface in the River channel and north of the River channel and below colluvium south of the River channel. Alluvium was identified in all borings and shallow sample locations except borehole B-102, where bedrock was identified at the ground surface. In the boreholes where the full thickness of the alluvium was penetrated, the thickness ranged from 4.5 to 17.0 feet and averaged 9.2 feet. Alluvium in the River channel (borings B-101, B-102, and B-104 and shallow samples SS-101, SS-102, and SS-103) consisted of poorly graded sand, poorly graded sand with gravel, poorly graded sand with silt, and silt with sand. The USCS group symbols were SP, SP-SM, and ML. Outside the River channel (borings B-103 and B-105), alluvium consisted of well-graded sand, poorly graded sand with clay, clayey sand, well graded gravel with sand, well graded sand with silt and gravel, and well graded sand with clay. The USCS group symbols were SW, SP-SC, SC, GW, SW-SM, and SW-SC. Gravel contents ranged from 0 to 70 percent but were typically less than 15 percent, sand contents ranged from 30 to 95 percent, and fines content ranged from 0 to 70 percent, but were typically less than 15 percent. The plasticity ranged from non-plastic to low plasticity and was typically non-plastic to low plasticity. The density ranged from very loose to medium dense and was typically very loose to loose. SPT N-values ranged from4 to 12 and averaged 6. The moisture content ranged from dry to wet and was typically moist to wet. Grain-size analyses were performed on four samples of alluvium collected adjacent to the River in shallow sample locations SS-101, SS-102, and SS-103, and borehole B-104. These samples classified as poorly graded sand and poorly graded sand with gravel with fines content ranging from 0.3 to 2.8 percent.

Pierre Shale

Pierre Shale was identified below alluvium in all borings except B-102 where it was identified at the ground surface. Bedrock was not encountered at the shallow sample locations. The depth to the top of bedrock ranged from 0.0 to 17.0 feet. The approximate elevation of the top of bedrock ranged from El. 4269.0 to El. 4283.8, but was generally between El. 4269.0 and El. 4270.3. The full thickness of the Pierre Shale was not penetrated during this investigation; however, published mapping reports a thickness of up to about 6,000 feet (Scott, 1978).

Rock types identified within the Pierre Shale are described in two groups, hard sandstone and soft rock. Hard sandstone was identified at the top of bedrock in borings B-101, B-102 and B-103 and below 1.7 and 12.0 feet of soft rock in borings B-104 and B-105, respectively. The elevation of the top of the hard sandstone layer was relatively consistent across the site ranging from about El. 4267.8 to El. 4271.8. The sand contents of the hard sandstone ranged from 80 to 100 percent and the fines contents ranged from 0 to 20 percent. The plasticity ranged from non-plastic to low plasticity. The degree of weathering in the recovered samples ranged from fresh to moderately weathered and the degree of fracturing ranged from unfractured to intensely fractured. however, the degree of fracturing ranged from slightly to very slightly fractured in outcrops at various locations along the downstream toe of the existing structure. The hardness ranged from hard to moderately hard. Augering through approximately 1 foot of hard sandstone required about 15 minutes. The moisture content ranged from dry to moist. The moisture content of one sample of the hard sandstone was 5.7 percent and the dry unit weight was 151.0 pounds per cubic foot (pcf). The unconfined compressive strength of one sample of the hard sandstone was 835,200 psf.

The second group of rock types within the Pierre Shale consisted of soft sandy claystone, clayey sandstone, and silty sandstone and is referred to as soft rock. Soft rock was identified below the hard sandstone in all borings and above the hard sandstone in borings B-104 and B-105. The thickness of the soft rock above the hard sandstone was from 1.7 to 12 feet. The sand contents of soft rock ranged from 20 to 80 percent and the fines content ranged from 20 to 80 percent. The plasticity ranged from non-plastic to medium plasticity and typically ranged from low to medium plasticity. The degree of weathering ranged from fresh to intensely weathered and the degree of fracturing ranged from slightly to moderately fractured. The hardness ranged from soft to very soft. Advancing the augers through 5 feet of soft rock required 1 to 2 minutes. The moisture content ranged from moist to wet. The moisture content of ten samples of soft rock that were tested ranged from 15.9 to 17.5 percent and averaged 16.6 percent. The dry unit weight of the same samples ranged from 112.9 to 116.8 pcf and averaged 115.3 pcf. The liquid limit of seven samples ranged from 35 to 41 and averaged 39. The plasticity index ranged from 17 to 26 and average 23.

In general, a 2- to 4-foot-thick weathered zone existed at the top of the soft rock. Weathered soft rock was commonly poorly cemented and slightly to intensely weathered. The soft rock below the weathered zone was better cemented and the degree of weathering ranged from fresh to slightly weathered. Soft rock within the weathered zone could generally be crumbled relatively easily between thumb and finger. The rock below the weathered zone required significant effort to crumble with thumb and finger and at times required a rock hammer to break. Consolidation and strength testing were performed on samples collected below the weathered zone.

Two samples of sandy claystone exhibited 0.00 and 0.02 percent consolidation after the samples were saturated under 5,000 psf of vertical stress. The unconfined compressive strength of two samples of sandy claystone were 61,573 and 73,607 psf. The unconfined compressive strength of one sample of clayey sandstone was 35,956 psf.

Three consolidated undrained triaxial shear strength tests were performed on samples of sandy claystone at confining stresses of 800, 1,800, and 3,800 psf. The drained strength was an effective friction angle of 39 degrees with 0 psf of effective cohesion. The undrained strength was a friction angle of 69 degrees with 8,800 psf of cohesion.

Groundwater

Groundwater was encountered in all boreholes and shallow sample locations. Water levels were estimated based on retrieval of samples that appeared to have free water through the sample. The depth to groundwater within the River channel ranged from about 0.0 to 6.0 feet below the ground surface (bgs) and was typically less than 1.0 foot bgs. Outside the River channel, groundwater was encountered about 4.0 and 9.3 feet bgs.

5.5 RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

This geotechnical investigation provides information for the preliminary design to assist in evaluation of the alternatives. Additional drilling, testing, and analysis would be necessary for detailed design of the selected alternative. RJH recommends the following additional geotechnical investigation based on their geotechnical and dam design experience:

- Perform a detailed survey of the UP&B and D&S property on the right and left abutments, which may be used as borrow and/or staging areas.
- Advance additional borings along the proposed embankment alignment to a depth of at least 15 feet below the hard sandstone.
- Perform water pressure tests (Packer tests) within bedrock to characterize the foundation permeability.

- Perform erodibility and dispersivity testing on the bedrock foundation.
- Advance borings and excavate test pits within UP&B property above the right abutment to evaluate quantity and suitability of potential embankment fill borrow material.
- Collect additional bulk samples of alluvium within the River channel to evaluate suitability for potential filter and drain borrow material.
- Perform index, compaction, strength, and permeability testing of potential embankment fill borrow materials.

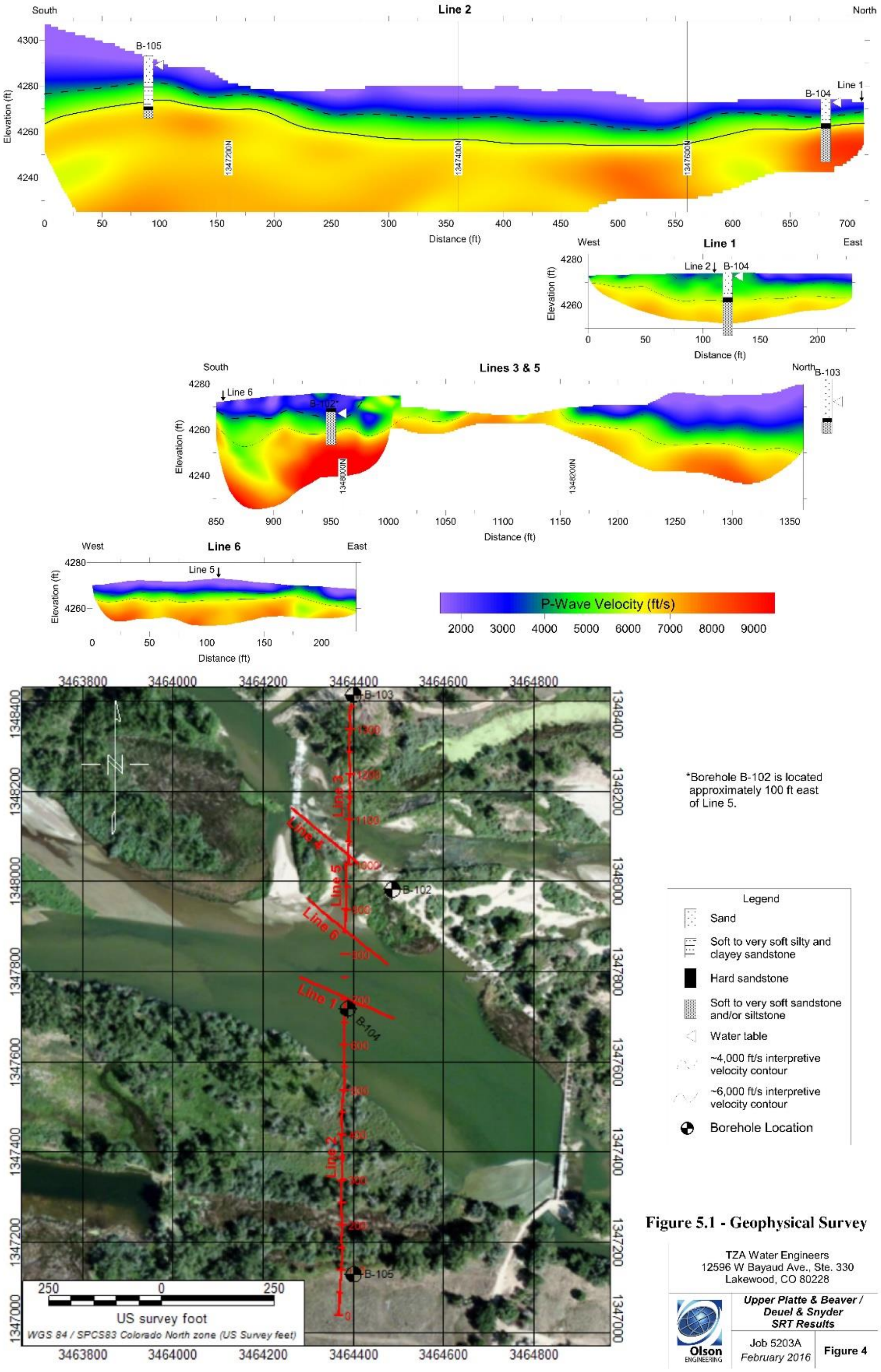


Figure 5.1: Geophysical Survey

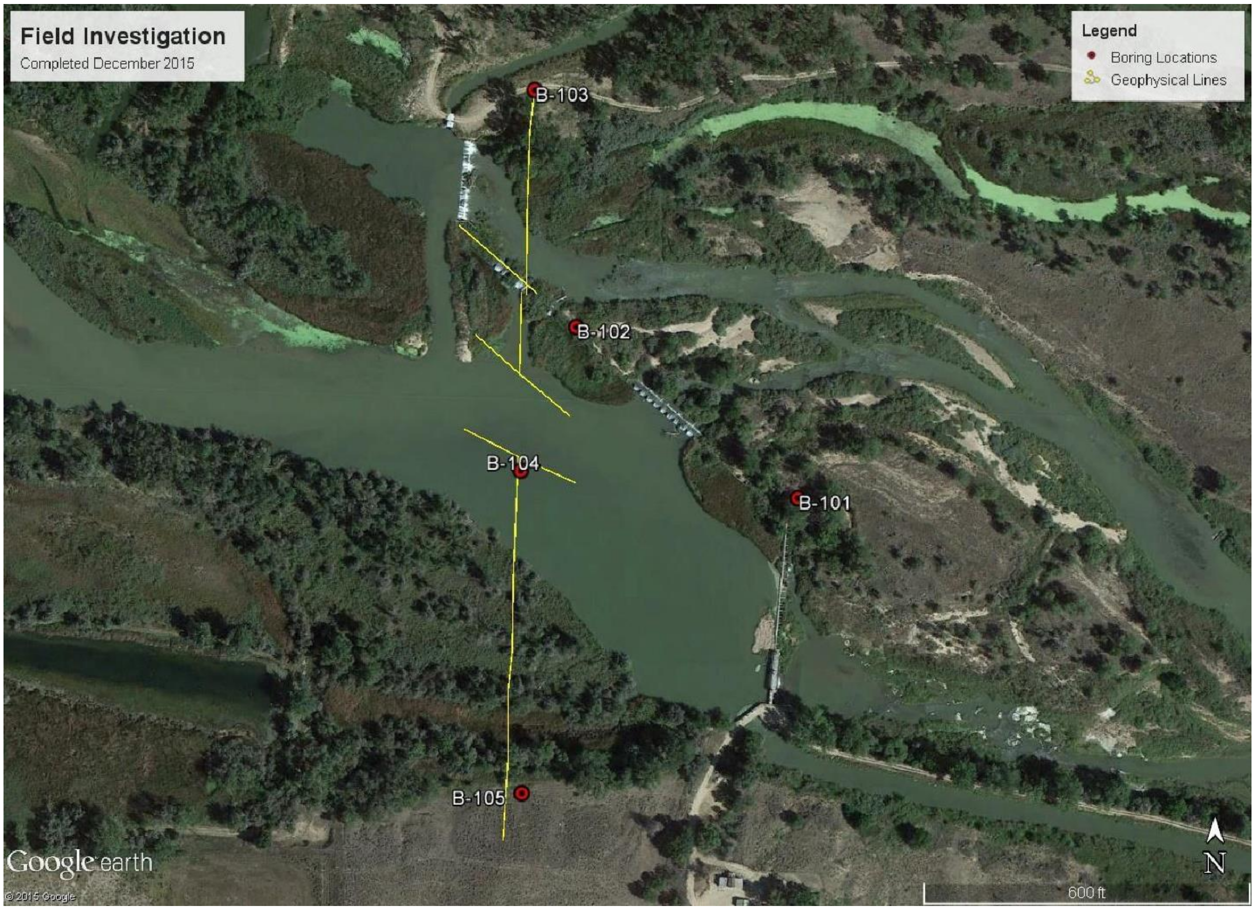


Figure 5.2: Geotechnical Investigation - Location of Borings

SECTION SIX: ENVIRONMENTAL EVALUATION

6.1 INTRODUCTION

TZA Water Engineers, Inc. retained ERO Resources Corporation (ERO) to conduct an environmental evaluation of the Upper Platte & Beaver / Deuel & Snyder project site to determine the environmental regulatory permitting requirements for the proposed alternatives identified in the feasibility study. The natural resource/environmental agencies with regulatory authority over the potential improvements were investigated and the permitting requirements, costs, and timing for regulatory approval identified. Wetlands identification and mapping at the location of the proposed alternatives was not included at this time since it has been determined that a Section 404 permit will not be required. The sections below summarize the evaluation of ERO regarding natural resources in the study area, the potential effects each alternative may have on natural resources, Endangered Species Act and/or Historic Preservation Act compliance and the Clean Water Act Section 404 regulations.

6.2 PROJECT AREA CONDITIONS

The project area is along the South Platte River near Fort Morgan, Colorado. The South Platte River is between 700 and 800 feet wide in the project area, with a wide adjacent riparian corridor. Potential wetlands occur along the banks of the South Platte River, within an existing island along the South Platte River, and along the riparian corridor where old irrigation ditches or side channels occur. In 2013, a major flood occurred along the South Platte River which caused extensive sedimentation upstream of the diversion structure and scouring downstream of the diversion structure. The South Platte River is considered a Traditional Navigable Water and under the jurisdiction of the U.S. Army Corps of Engineers (Corps). The wetlands abutting and/or adjacent to the South Platte River would also be considered jurisdictional by the Corps.

6.3 REGULATORY BACKGROUND

The Clean Water Act (CWA) protects the physical, biological, and chemical integrity of waters of the U.S. The Corps Regulatory Program administers and enforces Section 404 of the CWA. Under Section 404, a Corps permit is required for the discharge of dredged or fill material into wetlands and other waters of the U.S., unless the activity is considered exempt, as described below. The Corps defines waters of the U.S. as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters. The Federal regulation 33 USC 1344, Part 323.4 (a)(3) includes an exemption that states construction of diversion structures that are considered functionally related to irrigation ditches are exempt from Clean Water Act permitting requirements. The applicable section of 33 USC 1344 is listed below. The text relating to the diversion structure has been highlighted with bold font:

Section 323.4 - Discharges not requiring permits.

(a) General. Except as specified in paragraphs (b) and (c) of this section, any discharge of dredged or fill material that may result from any of the following activities is not prohibited by or otherwise subject to regulation under section 404:

(1) omitted

(2) Maintenance, including emergency reconstruction of recently damaged parts, of currently serviceable structures such as dikes, dams, levees, groins, riprap, breakwaters, causeways, bridge abutments or approaches, and transportation structures. Maintenance does not include any modification that changes the character, scope, or size of the original fill design. Emergency reconstruction must occur within a reasonable period of time after damage occurs in order to qualify for this exemption.

(3) Construction or maintenance of farm or stock ponds or irrigation ditches, or the maintenance (but not construction) of drainage ditches. **Discharges associated with siphons, pumps, headgates, wingwalls, weirs, diversion structures, and such other facilities as are appurtenant and functionally related to irrigation ditches are included in this exemption.**

6.4 REGULATORY REQUIREMENTS FOR PROPOSED ALTERNATIVES

On December 9, 2015, the project team met with Angelle Greer, a representative from the Corps Denver Regulatory office to discuss potential 404 permitting requirements for the project alternatives. The Corps representative did discuss 33 USC 1344, Part 323.4 (a)(2) regarding maintenance of an existing structure. The Corps representative indicated that if the proposed repair activities to the existing structure were completed within the existing footprint and with in-kind materials, they would qualify to fit under the 33 USC 1344, Part 323.4 (a)(2) exemption for maintenance activities to existing structures. However, the proposed alternatives would extend the footprint of the existing structure and include materials not currently present along the structure; therefore, as the alternatives are currently proposed, the maintenance exemption would not apply to either alternative.

ERO contacted the Corps after the concept design of the alternatives was completed to discuss the applicability of 33 USC 1344, Part 323.4 (a)(3). The Corps has indicated that both alternatives would fall under this exemption if the Upper Platte & Beaver Irrigation Company and the Deuel & Snyder Irrigation Company can demonstrate that at least 50% of the water in the irrigation ditches are for agricultural use. Therefore, a Section 404 permit for the proposed project would not be required. Once an alternative is chosen, ERO recommends submitting a letter to the Corps to verify the proposed activities would fall under the exemption and a Section 404 permit would not be required.

6.5 FEDERALLY THREATENED AND ENDANGERED SPECIES

ERO completed a desktop analysis for suitable habitat for federally listed threatened and endangered species protected under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA). Several species are listed as potentially occurring in Morgan County, Colorado (Table 6.1).

Table 6.1: Federally listed threatened and endangered species protected under the Endangered Species Act

Common Name	Scientific Name	Status*	Habitat	Potential Habitat Present or Effects Anticipated?
Mammals				
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	T	Shrub riparian/wet meadows	Yes
Birds				
Interior least tern**	*Sterna antillarum athalassos*	E	Sandy/pebble beaches on lakes, reservoirs, and rivers	Yes
Piping plover**	*Charadrius melodus*	T	Sandy lakeshore beaches and river sandbars	Yes
Whooping crane**	*Grus americana*	E	Mudflats around reservoirs and in agricultural areas	Yes
Fish				
Pallid sturgeon**	*Scaphirhynchus albus*	E	Large, turbid, free-flowing rivers with a strong current and gravel or sandy substrate	Yes
Plants				
Ute ladies'-tresses orchid	*Spiranthes diluvialis*	T	Moist to wet alluvial meadows, floodplains of perennial streams, and around springs and lakes below 6,500 feet in elevation	Yes
Western prairie fringed orchid**	*Platanthera praeclara*	T	Moist to wet prairies and meadows	Yes

*T = Federally Threatened Species, E = Federally Endangered Species.

**Water depletions in the South Platte River may affect the species and/or critical habitat in downstream reaches in other counties or states.

Source: Service 2016.

6.6 RECOMMENDATIONS AND PERMITTING REQUIREMENTS

The project area does contain potential habitat for Preble's meadow jumping mouse (Preble's), however several trapping surveys have been completed nearby with no Preble's found. In addition, the project area is several miles away from the nearest known population. Based on these reasons, it may be unlikely Preble's are present in the project area. The project area also contains potential habitat for Ute ladies'-tresses orchid (ULTO), however no ULTO populations have been found in Morgan County. ERO recommends completing a habitat assessment for both species if any activities are proposed within the wetland/riparian areas in the project area. The interior least tern, piping plover, whooping crane, pallid sturgeon, and western prairie fringed orchid are species that are affected by continued or ongoing water depletions to the Platte River system. The irrigation ditches would be considered a depletion to the South Platte River that would affect these species. Consultation regarding depletions would only be required if a Section 404 permit is required for the proposed project. Therefore, because the project would fall under the agricultural exemption and a Section 404 permit would not be required, consultation regarding these species would not be necessary.

The State of Colorado has set up the South Platte Water Related Activities Program (SPWRAP) to implement the Platte River Recovery Implementation Program (PRRIP) and mitigate for effects to these species from depletions under its members. If the Corpsdetermines a Section 404 permit is required and formal consultation with the Service is required for depletions, the Upper Platte & Beaver Irrigation Company and the Deuel & Snyder Irrigation Company would be required to become members of SPWRAP. A streamlined Biological Assessment would be required to be submitted to the Service as part of the Section 404 permit. The consultation with the Service would take approximately 3 to 6 months.

6.7 CULTURAL AND HISTORIC RESOURCES

Cultural and historic resources are protected under Section 106 of the National Historic Preservation Act (NHPA) when any project has a federal nexus. Because the project would fall under the agricultural exemption and is unlikely to have a federal nexus such as a Section 404 permit, consultation regarding cultural and historic resources would not be required. If the Corps determines a Section 404 permit is required for the proposed project, the Corps is required to comply with Section 106 of the NHPA. If a Section 404 permit is required, ERO recommends completing a cultural database search for cultural or historic resources and discussing with the Corps if a Class III survey would be required. If the existing structure is determined to be a historic resource or any other cultural or historic resources are identified in the project area that would be impacted by the project, consultation with the State Historic Preservation Office (SHPO) would be required. Consultation with SHPO would take approximately 4 to 8 months.

SECTION SEVEN: HYDRAULIC MODELING

7.1 PURPOSE AND SCOPE

TZA developed a hydraulic model of the South Platte River using an existing FEMA HECRAS model for Morgan County Colorado dated January 2010. The model was used to evaluate the hydraulics of the diversion structure alternatives during normal flows and flood events and to assess the performance of the alternatives to deliver water for irrigation. The analysis included review by Simons and Associates regarding the location and sizing of the proposed structures for sediment control and channel stabilization.

7.2 WATER RIGHTS

Table 7.1 lists the irrigated acres and water rights information for the UP&B and D&S. This information was obtained from the Structure Summary Report in the Colorado Water Resources Decision Support System (DSS) attached in Appendix G. The UP&B has a decreed absolute water right of 468.34 cubic feet per second (cfs) and decreed conditional water right of 234.17 cfs. The D&S has a decreed absolute water right of 136.4 cfs and decreed conditional water right of 31.6 cfs. Maximum and average diversions for each month are tabulated Table 7.2.

Table 7.1: Water Rights Data

Description	UP&B	D&S
Decreed Absolute Water Right (cfs)	468.34	136.40
Decreed Conditional Water Right (cfs)	234.17	31.60
Maximum Day Diversion (cfs)	270	69
Date of maximum	5-27-2002	4-26-2007
Acres Irrigated	14,000	2,600

Table 7.2: Historic Diversions (Maximum Monthly)

Month	UP&B-Cfs	D&S Cfs
November	41	9
December	34	3
January	74	2
February	71	12
March	101	19
April	120	21
May	183	35
June	147	32
July	164	35
August	171	30
September	110	33
October	103	30

Table 7.3: Historic Diversions (Average Monthly)

Month	UP&B- Cfs	D&S Cfs
November	2	0
December	1	0
January	2	0
February	4	0
March	9	1
April	40	5
May	75	17
June	83	17
July	99	15
August	97	11
September	74	12
October	37	6

7.3 STREAMFLOW

The South Platte River is located in the Plains Hydrologic Region as defined by USGS Water Resources Investigations Report 99-140. The South Platte drainage basin at the project site has a watershed area of 14,648 square miles. The basin is hydrologically diverse containing large tributaries draining the east slope of the Rockies with headwaters near 14,000 feet and many ephemeral tributaries that extend south to the Palmer Divide. Streamflow in the South Platte is principally the result of snowmelt, however, major flood events have historically been caused by convective storms in the foothills or the plains region. The snowmelt peak runoff usually occurs in early June. The major floods have occurred from May through September.

Gaging Stations

Streamflow records near the project site are available at three gaging stations on the South Platte. The stations are described below from upstream to downstream.

- South Platte River at Weldona, USGS Station No. 06758500, 5.9 miles upstream of the diversion site. The length of record for this station is 55 years from 1952 through 2007. The Weldona gage is located upstream of the confluence with Kiowa Creek and Bijou Creek and does not reflect the contribution of these creeks during major flood events

- South Platte River at Ft. Morgan, USGS Station 06759500, located 2 miles downstream of the diversion site. The length of record for this station is 29 years including a peak flow in 1935 and continuous record from 1943 through 1958 and from 2002 through 2015.
- South Platte River at Balzac, USGS Station 06760000, located 25 miles downstream of the diversion site. The length of record for this station is 63 years from 1917 through 1980.

Historic Floods

Numerous significant flood events have been documented on the South Platte River at Fort Morgan. The flood level of the South Platte in June of 1894 was reported to have reached the top of the bridge piling at Highway 52. This flood may have influenced the location of the original headworks for the Upper Platte and Beaver Canal which was adjudicated in 1895. The flooding in June 1921 was said to be comparable to the 1894 flood. The flood of May 30-31, 1935 (Cherry Creek Storm) resulted from 24 inches of precipitation centered in the Cherry Creek watershed and had a discharge of 84,300 cubic feet per second at Fort Morgan. The flood resulted in the relocation of the UP&B headworks to the present site and the construction of South Diversion Dam and the North Diversion Dam in 1936. The next major flood to impact the diversion dams occurred on June 16-17, 1965 and is known as the Plum Creek Storm. This storm dumped 18.1 inches centered on the Plum Creek and Bijou Creek watersheds. The flood elevation of the South Platte River at Highway 52 was 4272.6 feet. The 1965 flood washed out the island between the South Diversion Dam and the North Diversion Dam and allowed the river to bypass the diversion structures. The Diagonal Dam was constructed 1965 to connect the north and south sections of the diversion dam. The flood of September 2013 had a discharge of 60,000 cfs at Fort Morgan.

Streamflow

Tables 7.3, 7.4 and 7.5 summarize streamflow characteristics at the diversion point including flood discharges, the mean flow for each month and the flow duration exceedance values. The flood discharges are based on Table 6 – Discharge Data for the South Platte River in Morgan and Washington Counties, Colorado in Special Flood Hazard Information Report, South Platte River, Volume II, U.S. Army Corps of Engineers, May,1977. The discharges from the 1977 study were checked and confirmed using the USGS Annual Peak Flow Frequency analysis by the Bulletin 17B Procedure for 29 years of record for the South Platte River at Fort Morgan Gage No. 06759500. The discharge listed below for the 2-Year Flood was taken from the USGS analysis. The mean monthly flows and flow duration data were taken from the Weldona gage and used without modification.

Table 7.4: Flood Discharges

Flood Event	Peak Discharge (cfs)
2YR	4,800
10YR	24,000
50YR	73,000
100YR	114,000
500YR	300,000

Table 7.5: Mean Monthly Flow

Month	Mean flow Cfs
November	457
December	538
January	660
February	613
March	500
April	705
May	1600
June	2100
July	688
August	577
September	610
October	532

Table 7.6: Flow Duration Data

Percent Exceedance	Flow Cfs
10	704
20	430
30	305
40	472
50	361
60	282
70	219
80	167
90	124

7.4 HYDRAULIC MODEL

The U.S. Army Corps of Engineers HEC-RAS model of the South Platte River through Morgan County, Colorado was obtained from FEMA. The model was developed by Anderson Consulting Engineers, Fort Collins, Colorado under contract with the CWCB (COCWCB20) and is dated January 2010.

Cross section data in this model was cut with HEC-GeoRAS from five foot elevation contours provided by FUGRO Horizon. Additional elevation data was provided for specific cross sections by survey data from King Surveyors. Model data in the vicinity of the Upper Platte and Beaver Diversion dam was checked and additional topographical data surveyed by TZA Water Engineers. The model was modified to reflect the diversion dam alternatives including dam geometry, diversion gates and flood gates. The modified cross-sections are included in Appendix F. The location of the cross-sections in the vicinity of the dam and model output summaries are also included in Appendix F.

Hydraulic Design Criteria

The hydraulic design criteria for the diversion dam was selected to meet the irrigation demands of the UP&B and D&S Canal Companies, provide redundancy for operation and maintenance, minimize damage during flood events and maintain a stable channel environment. The design criteria is summarized below.

- Flood condition: Safely pass the 100-Year Flood without overtopping for the non-overflow sections of the dam. Scour protection is designed for the 2-Year and 5-Year Floods. Floods greater than the 5-Year Flood have high tailwater depths which reduce the potential for bed scour.
- High flow condition: River discharge taken as mean monthly flow for June. The diversion requirement is equal to the decreed absolute water right for UP&B and D&S.
- Average flow conditions: River discharge taken as the mean monthly flow for August. The diversion requirement is equal to the historic maximum flow for the UP&B and D&S.
- Low flow conditions: River discharge taken as the 80 percent exceedance flow. The diversion requirement is equal to the historic average diversion for the UP&B and D&S for the month of August.

7.5 HYDRAULIC MODEL RESULTS

Flood Simulation

The peak discharges for the 2-year through 500-year floods were modeled using HECRAS with the flood gate open. The results of the modeling are summarized in Table 7.7. The results indicate that the Alternative 2 diversion does not increase the flood elevations. Model cross-sections and output data is included in Appendix F.

Table 7.7: Flood Simulation Results with Dam in Place

Storm Event	Flood Discharge (cfs)	Alt. No. 1 (Existing) Flood Elevation (feet)	Alt. No.2 flood Elevation (feet)
2YR	4,800	4279.2	4276.6
10YR	24,000	4282.4	4282.8
2013 Flood	60,000	4287.8	4287.4
50YR	73,000	4289.1	4288.7
100YR	114,000	4292.4	4291.7
500YR	300,000	4302.1	4300.9

Diversion Simulation

The hydraulic performance of the diversion gates for the design flow conditions is summarized in Table 7.8. The water surface elevations in the South Platte River were calculated using the HEC-RAS model for each flow conditions. The corresponding water surface in the downstream canal was calculated using standard open channel flow equations. The gate opening required to pass the diversion flow was calculated for the canal headgates using standard gate hydraulic equations with correction for submergence. The capacity calculations are attached in Appendix F. A single 15' wide headgate was assumed to be operating for the UP&B and the existing 10' wide headgate was assumed to be operating for the D&S. The flood gates and sluice gates were assumed to be closed for the calculations.

Table 7.8: Diversion Simulation results

Description	High Flow Condition	Average Flow Condition	Low Flow Condition
River Discharge (cfs)	2100	577	167
River Water Surface Elevation (ft)	4280.5	4278.2	4276.7
Diversion Requirement UP&B/D&S (cfs)	468 / 136	270 / 69	97 / 11
Canal Water Surface (UP&B)(ft)	4277.05	4276.22	4275.24
Gate Position UP&B (percent open)	72%	93%	93%
Gate Position D&S (percent open)	37%	66%	74%

The results summarized in Table 7.8 indicate the new diversion structure will be able to supply the diversion requirements for both the UP&B and D&S canals.

River Mechanics Review

TZA retained Simons & Associates to review the preliminary plans for the alternatives. The review agreed with the analysis/evaluation of the existing diversion structure and the recommendation for a new diversion structure. The review had the following comments to consider in developing the final design for the new structure regarding river mechanics/geomorphology, and sediment transport:

- The new structure is located a few hundred feet upstream of the existing structure (on the south side of the river). Sediment has deposited upstream of the existing structure which may reduce the effectiveness of sediment sluicing through the new structure. At the existing structure there is considerable elevation drop from upstream to downstream which provides significant energy to sluice sediment. At the new structure on the south side the sediment deposit upstream of the existing structure reduces the potential for sediment sluicing through the new structure. A pilot channel may need to be excavated to start the process of sediment sluicing for the new structure. Removal of all or part of the existing structure would enhance sediment transport downstream of the new structure and should be considered. Placing the sediment sluicing gates on the north side of the river adjacent to the diversion intake should enhance flushing of sediment on this side of the river.

- The new structure, being located upstream of the existing structure (on the south side of the river) will cause a backwater effect extending farther upstream of the existing structure. There is an existing side channel on the north side of the river upstream of the existing structure and low floodplain, and with the backwater extending farther upstream some berms, guide banks, or levees may need to be constructed on the north side of the river to keep the river from shifting to the north and bypassing the structure either partially or fully which would be a huge problem in the functionality of the structure.
- As part of the final design, some analysis should be conducted regarding sediment sluicing through and past the new structure and ensuring that the river continues to flow to the structure are recommended.

TZA has addressed the concerns noted in the comments as follows:

- Most of the existing dam will be removed to enhance the passage of sediment downstream.
- The North Flood Dike has been added to close off the side channel on the north side of the dam and prevent the river from shifting north around the dam.
- The scope for the final design will include a sediment transport analysis through the new structure.

SECTION EIGHT: ALTERNATIVE 1 – REHABILITATE THE EXISTING DAM

8.1 INTRODUCTION

Alternative 1 consists of rehabilitating the existing diversion structure to prevent catastrophic failure and permit continued efficient operation of the irrigation systems. The visual inspection found that the South Dam, Diagonal Dam and North Dam were in poor to unsatisfactory condition. The inspection found that the canal headworks, flood gates and sluice gate were in satisfactory condition and appear to meet diversion requirements. Therefore, the Alternative 1 improvements primarily address the structural components of the dams. The secondary goal of channelization of the South Platte River to minimize flood impacts and improve sediment transport is not economically feasible by modifying the existing diversion. This would require the installation of a large bladder gate in the diagonal dam which would not be efficiently oriented for channelization and sediment transport.

The primary deficiencies identified in the South dam, Diagonal Dam and North Dam are described below.

- Seepage under the structure has eroded the foundation and undermined the slab.
- Erosion from overtopping has undermined the toe of the downstream base slab and has exposed the shear keys beneath the slab.
- Significant concrete deterioration has occurred in the buttresses and concrete base slabs. The deterioration has led to corrosion of reinforcement steel, and likely reduced the kinematic stability of the structure.

Repair of the concrete base slab is considered important to restore the kinematic stability of the section. The concrete base slab should be repaired so as to provide protection against foundation erosion, and should include a cutoff wall at the upstream and downstream toe to provide protection against undermining erosion. In addition, the concrete buttresses, slab sections that are not replaced and appurtenances such as the concrete walkway bridge should be repaired. The completed improvements will address the observed deficiencies and are expected to provide reasonable service in the future. However, unknown problems in the existing structures may result in necessity for future maintenance and corrective actions. The preliminary plans for Alternative 1 – Rehabilitate the Existing Diversion are attached in Appendix A. The improvements are described in the following section.

8.2 DESCRIPTION OF IMPROVEMENTS

Upstream Cut-Off Wall

The primary failure mechanism at the dam is overtopping and scour under the downstream slab. Additionally, seepage under the structure through the soft bedrock has contributed to the failure of the downstream slab. The dam was originally founded on a relatively thin section of hard sandstone underlain by soft claystone. The claystone is easily weathered and eroded. The head pressures created by the dam are sufficient to develop seepage paths and erosion of material under the dam. The upstream cut-off wall will consist of a barrier to seepage and will confine and protect the claystone bedrock. The cut-off wall will extend at least 10 feet below the surface of the bedrock. The cut-wall will be located as close to the existing structure as possible. A new upstream slab will be extended to connect to the existing structure foundation.

Repair of Downstream Slab

The downstream slab is cracked and broken at many locations where it extends past the end of the buttresses. The existing slab will be saw cut at the end of the buttresses and removed. The voids und the structure will be filled with concrete backfill. Voids extending a significant distance under the structure will be grouted by drilling through the slab. A new slab extending 10 feet downstream of the buttress terminating in a cut-off wall will be constructed. The slab will be structurally connected to the existing slab. The constructability of the repairs to the existing slab may be difficult due to unknowns in the condition of the slab and foundation.

Downstream Cut-Off Wall

The downstream cut-off wall will be extended a minimum of 10 feet below the surface of the bedrock similarly to the upstream cut-off wall.

Downstream Scour Protection

The scour potential from the overtopping is severe as evidenced by the erosion at the toe of the dam. A concrete scour pad will be constructed to extend 20 feet from the downstream cut-off wall. The scour pad will terminate in a key extending 5 feet below the bedrock surface. The length of the scour protection is sufficient to contain the hydraulic jump downstream of the dam for the 2-Year and 5-Year Floods. Floods greater than the 5-Year Flood have high tailwater depths which reduce the potential for scour.

Concrete Repair

The existing concrete structure including buttresses, slabs walkways and other appurtenances will be inspected for cracks, spalling, delamination and exposed rebar. Deficiencies will be corrected by removing concrete to expose a sound surface and provide sufficient depth for a structural repair.

8.3 CONSTRUCTION CONSIDERATIONS

Dewatering and Diversion

The construction of the upstream slab and cutoff wall will require diversion and dewatering of river flows. Adequate gates for diversion exist at the both the south and north ends of the dam. The river may be diverted to the south side or north side as needed to facilitate the construction. The timing of the diversion must be scheduled with irrigation diversion requirements. Dewatering of the cutoff wall trench will be required. Local river bed materials may be used to direct the flow and protect the construction areas.

Schedule

The construction will involve excavation of about 2300 cubic yards of cut-off wall and placement of about 6600 yards of new concrete. Approximately 400 cubic yards of existing concrete slab will be saw cut and removed. The north flood dike will require about 600 cubic yards of embankment from fill. Based on these quantities the construction may take up to 6 months and can be completed in one season. Work should be avoided during the peak runoff periods of May and June although work on the downstream face of the existing dam may be possible depending on the snowmelt conditions. The low flow period of the river generally extends from August through December.

8.4 PROJECT COST

The engineer's opinion of project cost has been prepared to establish budgetary requirements and facilitate economic analysis. Construction pricing is in current dollars and intended to be for "contract" construction cost. Construction material is assumed to be sourced within a reasonable distance, not requiring an escalated cost to bring construction material to the site. This includes, but is not limited to, concrete material, reinforcing, fill, etc.

During the development of the 30 percent design, major construction items have been identified to represent the work effort. Quantity estimates for each item have been developed based on the current level of detail of the design. Minor features of the work are assumed to be included in the major construction items.

Pricing includes the use of statistical unit pricing, information from contractors, and the development of unit prices by applying production rates to labor, equipment, and material cost. Unit pricing is assumed to be produced in a process similar to that of a competent and qualified contractor. Bids are also assumed to be advertised in an open and competitive construction market.

The engineer's opinion of project cost is based on applying unit prices to the quantities for each construction item. A 30 percent contingency has also been added to the subtotal to be in keeping with the level of the unknowns in the preliminary design. Costs for engineering and construction services are estimated in accordance with the guidelines from the American Society of Civil Engineers Manual of Practice No. 45. Estimated project cost does not include other owner costs such as legal, permits, land acquisition, procurement requirements, environmental mitigation and construction cost growth after contract. A summary of the cost is provided in Table 8.1.

Table 8.1: Alternative 1 Project Cost Estimate at 30 Percent Design Stage

Description	Values
Diversion and Dewatering	$225,000
Demolition and Temporary Access	$79,000
Earthwork (incl. riprap)	$310,000
Concrete Backfill and Grouting	$435,000
Reinforced Concrete (slab, cutoffs and scour pad)	$2,910,000
Concrete Repair	$105,000
Subtotal	**$4,064,000**
Contingency (30 percent)	$1,220,000
Engineering	$344,000
Construction Services	$291,000
Total Project Cost	**$5,919,000**

SECTION NINE: ALTERNATIVE 2 – NEW DIVERSION DAM

9.1 INTRODUCTION

Alternative 2 consists of constructing a new diversion structure upstream along the alignment of the existing North Dam. The new diversion structure will have an expected operational life of 80 years or more and address all project goals to provide an efficient, safe, diversion structure. Additional benefits include, but are not limited to the following:

- Channelization of the South Platte River to minimize flood impacts and ongoing erosion on the north and south banks of the South Platte River at and near the diversion structure
- Bank stabilization
- Protection of existing downstream infrastructure (Morgan County Quality Water, Morgan Heights, etc…)
- Safe operations
- Fish passage structure(s) designed to provide a detour route for migrating native Colorado fish

The new diversion structure will connect to the existing North Dam and extend across the river to the south bank. The total length of the dam will be reduced from 1410 feet for the existing dam to 1000 feet for the new diversion structure. Construction in the river bed will be limited to 500 feet and will include a concrete ogee section and a bladder dam. The south flood dike will be an earth embankment which will provide access to the gate structures and prevent floods from going around the south side of the structure. The UP&B canal will be extended upstream about 700 feet to the location of the new diversion structure. The new diversion location will require jurisdictional approval for a new point of diversion for the UP&B Canal. The canal headworks and river sluices are designed for 100 percent back-up so maintenance can be performed without impacting diversion. The design criteria for the new diversion is taken from the U. S. Bureau of Reclamation Design Standards No. 3, Canals and Related Structures, Chapter 3, Diversion Dams. The preliminary plans for the Alternative 2 – New Diversion Structure are attached in Appendix A. The improvements and specific design criteria is described in the following section.

9.2 DESCRIPTION OF IMPROVEMENTS

Concrete Ogee Dam

A Concrete Ogee Dam will be located near the center of the South Platte River. The structure will have a height of 7 feet and an Ogee shaped crest for efficient passage of flood flows. The crest elevation will be 4280.0 to match the existing dam crest. The Ogee dam will direct flood flows toward the center of the river to help maintain the channel alignment in the center of the river. The Ogee gravity structure will be less likely to be damaged from flood overtopping and will have a longer service life than a slab and buttress structure. The design includes a cut-off wall extending at least 10 feet below the surface of the bedrock on the upstream and downstream sides of the structure. The structure will be founded on bedrock and designed for the allowable bearing pressure of the claystone formation. All joints will include waterstops. A concrete erosion scour pad will extend 20 feet downstream of the cut-off wall and terminate in a key with a depth of 5 feet into the bedrock. The length of the scour protection is sufficient to contain the hydraulic jump downstream of the dam for the 2-Year and 5-Year Floods. Floods greater than the 5-Year Flood have high tailwater depth which reduces the potential for scour.

Bladder Flood Gate

The floodgate will allow release of normal river flows and will increase the capacity of the diversion structure during major floods. The fully open bladder gate will result in velocities which will scour sediment from the center of the river channel and help maintain the channel alignment in the floodplain. The sill of the floodgate will match the river bed elevation of 4272. The bladder gate will be an Obermeyer type gate with a upstream steel face which is raised and lowered by pneumatically operated reinforced rubber bladders. The length of the gate is 200 feet. The ogee dam and bladder gate will handle minor floods up to the 10-Year Flood. The pneumatic equipment for the gate operation will include an air compressor and tank which will be located in a gate house near the canal headworks on the south bank of the River. The Obermeyer gate will be mounted on a concrete slab founded on bedrock with upstream and downstream cut-off walls. A concrete scour pad will extend 20 feet downstream of the cutoff wall as for the Ogee dam.

River Sluices

River sluices will be on the north side of the river and the south side to keep sediment from building up near the headworks for the UP&B and the D&S canals. The river sluice for the UP&B headworks will be located adjacent to the headgates. The river sluice for the D&S headworks will be located about 150 feet from the D&S headgate. The river sluices for both canals will consist of two radial gates 10 feet in width. The dual gates will allow one gate to remain in service during repair or maintenance of the other gate. The gates will include stop log grooves for maintenance. The sill of the sluice gates will be set 2 feet below the riverbed elevation of 4272 and 5 feet below the sill of the canal headgate for efficient removal of sediment. The gates will be electrically operated. The power cable for the gate on the north side of the river will be extended from the gate house on the south bank in a conduit embedded in the concrete base slab for the floodgate and Ogee structures.

Canal Headworks

The existing bladder headgate for the D&S Canal will continue to be used. Power can be extended to the D&S gate house if desired for installation of a compressor and controls for the gate.

The headworks for the UP&B Canal will consist of two bladder gates 15 feet in width. The gates will be Obermeyer type gates similar to the floodgate. The sills of the gates will be set to match the existing D&S gate at approximately elevation 4275. The capacity of each gate during the design flow conditions is adequate to meet diversion requirements as discussed in Section 7.5. The dual gates will allow one gate to remain in service during maintenance or repair of the other gate. The headgate will have a sill elevation 3 feet above the river bed elevation of 4272 and 5 feet above the sluice gate sill elevation of 4270. A gate house will be located adjacent to the gates to house the pneumatic operation and control equipment. The gate house will be accessed using a gravel surfaced road from the south bank and a pre-fabricated bridge (Big R Bridge) over the canal.

Extension of UP&B Canal

The UP&B Canal will be extended approximately 700 feet to the new headworks structure for Alternative 2. The alignment of the canal will follow the existing south bank of the river. The canal will be excavated into the existing ground and have a bottom width of 24 feet and side slopes of 2:1 horizontal to vertical. The slope of the canal will be 0.175 percent. The design capacity of the canal is 470 cfs with a depth of 3.1 feet and a velocity of 5.1 feet per second. This depth and velocity results a shear force which will be non-erosive in the canal. An earth embankment will protect the canal from normal river flows up to the 10-Year Flood level. The river side of the embankment will be armored with riprap. The top width of the embankment will be 10 feet to allow equipment to travel along the dike for maintenance of the canal with access from the existing road at the old canal headworks. A pre-fabricated bridge (Big R Bridge) will be required at the location of the existing road to continue access to the existing canal downstream.

Fish Passage

A vertical slot fish passage will be located at the north end of the Ogee dam near the connection to the existing North Dam. The passage is designed to accommodate the Brassy Minnow based on guidelines in the report “Fish Barriers and Small Plains Fishes: Fishway Design Recommendations and the Impact of Existing Instream Structures”, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, June 2007. The fish passage is 75 feet in length and consists of 25 pools three feet in length and 10 feet in width. The pools are defined by vertical slot flumes one foot in width. The hydraulics of the flumes limit the vertical elevation between the pools to 0.16 feet and the velocity in the pools to about 1 F/S for average flow conditions with a flow rate of about 10 cfs.and a pool depth of 2.4 feet. The vertical slot flumes maintain similar hydraulic conditions for the design criteria of high flow, average flow and low flow . The fish passage was modeled using HECRAS for the river water surface elevations for each flow condition. Calculations and HECRAS model output data are included in Appendix F.

South Flood Dike

The South Flood Dike will connect the canal headworks to the high ground on the south side of the river. The dike will prevent floods from by-passing the structure on the south side. The South Flood Dike will consist of an earth embankment with a top width of 20 feet and 3:1 (horizontal: vertical) side slopes. The crest of the dike will be elevation 4292.0 above the 100-Year Flood and the average height of the dike will be about 10 feet. The dike will be about 500 feet in length and require about 12,000 cubic yards of fill material. A gravel surface access road will be located on the flood dike. The access road will connect to the existing road near the UP&B operator's house. The excavation of the access road into the hillside should provide adequate material for the flood dike. The upstream side of the dike will be armored with riprap.

North Bank Protection

Bank stabilization and erosion protection will be constructed on the north bank of the South Platte River from the D&S headworks upstream about 600 feet. The bank protection will consist of grading the top of the bank to elevation 4284 with a 2:1 slope to the river bed. The bank elevation may need to be raised at some locations by constructing a dike with a top width of 10 feet and 2:1 side slopes. Riprap will be placed on the bank extending 3 feet below the bed of the river. The bank protection will prevent the river from cutting a channel around the diversion structure, but will not reduce the capacity of the floodplain during major flood events..

Repair of North Dam

The existing North Dam will be repaired as described in Section 8.2. A new concrete walkway will be constructed along the top of the buttresses to provide access to the River Sluice radial gates.

9.3 CONSTRUCTION CONSIDERATIONS

Dewatering and Diversion

The construction of the Ogee structure and floodgate will require diversion and dewatering of river flows. The river may be diverted to the south side or north side as needed to facilitate the construction. The timing of the diversion must be scheduled with irrigation diversion requirements. Dewatering of the cutoff wall trench will be required. Local river bed materials may be used to direct the flow and protect the construction areas. The diversion flow can be released through the river sluices once the sluice gates are constructed

Schedule

The construction will involve excavation of about 1500 CY of cutoff trench and placement of about 4700 yards of new concrete. Additional earthwork for the canal extension and south flood dike will involve about 12,600 CY of excavation and 13,300 CY of embankment. Based on these quantities the construction may take up to 8 months and can be completed in one season. Adequate lead time must be incorporated for manufacture of gates and bladder dam components. Work should be avoided during the peak runoff periods of May and June although work on the downstream face of the existing north dam may be possible depending on the snowmelt conditions. The low flow period of the river generally extends from August through December.

9.4 PROJECT COST

The engineer’s opinion of project cost has been prepared to establish budgetary requirements and facilitate economic analysis. Construction pricing is in current dollars and intended to be for “contract” construction cost. Construction material is assumed to be sourced within a reasonable distance, not requiring an escalated cost to bring construction material to the site. This includes, but is not limited to, concrete material, reinforcing, fill, etc.

During the development of the 30 percent design, major construction items have been identified to represent the work effort. Quantity estimates for each item have been developed based on the current level of detail of the design. Minor features of the work are assumed to be included in the major construction items.

Pricing includes the use of statistical unit pricing, information from contractors, and the development of unit prices by applying production rates to labor, equipment, and material cost. Unit pricing is assumed to be produced in a process similar to that of a competent and qualified contractor. Bids are also assumed to be advertised in an open and competitive construction market.

The engineer’s opinion of project cost is based on applying unit prices to the quantities for each construction item. A 20 percent contingency has also been added to the subtotal to be in keeping with the level of the unknowns in the preliminary design. Costs for engineering and construction services are estimated in accordance with the guidelines from the American Society of Civil Engineers Manual of Practice No. 45. Estimated project cost does not include other owner costs such as legal, permits, land acquisition, procurement requirements, environmental mitigation and construction cost growth after contract. A summary of the cost is provided in Table 9.1.

Table 9.1: Alternative 2 Project Cost Estimate at 30 Percent Design Stage

Description	**Values**
Diversion and Dewatering	$225,000
Demolition and Temporary Access	$25,000
Earthwork (incl. riprap and gravel surfacing)	$1,072,000
Reinforced Concrete (ogee dam, slabs, walls and scour pad)	$2,489,000
Bladder Dam	$800,000
River Sluice Radial Gates	$264,000
Bladder Headgates	$288,000
Gate House (incl. power service)	$80,000
Access Road Bridges	$270,000
Subtotal	**$5,514,000**
Contingency (20 percent)	$1,103,000
Engineering	$431,000
Construction Services	$364,000
Total Project Cost	**$7,412,000**

SECTION TEN: RECOMMENDATION

10.1 RECOMMENDATION

TZA recommends that the UP&B and D&S select Alternative 2 – New Diversion Structure. The preliminary plan should be advanced to final design with additional geotechnical and river mechanics analysis to confirm the design assumptions. This recommendation is based on the following considerations:

- Safeguard Diversion: The existing diversion structure is in danger of imminent structural failure. Loss of diversion would result in the inability to irrigate about 17,000 acres with severe economic consequences. Alternative 2 would provide the means to continue diversions and protect existing water rights.
- Useful service life: The project life of rehabilitating the dam is unknown given the current condition of the structure. The service life for the Alternative 2 diversion structure is approximately 80 years and has the potential to be greater with proper maintenance.
- Water quality and environmental enhancement: Alternative 2 would stabilize the river channel, protect streambanks from erosion and allow sediment to pass downstream restoring the natural sediment balance to the South Platte.
- Operational Safety: Alternative 2 would provide safe access for operation of diversion, sluice and flood gates.
- Fish passage: Alternative 2 would provide a vertical slot fish passage designed to provide a detour route for migrating native Colorado fish.

SECTION ELEVEN: REFERENCES

11.1 REFERENCES

1. Design of Small Dams, U. S. Bureau of Reclamation, 1987.

2. Design Standards No. 3, Canals and Related Structures, U. S. Bureau of Reclamation, December 8, 1967.

3. Fish Barriers and Small Plains Fishes: Fishway Design Recommendations and the Impact Of Existing Instream Structures, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, June 2007.

4. Geological Survey Water Supply-Paper 1850-B, “Floods of June 1965 in South Platte River Basin Colorado,” U.S. Geological Survey, 1969.

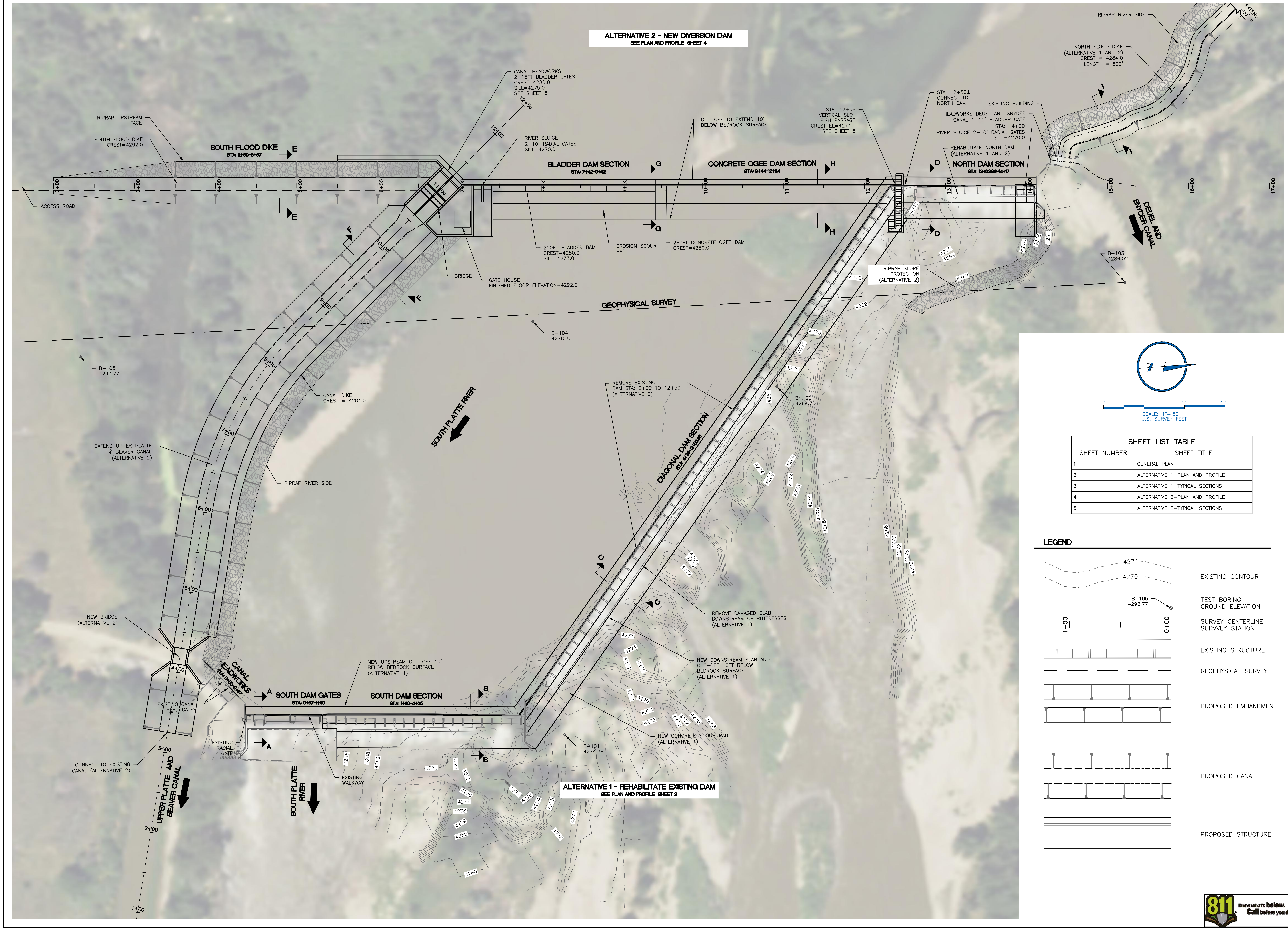
5. Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25, U. S. Bureau of Reclamation, May 1984.

6. Scientific Investigations Report, “Flooding in the South Platte River and fountain Creek Basins in Eastern Colorado, September 9-18, 2013,” U.S. Geological Survey, 2015.

7. Special Flood Hazard Information Report, South Platte River, Volume II, U.S. Army Corps of Engineers, May,1977

Appendices

Appendix A Preliminary Plan



SHEET LIST TABLE	
SHEET NUMBER	SHEET TITLE
1	GENERAL PLAN
2	ALTERNATIVE 1–PLAN AND PROFILE
3	ALTERNATIVE 1–TYPICAL SECTIONS
4	ALTERNATIVE 2–PLAN AND PROFILE
5	ALTERNATIVE 2–TYPICAL SECTIONS

LEGEND

4271 4270	EXISTING CONTOUR
B–105 4293.77	TEST BORING GROUND ELEVATION
1+00 0+00	SURVEY CENTERLINE SURVEY STATION
	EXISTING STRUCTURE
	GEOPHYSICAL SURVEY
	PROPOSED EMBANKMENT
	PROPOSED CANAL
	PROPOSED STRUCTURE

811 Know what's below. Call before you dig

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VJG
DESIGNED BY
JDA
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06–27–16
JOB NUMBER-TASKS
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UPPER PLATTE AND BEAVER / DEUEL & SNYDER FEASIBILITY STUDY
MORGAN COUNTY,COLORADO

PRELIMINARY PLAN
DIVERSION DAM ALTERNATIVES
GENERAL PLAN
ALTERNATIVES 1 AND 2

PRELIMINARY

NOT RELEASED FOR CONSTRUCTION
JOHN D. ALLIS

SHEET
1 OF 5

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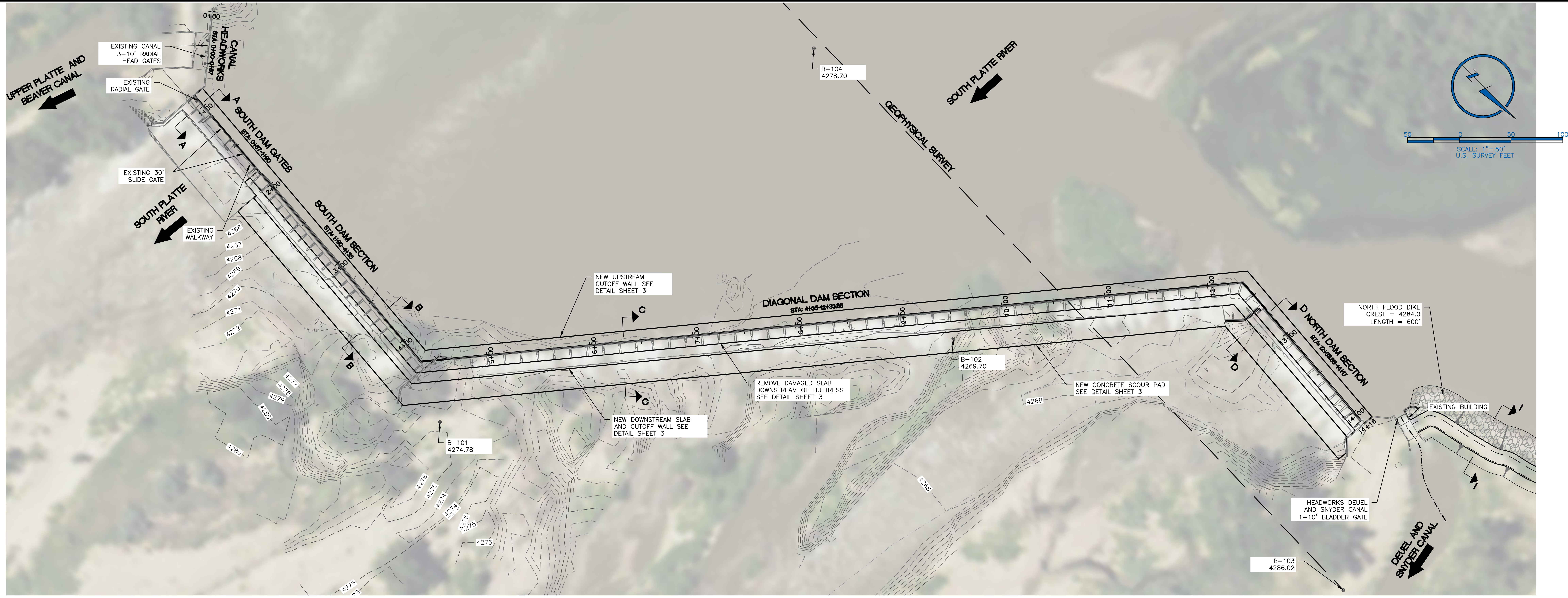

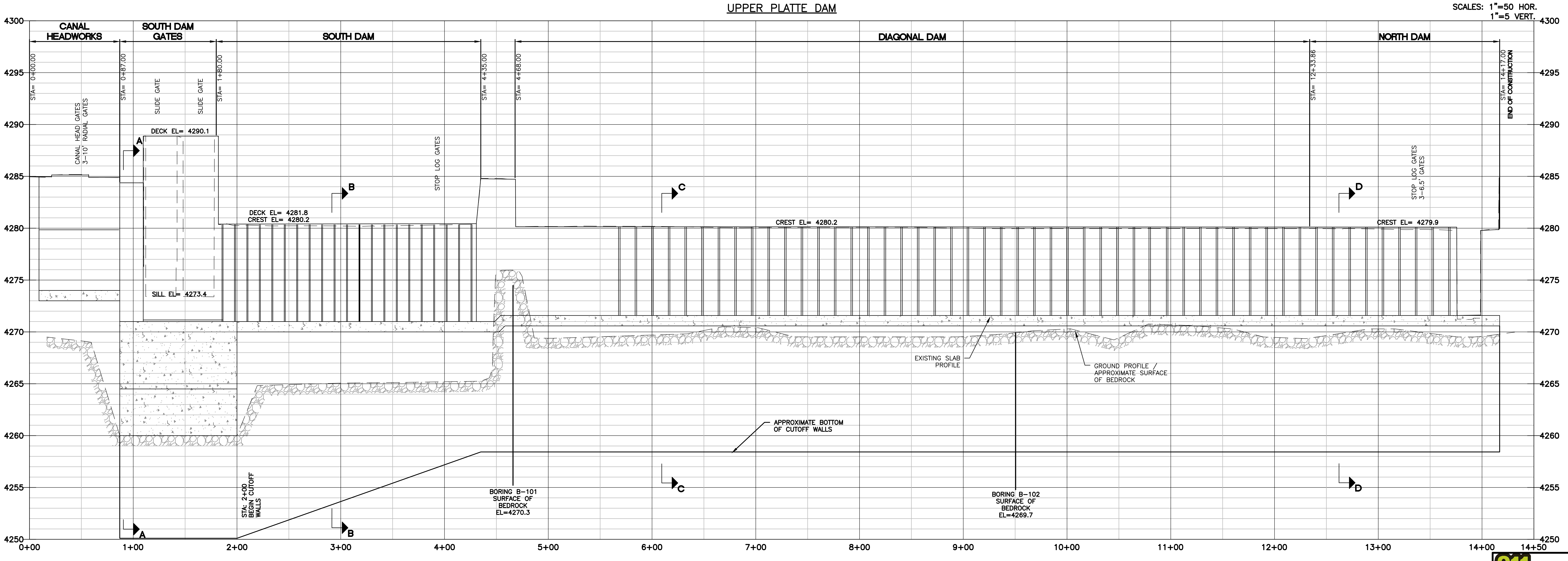

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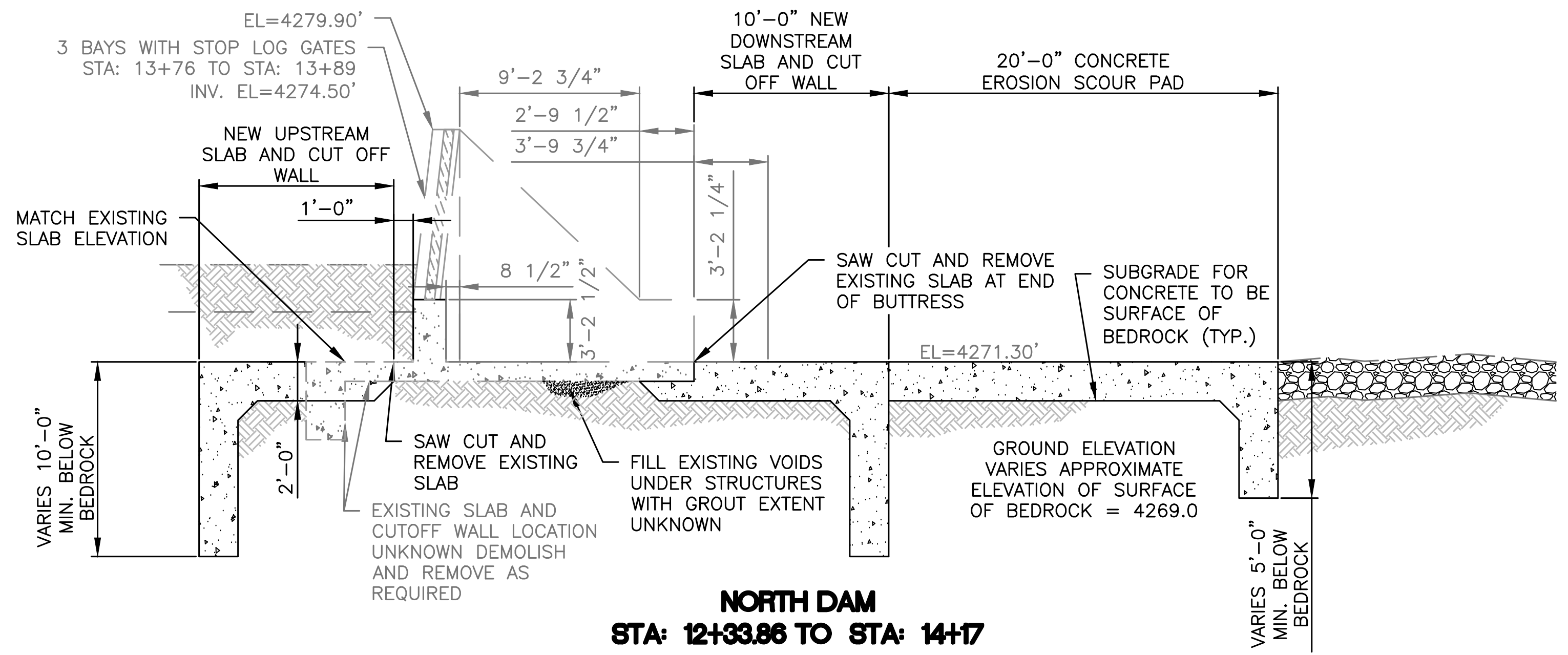
MORGAN COUNTY,COLORADO

PRELIMINARY PLAN
DIVERSION DAM ALTERNATIVES
ALTERNATIVE 1
PLAN AND PROFILE

PRELIMINARY

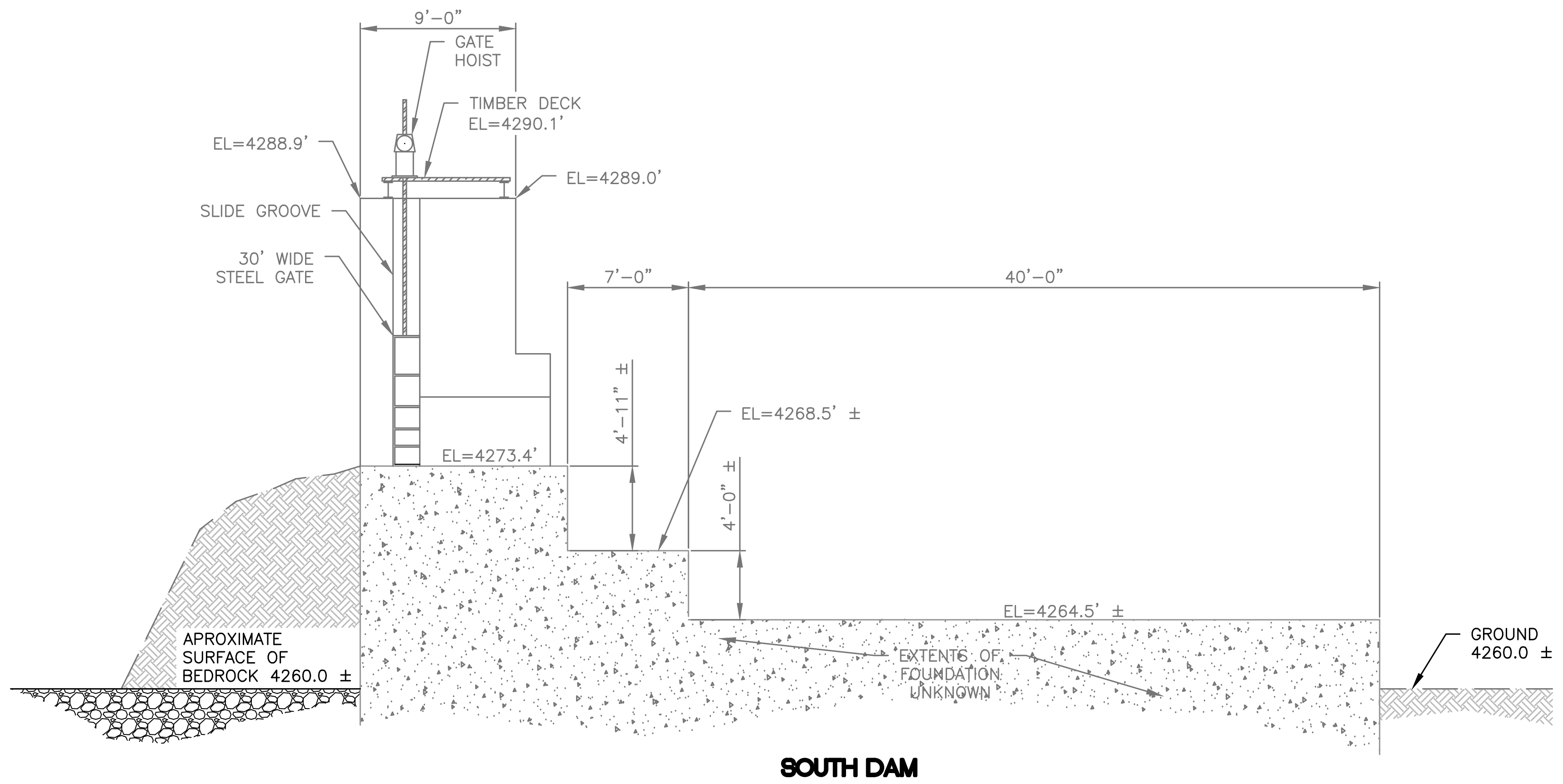
NOT RELEASED FOR CONSTRUCTION
JOHN D. ALLIS

SHEET
2 OF 5



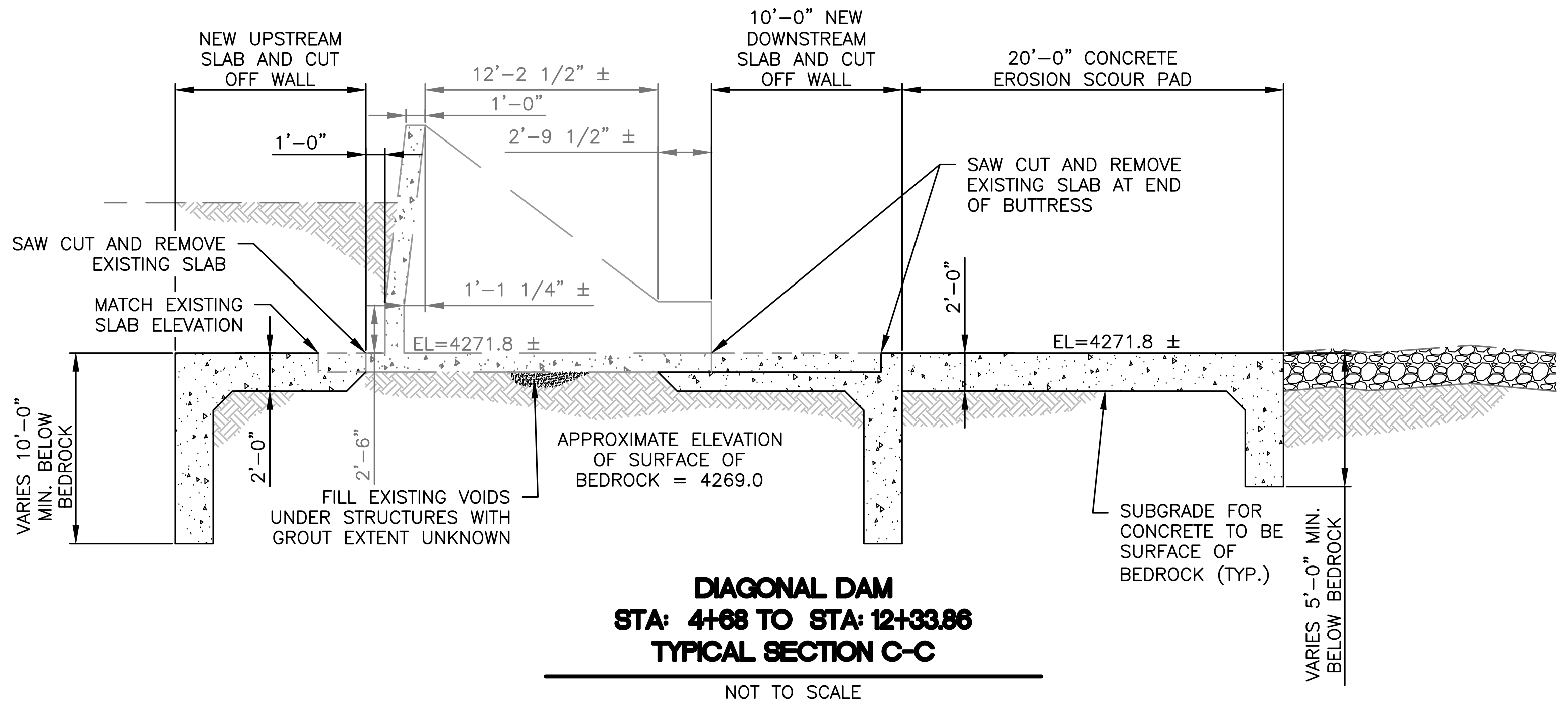
NORTH DAM
STA: 12+33.86 TO STA: 14+17
TYPICAL SECTION D-D

NOT TO SCALE



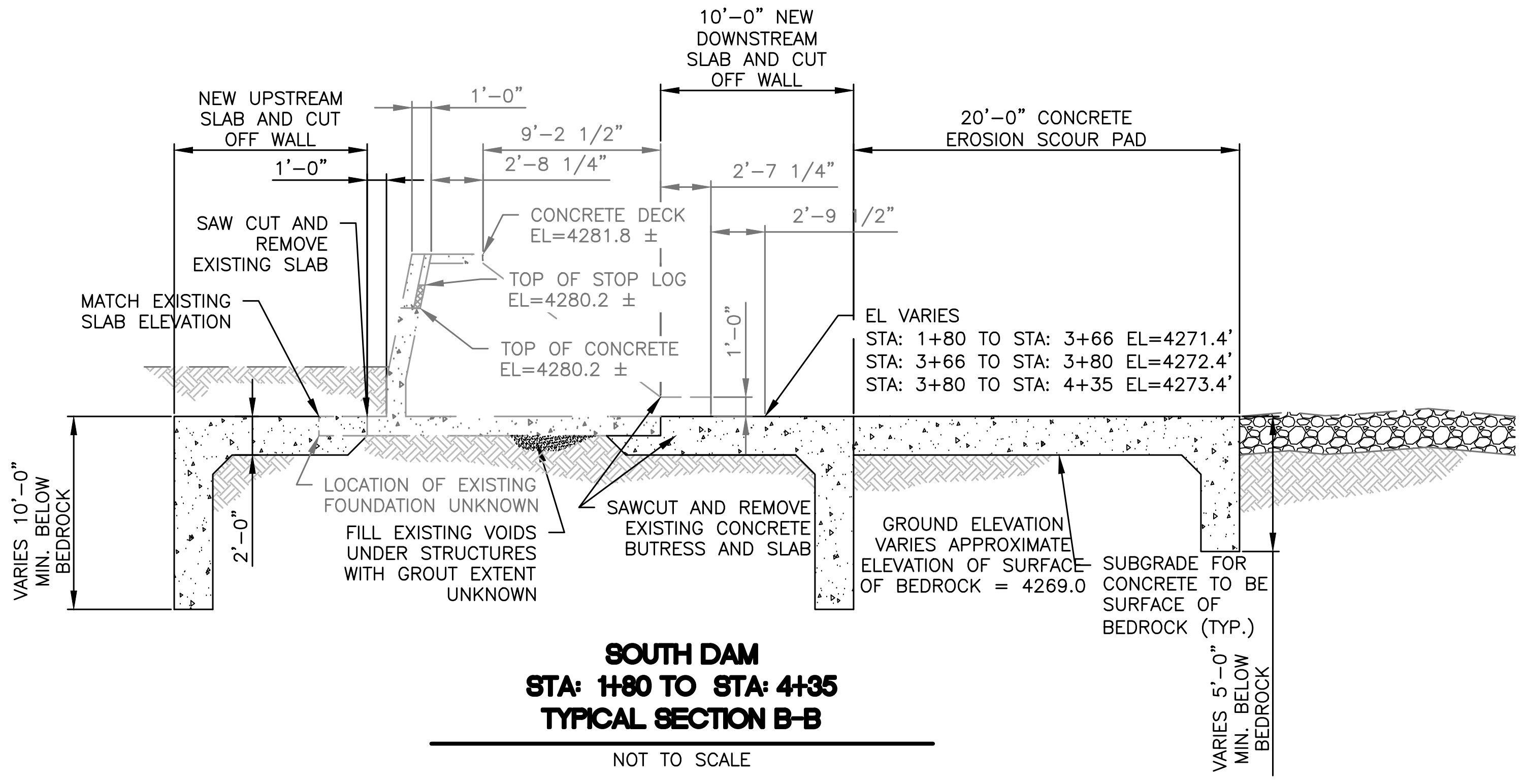
SOUTH DAM
STA: 0+87 TO STA: 1+80
TYPICAL SECTION A-A

NOT TO SCALE



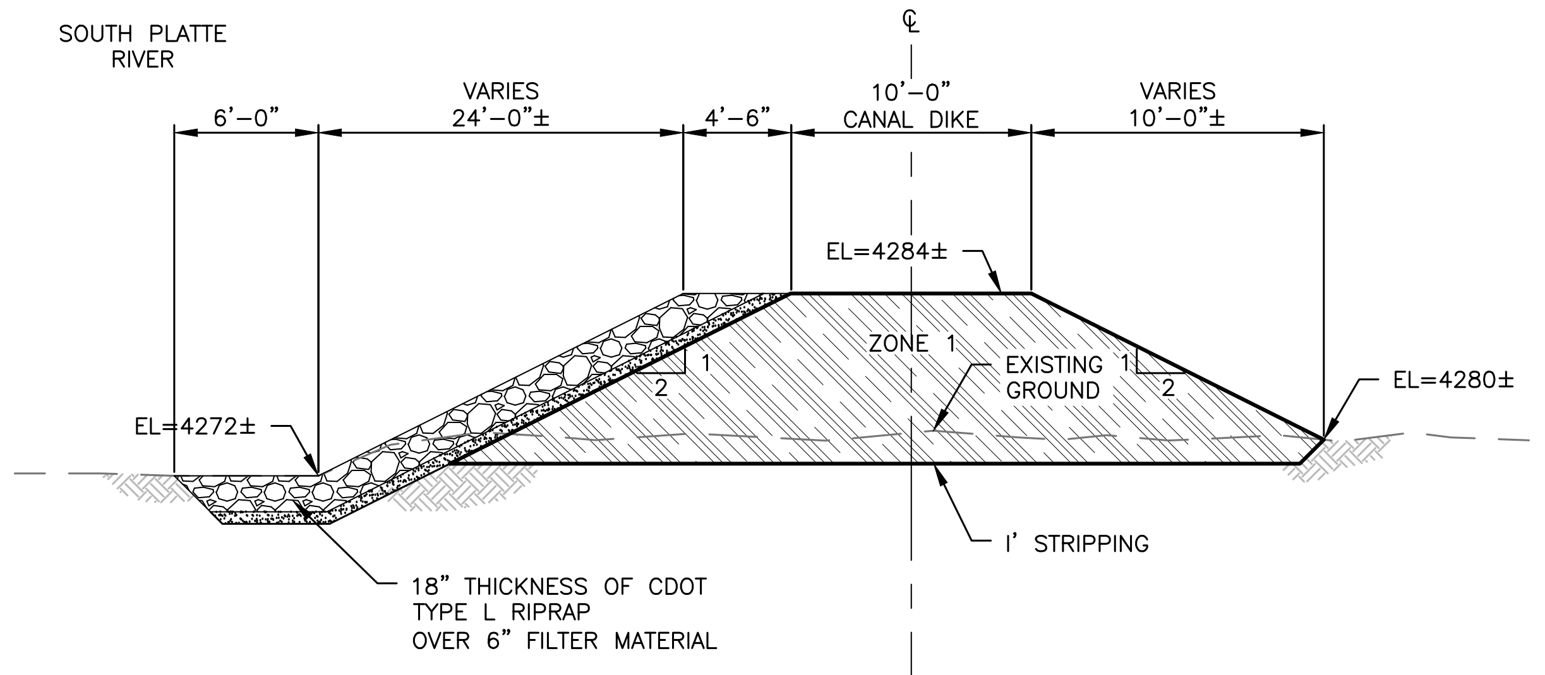
DIAGONAL DAM
STA: 4+68 TO STA: 12+33.86
TYPICAL SECTION C-C

NOT TO SCALE



SOUTH DAM
STA: 1+80 TO STA: 4+35
TYPICAL SECTION B-B

NOT TO SCALE



NORTH FLOOD DIKE
TYPICAL SECTION I-I

NOT TO SCALE

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MORGAN COUNTY,COLORADO

PRELIMINARY PLAN
DIVERSION DAM ALTERNATIVES
ALTERNATIVE 1
TYPICAL SECTIONS

PRELIMINARY

NOT RELEASED FOR CONSTRUCTION

JOHN D. ALLIS

SHEET
3 OF 5

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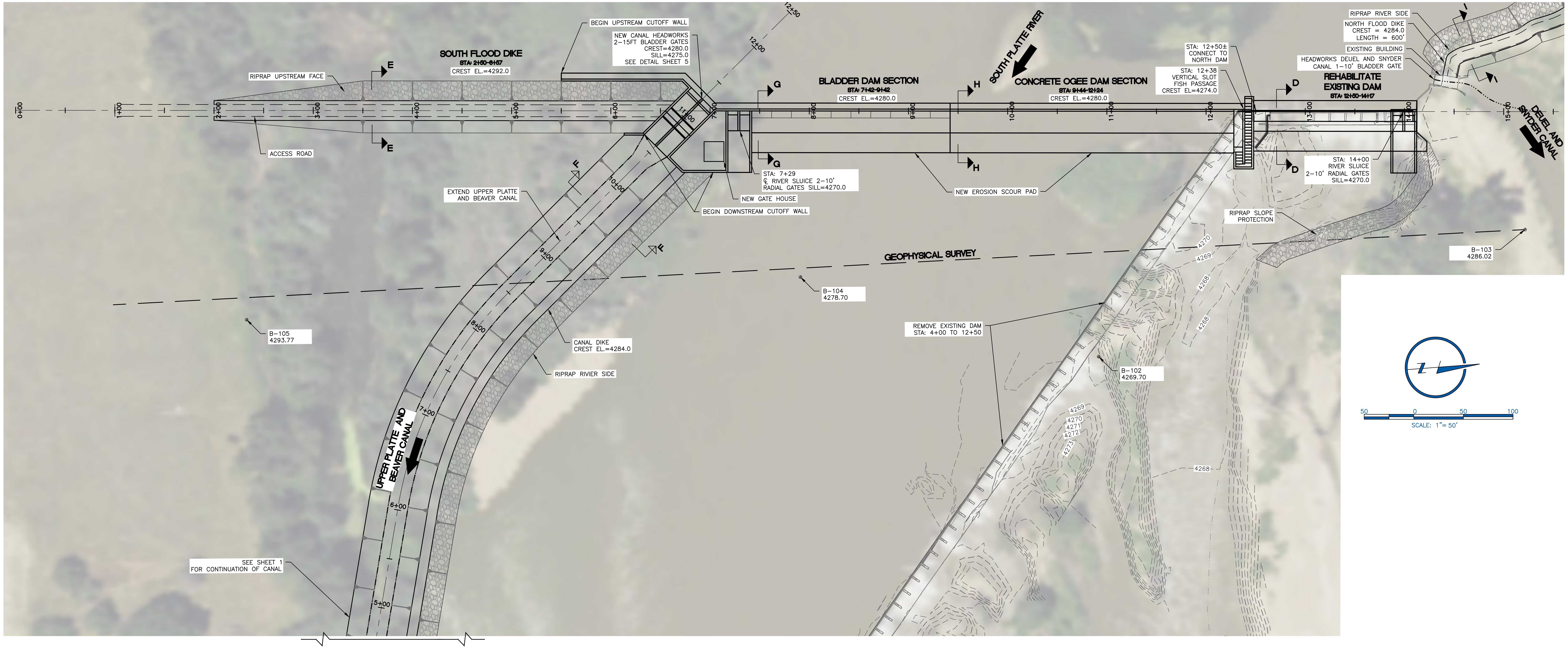
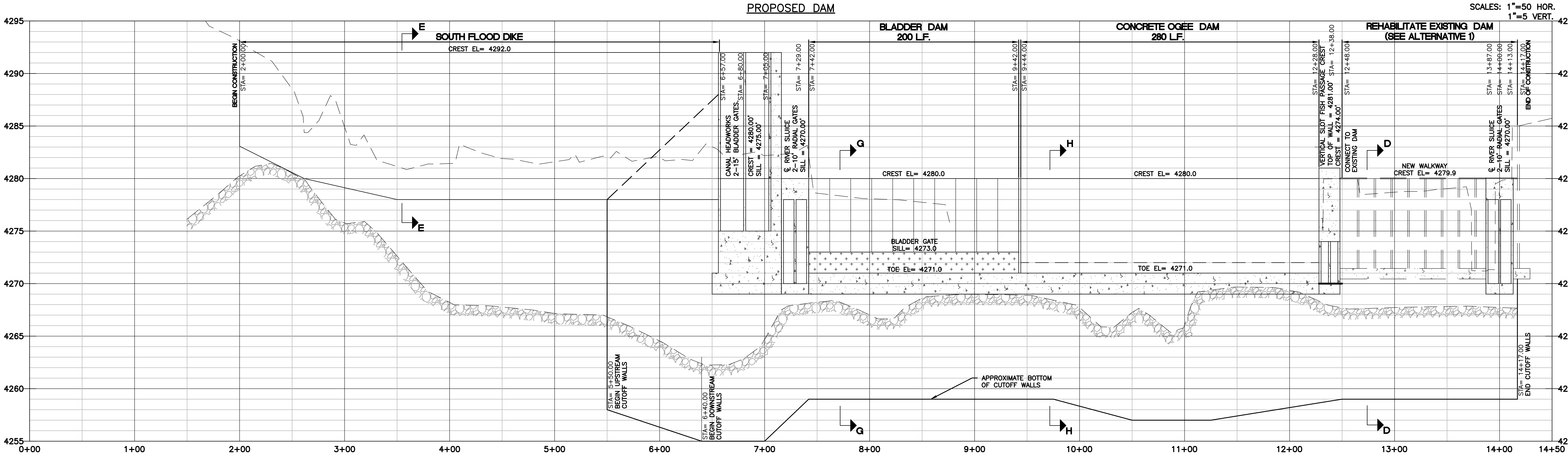


PROPOSED DAM

SCALES: 1"=50 HOR.
1"=5 VERT.



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MORGAN COUNTY,COLORADO

PRELIMINARY PLAN
DIVERSION DAM ALTERNATIVES
ALTERNATIVE 2
PLAN AND PROFILE

PRELIMINARY

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SHEET
4 OF 5

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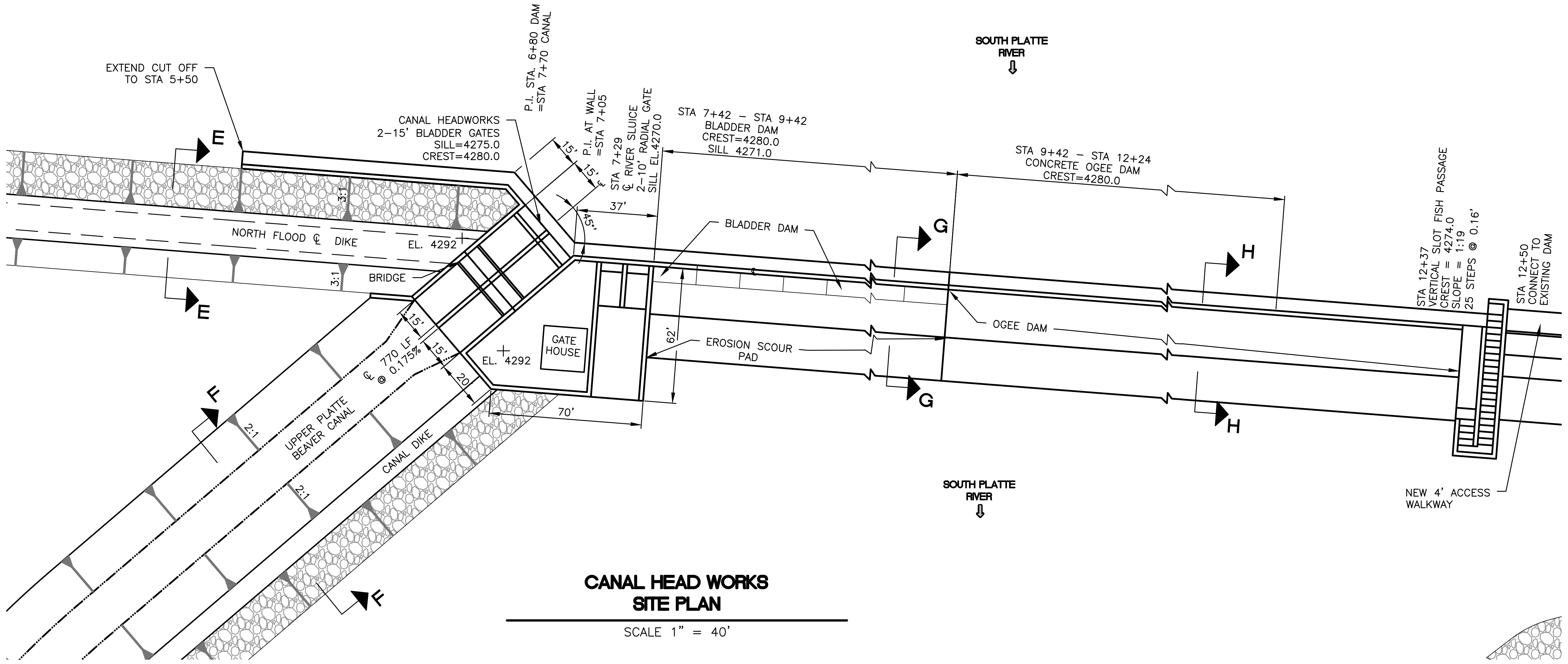
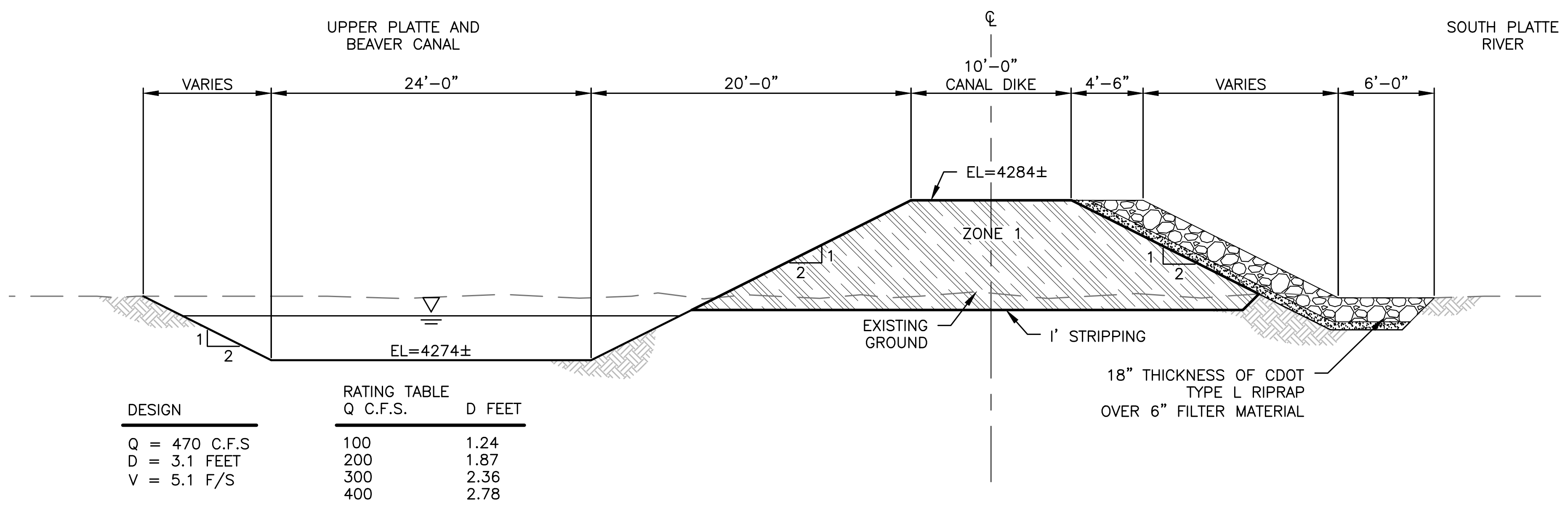


CANAL HEAD WORKS SITE PLAN

SCALE 1" = 40'



DESIGN

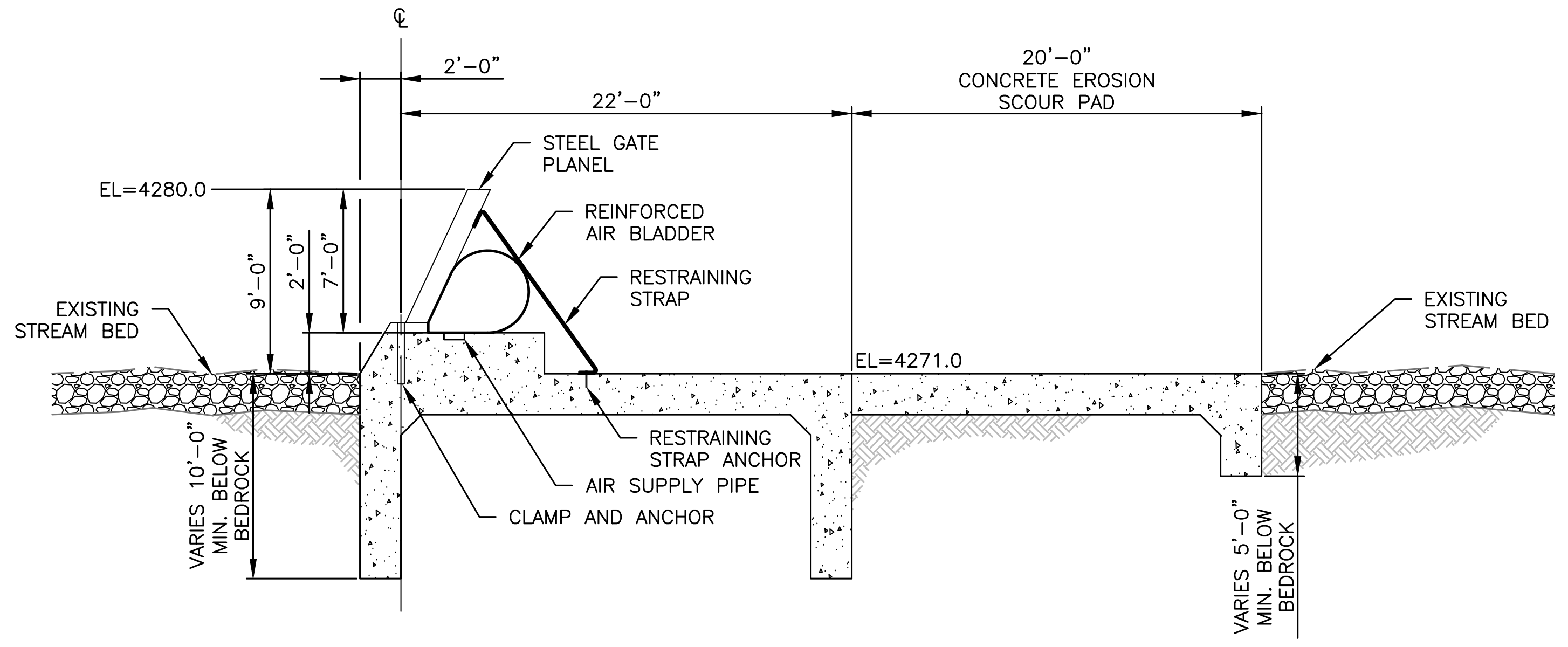
Q = 470 C.F.S
D = 3.1 FEET
V = 5.1 F/S

RATING TABLE

Q C.F.S.	D FEET
100	1.24
200	1.87
300	2.36
400	2.78
500	3.16

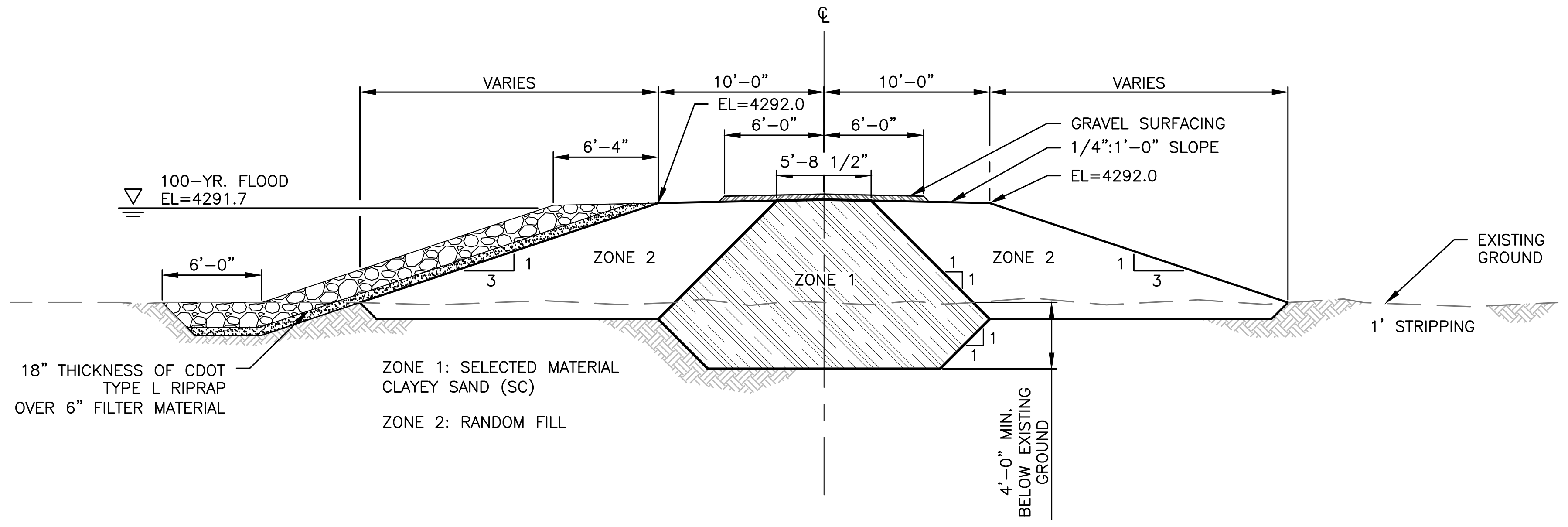
UPPER PLATTE AND BEAVER CANAL TYPICAL SECTION F-F

770 L.F. AT 0.175%
NOT TO SCALE



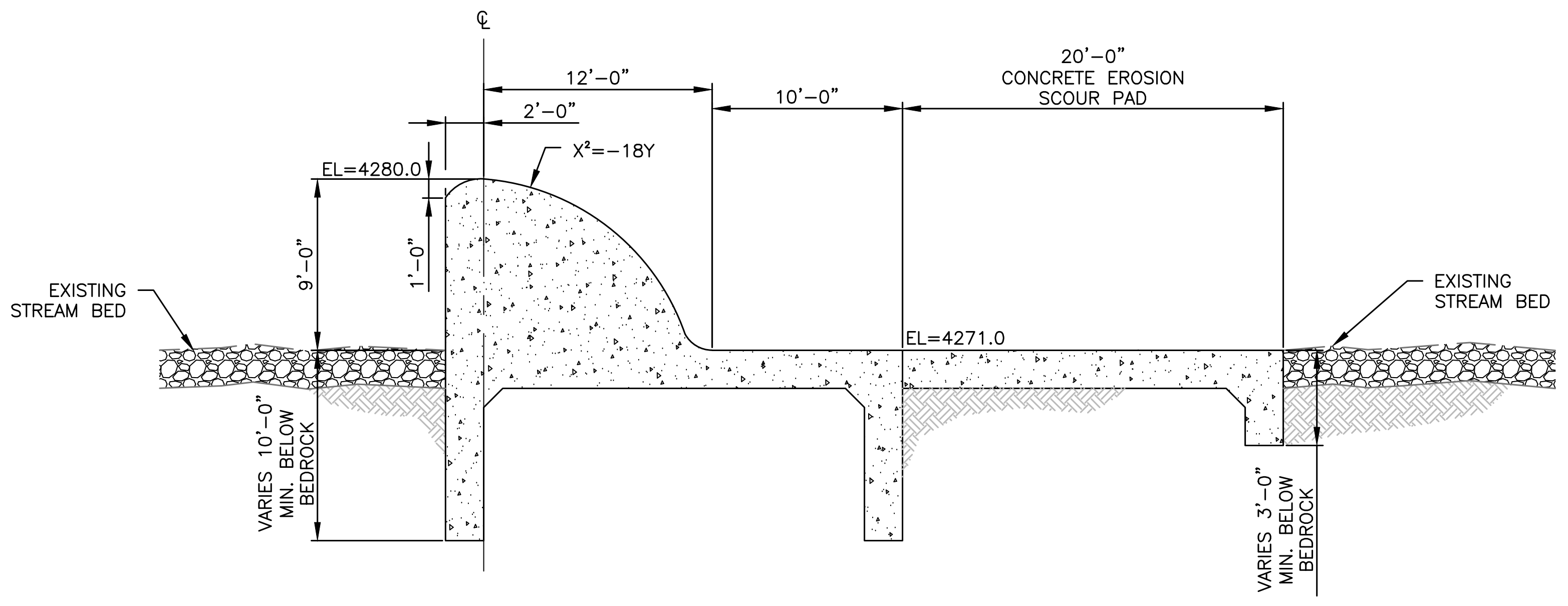
BLADDER DAM TYPICAL SECTION G-G

NOT TO SCALE



SOUTH FLOOD DIKE TYPICAL SECTION E-E

NOT TO SCALE



CONCRETE DAM TYPICAL SECTION H-H

NOT TO SCALE

DRAWN BY VJG
DESIGNED BY JDA
DATE 06-27-16
JOB NUMBER-TASKS 0414617.01
BOOK AND PAGE

REVISIONS

TZA Water Engineers
a Lamp Rynearson Company
12596 West Bayaud Avenue, Suite 330 303.971.0030 | P
Lakewood, Colorado 80228 303.971.0077 | F
LRA-Inc.com / tza4water.com

UPPER PLATTE AND BEAVER / DEUEL & SNYDER FEASIBILITY STUDY
MORGAN COUNTY,COLORADO

PRELIMINARY PLAN
DIVERSION DAM ALTERNATAVES
ALTERNATIVE 2
TYPICAL SECTIONS AND DETAILS

PRELIMINARY

NOT RELEASED FOR CONSTRUCTION
JOHN D. ALLIS

811 Know what's below. Call before you dig

SHEET
5 OF 5

P:_Engineering\0414617 Platte and Beaver Ditch\DRAWINGS\PRODUCTION\0414617-DET-101.dwg, 7/12/2016 2:57:00 PM, VINCENT GENTRY, LAMP RYNEARSON & ASSOCIATES

Appendix B Visual Inspection

January 27, 2016

Lamp Rynearson & Associates, Inc.
dba TZA Water Engineers
Attn.: Mr. John Allis, PE
Senior Project Manager
12596 W. Bayaud Avenue
Suite 330
Lakewood, CO 80228
303.971.0030

Subject: Upper Platte and Beaver Diversion Dam,
Site Visit Letter Report

Dear Mr. Allis:

Gannett Fleming is pleased to provide this letter report as required by the agreement between Gannett Fleming, Inc. and Lamp Rynearson & Associates, Inc. (dba TZA Water Engineers) dated 17 November 2015. This letter is considered is to be Deliverable No. 1 as defined in the scope of work, and documents the observations made by Mr. Guy S. Lund, PE, Gannett Fleming, during the site visit to the Upper Platte and Beaver Diversion Dam on 9 December 2015. The diversion structure is located on the South Platte River just northwest of the town of Fort Morgan, CO.

1.0 Site Visit

The Upper Platte and Beaver Diversion Dam is located west-northwest of Ft. Morgan, Colorado. An aerial view of the project is show in Figure 1 of Attachment A. The Diversion Dam primarily consists of three (3) sections, which have been for this letter report are called the Northern, Diagonal, and Southern Sections.

Photographs taken during the site visit are contained in Attachment A to this letter. The approximately location of the photographs with respect to the dam features is shown in Figure 2 of Attachment A.

The site visit of the Upper Platte and Beaver Diversion Dam was performed on 9 December 2015.

Releases through the spillway slide gates was approximately 720 ft^3/sec. The weather was sunny, with temperatures ranging from the lower 30s to middle 40s degrees Fahrenheit (°F).

The inspection team consisted of the following individuals:

Table 5-1
Site visit Participants
December 9, 2015

Name	Affiliation	Phone
John Allis, P.E.	TZA Water	720.692.7031
Tom Dea, P.E.	TZA Water	303.971.0030
Kevin Mininger	RJH Consultants	303.515.1640
Bob Simons	Simons & Associates	970.988.2880
Philip Mortensen	UP&B Canal Co.	970.768.2656
Brad Mortensen	UP&B Canal Co.	970.380.8961
Brian Rosenbrock	UP&B Canal Co.	970.380.0185
Everett Matheny	UP&B Canal Co.	970.380.3973
Guy S. Lund, P.E.	Gannett Fleming, Inc	303.242.9792
Aimee L. Corn	Gannett Fleming, Inc.	303.242.9792
Dan Kendrick	D&S Canal Co.	970.768.3265
Sumner Rule	D&S Canal Co.	303.809.3784

2.0 Site Observations

The condition of the structures were classified using the following terms:

Excellent	Visual appearance is nearly the same as post-construction. There are no problems with operation, and the features operate as intended in the design. Maintenance requirements are equal to or less than intended in the design.
Good	Visual appearance shows minor deterioration (i.e., concrete shrinkage cracks, weather related joint openings, etc.), which would be considered normal for structures and systems of similar age. Operation is normal, considering the age, and the structure performs its intended function. The maintenance is minor (i.e., lubricating, painting, cleaning, etc.).
Satisfactory	Visual appearance shows deterioration, probably due to age, weathering, or minor weakened structural integrity (i.e., freeze-thaw, cracking, corrosion,

	loss of material, etc.). No visual observations are made that would indicate the structure has a reduced capacity for design loads. The system operates but may require manipulation and/or modifications to perform the intended procedure. Maintenance and repairs are required and are considered to be normal or slightly greater than typical.
Poor	Visual appearance shows significant deterioration, and there may be a reduction in the structural integrity from original design. The operation of the facility is very difficult or inoperable. The facility requires rehabilitation (repair or replacement) for adequate operation. Maintenance costs are a concern for the owner.
Unsatisfactory	Visual appearance shows major deterioration or imminent failure, such that there is an immediate concern for the safety of Development staff and/or public. This condition may require an immediate action.

2.1 Northern Section

The Northern Section of the dam consists of the intake structure to the Upper Platte and Beaver Canal and the north buttress section. The intake structure is located upstream of the dam on the left (north) abutment. The axis of the north buttress section is approximately north-south, and extends from approximately Station (Sta.) 14+16 at the left (north) abutment to Sta. 12+65, based on the survey performed during December 2015.

2.1.1 North Buttress Section

The inspection of the north buttress section was performed from the right abutment, and the downstream river channel. Based on the visual observations during the site visit, the structure is considered to be in poor condition primarily due to the following reasons:

- Erosion has undermined the toe of the downstream base slab, as shown in Photo No. 2. A closer view of the undermining erosion is shown in Photo No. 15. The undermining has reduced the kinematic (i.e., overturning or sliding) stability of the section, which is directly related to the condition of the concrete base slab on the foundation.
- Concrete deterioration of the downstream base slab, as shown in Photo No. 3. The deterioration may provide a path for water to flow to the foundation, and potentially contribute to the erosion.

Repair of the concrete base slab is considered important to restore the kinematic stability of the section. The concrete base slab should be repaired so as to provide protection against foundation erosion. In addition, it is recommended that a cutoff wall be constructed at the downstream toe of the base slab to provide protection against undermining erosion.

2.1.2 Intake Structure for Upper Platte and Beaver Canal

The inspection of the intake structure to the Upper Platte and Beaver Canal was performed from crest of the structure and the downstream area adjacent to canal. The structure is shown in Photo No. 14.

Based on the visual observations during the site visit, the intake structure is considered to be in good condition. There were no significant deterioration or deficiencies noted. However, the canal was not operating, and so these observations do not reflect any issues that may develop due to operation.

3.0 Diagonal Section

The diagonal section of the dam consists of a transition section and the central buttress section. The transition section facilitates the approximately 135 degree horizontal bend in the axis of the dam. The section abuts against the north buttress section at approximately Sta. 12+65.

The central buttress section extends in the south-east direction from the transition section. The length of the central buttress section is approximately 747 feet, extending from approximately Sta. 12+00 (at the transition section) to Sta. 4+53.17.

3.1 Transition Section

The inspection of the transition section was performed from the area downstream of the structure, as shown in Figure 2, Photo No. 4 and Photo No. 16. Based on the visual observations from the site visit, the transition section is considered to be in satisfactory to poor condition. Although there are areas of concrete where deterioration has developed (i.e., along the top of the buttresses and vertical walls and base of the buttresses as shown in Photo No. 16 and Photo No. 17), it is not considered to be sufficient to reduce the structural capacity.

The poor condition rating is primarily due to the undermining erosion visible beneath the concrete base slab, as shown in Photo No. 4 and Photo No. 16. The undermining needs to be repaired to restore the kinematic stability. The repair should include construction of a cutoff wall at the downstream toe of the base slab to provide protection against undermining erosion.

3.2 Central Buttress Section

The inspection of the central buttress section was performed from the downstream river channel, and the downstream concrete slab where accessible, as shown in Photo No. 5 through Photo No. 8. The central buttress section was considered to be unsatisfactory condition due to the following observations:

- There has been significant erosion that has undermined the toe of the concrete base slab. The loss of foundation material beneath the base slab has resulted in the structural failure of the slab is many area, as shown in Photo No. 18, Photo No. 19 and Photo No. 20. The failure of slab has likely reduced the kinematic stability of the structure.
- Deteriorated condition of reinforcing steel in concrete slab. As shown in Photo No. 20, the structural failure of the base slab, in conjunction with the undermining erosion, has resulted insignificant deterioration of the reinforcement steel. Based on visual observations, it appears that the current condition of the reinforcement steel is inadequate for the base slab. The loss in capacity would result in reduced kinematic stability for the structure.
- Potential deterioration in wall slabs. There were several areas where seepage had developed through the wall slab, as shown in Photo No. 21. The seepage could result in corrosion of the reinforcement steel, which would potentially reduce the structural capacity of the wall slab.

Repair of the concrete base slab is considered important to restore the kinematic stability of the section. Repairs to the concrete base slab should be sufficient to protect the foundation against erosion during high flow, or overtopping events. In addition, it is recommended that a cutoff wall be constructed at the downstream toe of the base slab to provide protection against undermining erosion.

Evaluations should be performed to assess the potential effects of reinforcement steel corrosion in the wall slab due to seepage. The evaluations should determine if a potential reduction in structural capacity of the wall slab is a concern for the diversion dam.

4.0 Southern Section

The Southern Section consists of the intake structure to the Duel and Snyder Canal, spillway drop gate structure, and south buttress section. The alignment of the southern section is in approximately the north-south direction.

The south buttress section extends from the southern tip of the diagonal section to the spillway drop gate structure (see Photo No. 8). The length of the south buttress section is approximately 270 feet, from approximately Sta. 4+50 (where it abuts to the central buttress section) to approximately Sta. 1+80 (abuts to drop spillway gate structure).

The spillway drop gate structure is located to the right (south) side of the south buttress section, and contains two drop gates and one radial gate that are used to release flows into the downstream river channel (see Photo No. 10, Photo No. 11, and Photo No. 13).

The intake structure for the Duel and Snyder Canal is located just upstream of the dam, on the right (south) abutment. The upstream face of the intake structure is shown in Photo No. 12.

4.1 South Buttress Section

The inspection of the south buttress section was performed from the crest of the structure and the downstream channel. Photo No. 9 shows a view of the south buttress section from the downstream river channel. Photo No. 22 through Photo No. 25 show the general condition of the structure. Based on observations taken during the site visit the south buttress section is considered to be poor to unsatisfactory condition, due to the reasons listed below:

- Erosion has undermined the toe of the downstream base slab, as shown in Photo No. 22, and has exposed the shear keys beneath the slab (inset to Photo No. 22). The erosion has reduced the kinematic stability of the section and will need to be repaired.
- Significant concrete deterioration of the buttresses and concrete base slab, as shown in Photo No. 23. The deterioration has led to corrosion of reinforcement steel, and likely reduced the kinematic stability of the structure.
- Concrete deterioration of Walkway Bridge, as shown in Photo No. 24.

Repair of the concrete base slab is considered important to restore the kinematic stability of the section. The concrete base slab should be repaired so as to provide protection against foundation erosion, and should include a cutoff wall at the downstream toe to provide protection against undermining erosion.

In addition, the concrete buttresses and concrete walkway bridge should be repaired.

4.2 Spillway Drop Gate Structure

The inspection of the spillway drop gate structure was performed from the crest of the structure, and the downstream river channel, as shown in Photo No. 10 and Photo No. 11. The drop gate structure appears to be in satisfactory condition.

During the site visit, one gate was open (up position) and releasing water while the other gate was closed (down position).

4.3 Intake Structure for Duel and Snyder Canal

The inspection of the intake structure was performed from the crest of the structure, and both the upstream and downstream areas on the right (south) abutment, as shown in Photo No. 12. The intake has no visual signs of deterioration or deficiencies and was considered to be in good to satisfactory condition.

Thank you for the opportunity to work with you on this project. If you require any additional services, or have questions, please don't hesitate to call me at (303) 242-9792.

Sincerely,

Guy S. Lund, P.E.
Principal Engineer
Gannett Fleming, Inc.

Gannett Fleming
100 Years
of Excellence Delivered **As Promised**

Attachment A
Site Visit Figures and Photographs

Gannett Fleming, Inc.
N Central Ave, Suite 1900, Phoenix, AZ 85012
t 602.553.8817 | **f** 602.553.8816 |
www.**gannettfleming**.com

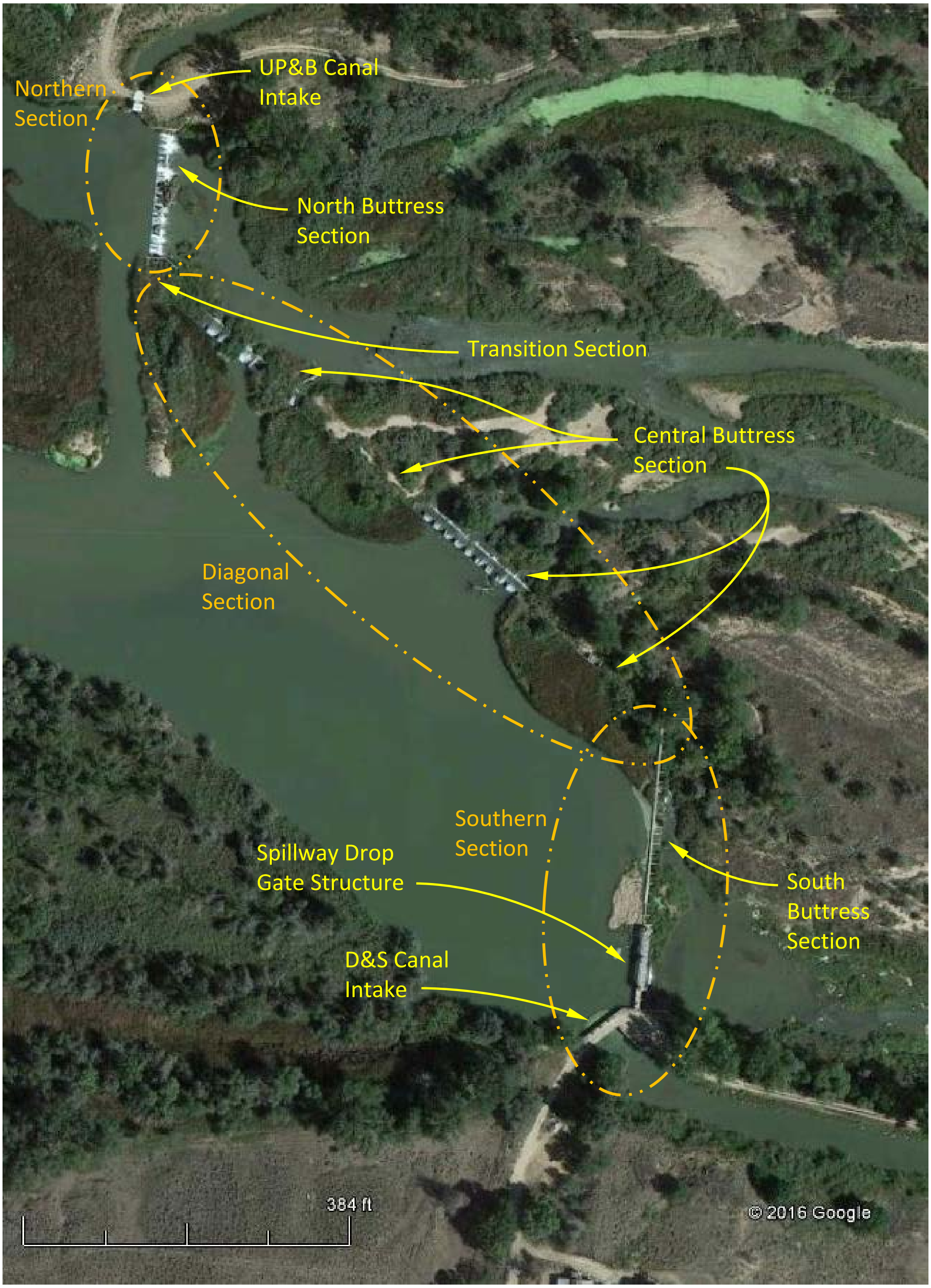


Figure 1 Aerial view of the Upper Platte and Beaver Diversion Dam.

UPPER PLATTE AND BEAVER DIVERSION DAM

Inspection Photographs

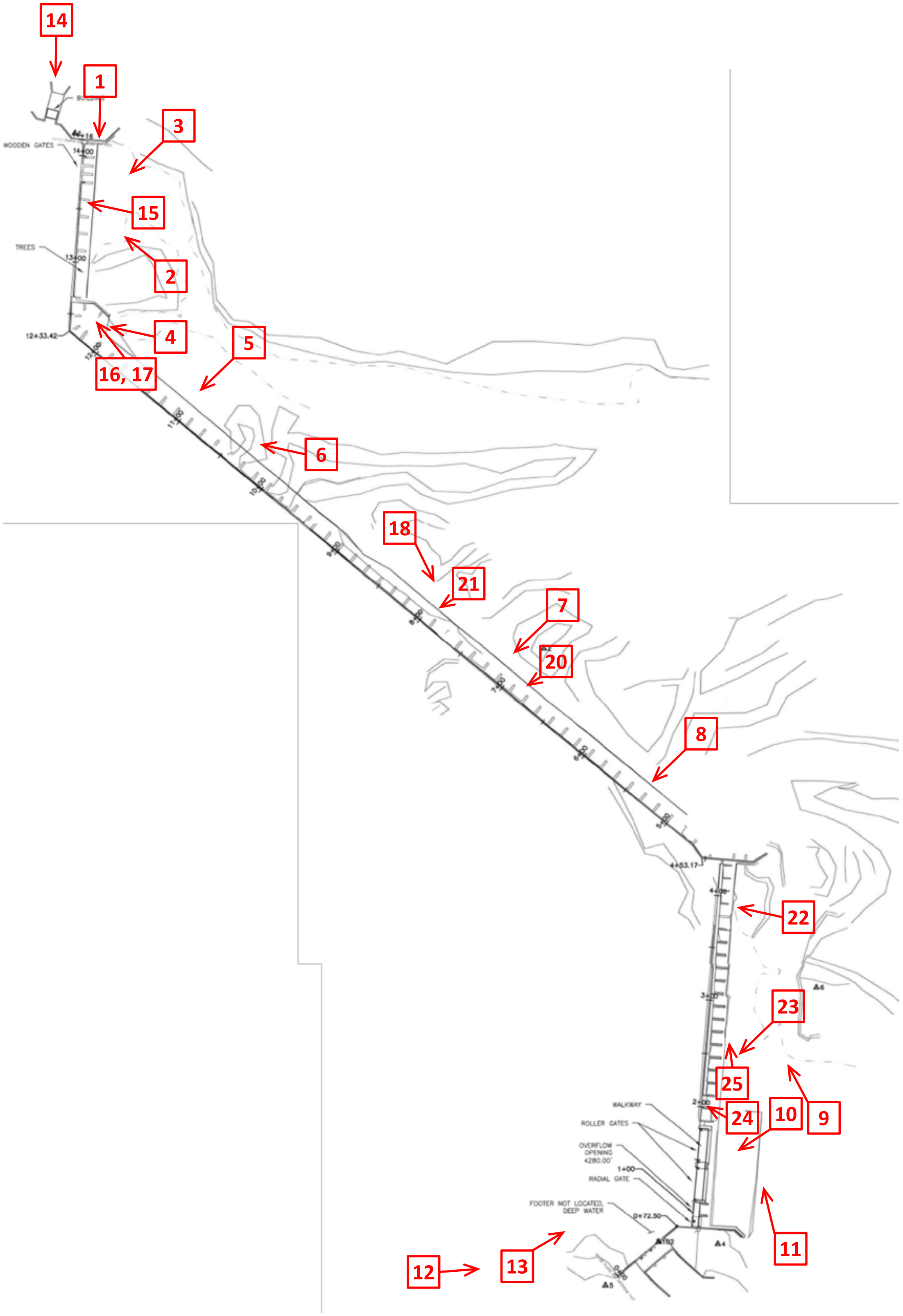


Figure 2 Approximate location of photograph taken during site visit.

UPPER PLATTE AND BEAVER DIVERSION DAM

Inspection Photographs

Photo No. 1 North Buttress Section. View of taken from left (north) abutment, looking south. There is significant reservoir sedimentation upstream of the dam, and woody debris on the crest from previous flood events.

Photo No. 2 North Buttress Section. View of the upstream slab and buttresses, taken from the downstream channel.

Photo No. 3 North section looking upstream towards north abutment.

Photo No. 4 Transition Section. View looking northwest into the transition section of the dam.

Photo No. 5 Diagonal Section. View looking at the downstream side of the diagonal section, taken near Sta. 11+00.

Photo No. 6 Diagonal Section. View looking northwest, toward approximately Sta. 10+00.

Photo No. 7 Diagonal Section. View taken from downstream channel area, looking toward approximate Sta. 6+00.

Photo No. 8 Diagonal Section. View taken from downstream channel area, looking towards approximate Sta. 5+00.

Photo No. 9 South Section. View looking upstream at the south buttress section.

Photo No. 10 South Section. View from downstream channel looking upstream at the spillway slide gate structure.

Photo No. 11 South Section. Looking at the spillway drop gate structure and the south buttress section, taken from the downstream right (south) abutment.

Photo No. 12 South Section. Upstream face to the Duel & Snyder canal intake structure

Photo No. 13 South Section. View looking downstream from abutment at the upstream face of the spillway drop gate structure.

Photo No. 14 North Section. View of the Upper Platte and Beaver Canal intake structures, taken from the canal, just downstream of the structure..

Photo No. 15 North Section. Closer view of the north buttress section, taken from the downstream channel.. Note, undermining (erosion) beneath the downstream slab.

Photo No. 16 Transition Section. Deterioration and undermining on the transition section. Taken looking towards the north section. Inset shows close up view of typical deterioration along top of buttress and slab walls.

Photo No. 17 Transition Section. Seepage through construction joint in upstream slab, and deterioration at base of buttress.

Photo No. 18 Diagonal Section. View shows typical undermining erosion that resulted in collapse of base slab.

UPPER PLATTE AND BEAVER
DIVERSION DAM

Inspection Photographs

Photo No. 19 Diagonal Section. View of failed base slab, due to undermining (erosion) of foundation material from beneath the slab.

Photo No. 20 Diagonal Section. Closer view of the deterioration of base slab. Note, exposed and deteriorated reinforcement. .

Photo No. 21 Diagonal Section. Inspection observed ice (from ponding) on the downstream slab in the central section as shown above. Inset photograph shows seepage through the upstream wall slab that caused the pool to develop.

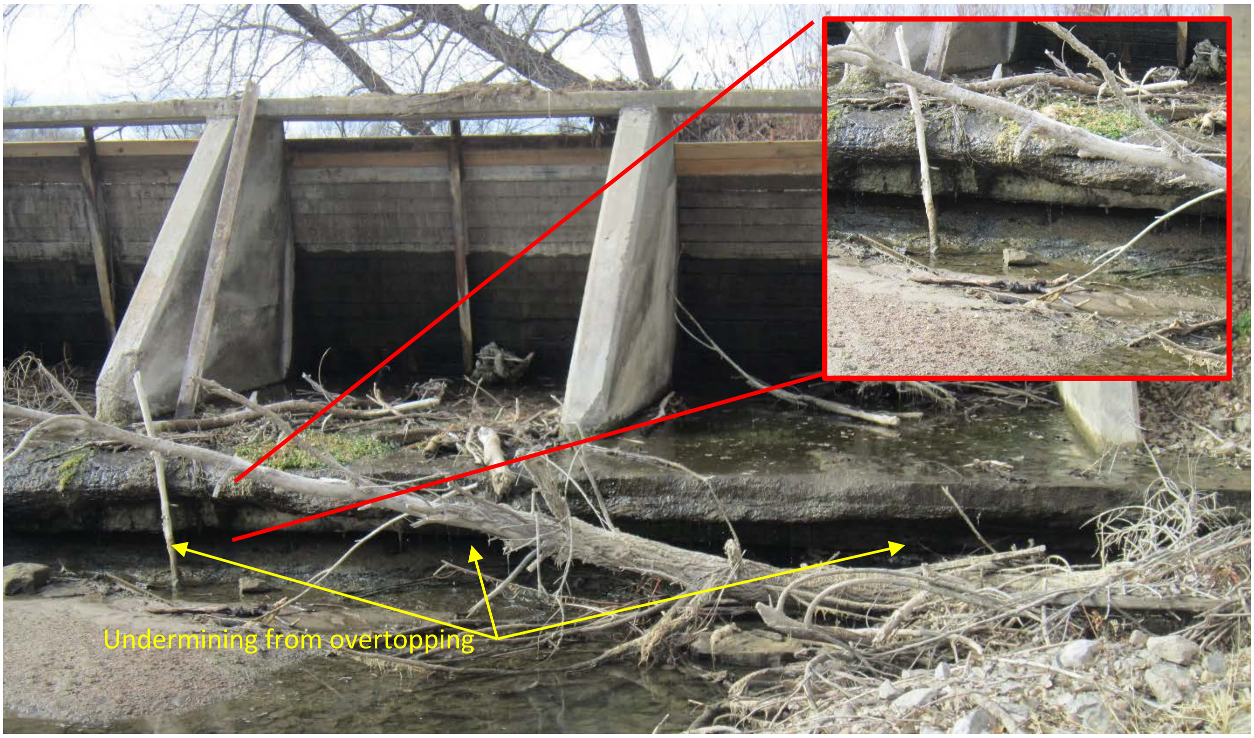


Photo No. 22 South Section. Closer view of the south buttress section, showing undermining (erosion) of foundation material beneath base slab. Note, the view shows exposed shear key (inset). .

Photo No. 23 South Section. View shows concrete deterioration of buttress (inset).

Photo No. 24 South Section. View showing deteriorated walkway that spans south buttresses and leads from the drop gate structure.

Photo No. 25 South Section. View showing exposed reinforcement in bottom slab of the south buttress section.

Appendix C Geophysical Survey

INFRASTRUCTURE IMAGING AND NDE
ASSESSMENT, MONITORING AND REPAIR

Olson
ENGINEERING

Corporate Office:
12401 W. 49th Ave.
Wheat Ridge, CO 80033-1927 USA
phone: 303.423.1212
fax: 303.423.6071

February 17, 2016

TZA Water Engineers
12596 W Bayaud Ave., Ste. 330
Lakewood, CO 80228

Attn: John Allis Jr., P.E.
Office: 303.971.0030
Email: jallis@tza4water.com

Re: Geophysical investigation on the Upper Platte & Beaver / Deuel & Snyder Feasibility Study, Morgan County, CO
Olson Project No. 5203A

Olson Engineering, Inc. (Olson) conducted a geophysical investigation for TZA Water Engineers (TZA) as part of the Upper Platte & Beaver / Deuel & Snyder Feasibility Study located in Morgan County, CO (Figure 1). The objectives of the investigation were to determine the thickness of unconsolidated alluvial sediments overlying the shale bedrock, and to determine the lateral and vertical variability of stiffness in the overburden and the shale bedrock. Olson initially planned to meet these objectives by using multichannel analysis of surface waves (MASW). It was anticipated that the shallow ground water on the site would make MASW more effective than Seismic Refraction Tomography (SRT) due to the effect soil saturation can have on SRT. However, data were collected in a manner that allows for MASW and/or SRT processing. In the data processing stage, it was determined that SRT was more effective than MASW, and therefore SRT was used to generate all of the results and interpretations presented in this report.

A total of six seismic lines, totaling 1,860 linear feet of geophysical coverage, were collected (Figure 2). The seismic survey was performed based on the scope of work outlined in Olson Proposal No. P2015334.1PG. Field work was conducted December 3rd and 4th, 2015 by Olson geophysicists Paul Schwering, Jacob Sheehan, and Miriam Moller. The following report presents results from the investigation and summarizes the site conditions, data acquisition, processing procedures, and interpretation approach. For further information regarding the intricacies of the MASW or SRT methods used for this investigation, Olson can submit a method addendum, per method, to this report upon request.

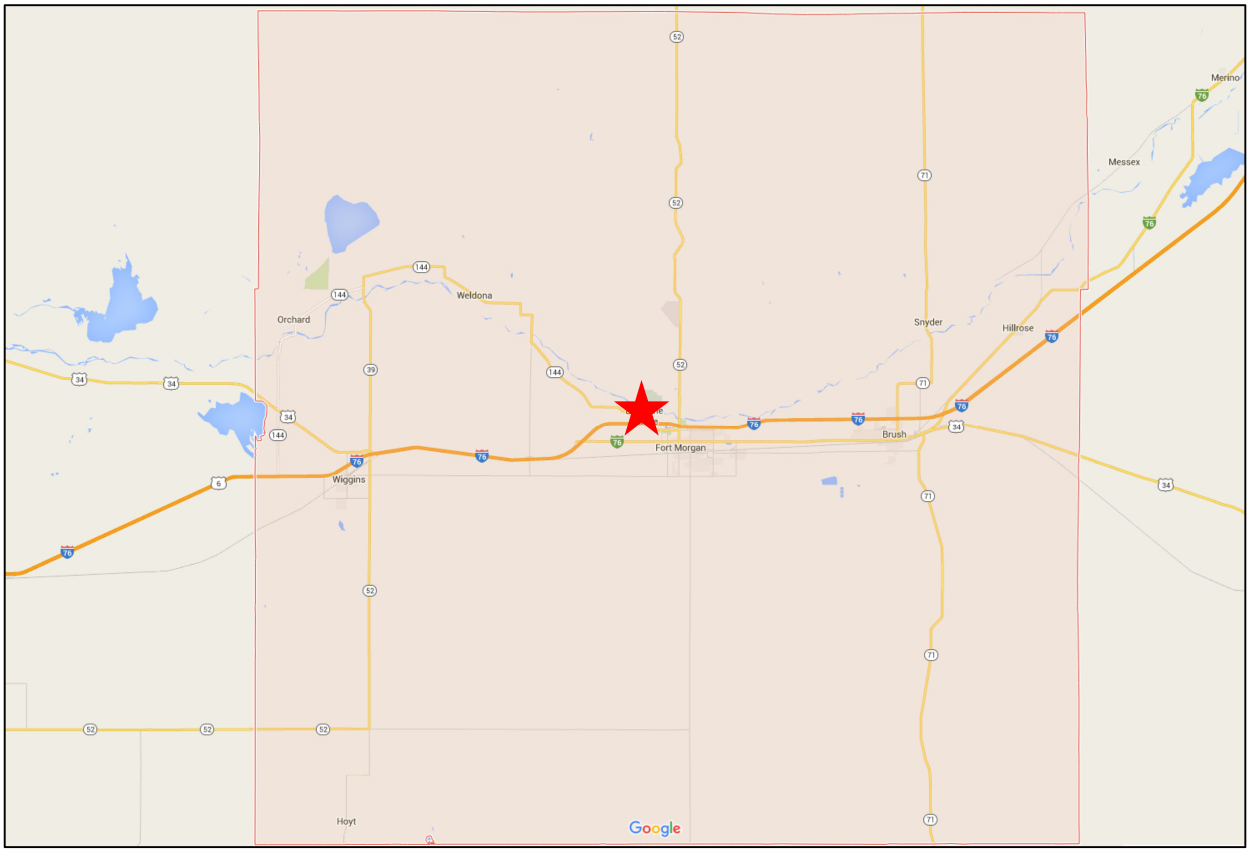


Figure 1: Map of Morgan County (outlined in red) showing approximate location of the investigation area (red star).

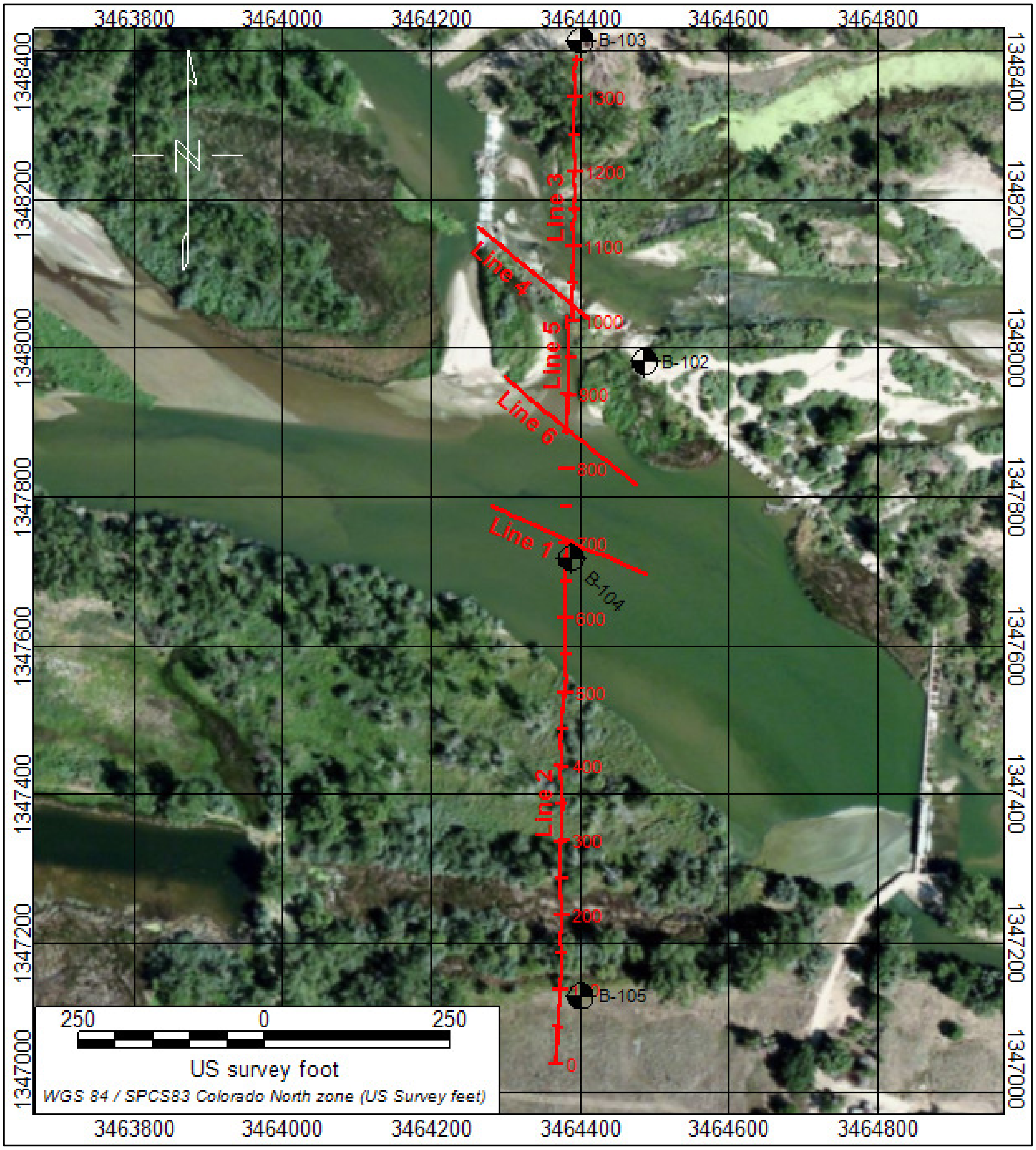


Figure 2: Aerial view of the six seismic line locations (red lines) and proximal borehole locations (black crosshairs). Note the aerial imagery (courtesy Bing Maps) does not reflect the conditions encountered during the investigation.

Site Conditions

The site ranged from minimally- to heavily-vegetated. The terrain was generally mild/rolling except for the dam crossing between Lines 3 and 5. The South Platte River was being drained/diverted such that the river channel was flowing between Lines 1 and 6 at the time of the investigation. The recent lowering of the water level combined with recent precipitation made large portions of site very muddy and difficult to traverse (*inset photo from this investigation at right*). Line 4 was positioned on the concrete along the downstream toe of the dam. RJH Consultants, Inc. (RJH) supplied Olson with lithologic data from four boreholes located proximal to the seismic lines (Figure 2). The general geologic composition at the site is overburden on bedrock. The overburden is comprised primarily of sandy alluvium. Bedrock at the site is generally flat-lying sandstone and/or siltstone.

Method

In a SRT survey, an impulse (shot) is imparted to the ground (e.g., via a sledge hammer) and the seismic waves generated by the impulse are detected along an array of receivers (geophones). The propagation of seismic waves is governed by the stiffness of the soils or the hardness of rock formations. The variability of the soil deposits can be mapped laterally, and depth to competent bedrock can be imaged, with a modeling process called tomographic inversion. For this project, P-wave energy was used for the analysis.

Data Acquisition

Initially, the data were collected and processed for both passive- and active-source MASW. However, the passive-source MASW data was unusable at this particular site and the active-source MASW results proved inconclusive as stand-alone results. Therefore, the same seismic data was also processed using the SRT approach. The SRT results proved to be more useful for interpretation and presentation.

Seismic data were acquired using one (Lines 1, 4, 5, and 6) or two (Lines 2 and 3) Geometrics Geode 24-channel seismographs (*inset photo from this investigation at left*) with up to forty-eight 4.5 Hz vertical component geophones spaced at a 10 foot interval. Data were recorded on a Panasonic Toughbook laptop. Acquisition parameters of the seismic system consisted of 2 second records sampled at a 0.125 millisecond (ms) rate. Shot points were located every 30 feet. A sledge hammer impacting a plastic strike plate was used to generate seismic energy.

The six seismic lines were positioned and oriented in the field based on recommendations of TZA personnel and accessibility/safety constraints. The location and orientation of each line was measured with a Trimble GeoHX 6000 series GPS unit capable of sub-meter spatial precision. Lines were numbered sequentially in the order they were acquired.

Data Processing

The refraction data from this project were processed using Rayfract, version 3.33, by Intelligent Resources, Inc. The two major processing steps involved with SRT are first arrival picking and data inversion. The first arrival picking step consists of picking the time for each trace (signal) where the first arrival of wave energy is observed at that geophone position. Figure 3 illustrates the picking approach used for SRT records, with an example acquired during this investigation. After picking is completed, a two-dimensional (2D) P-wave velocity (Vp) model is generated that best fits the first arrival picks by iteratively modifying a Vp grid model until the misfit between the modeled and real travel time values is minimized, subject to smoothing constraints.

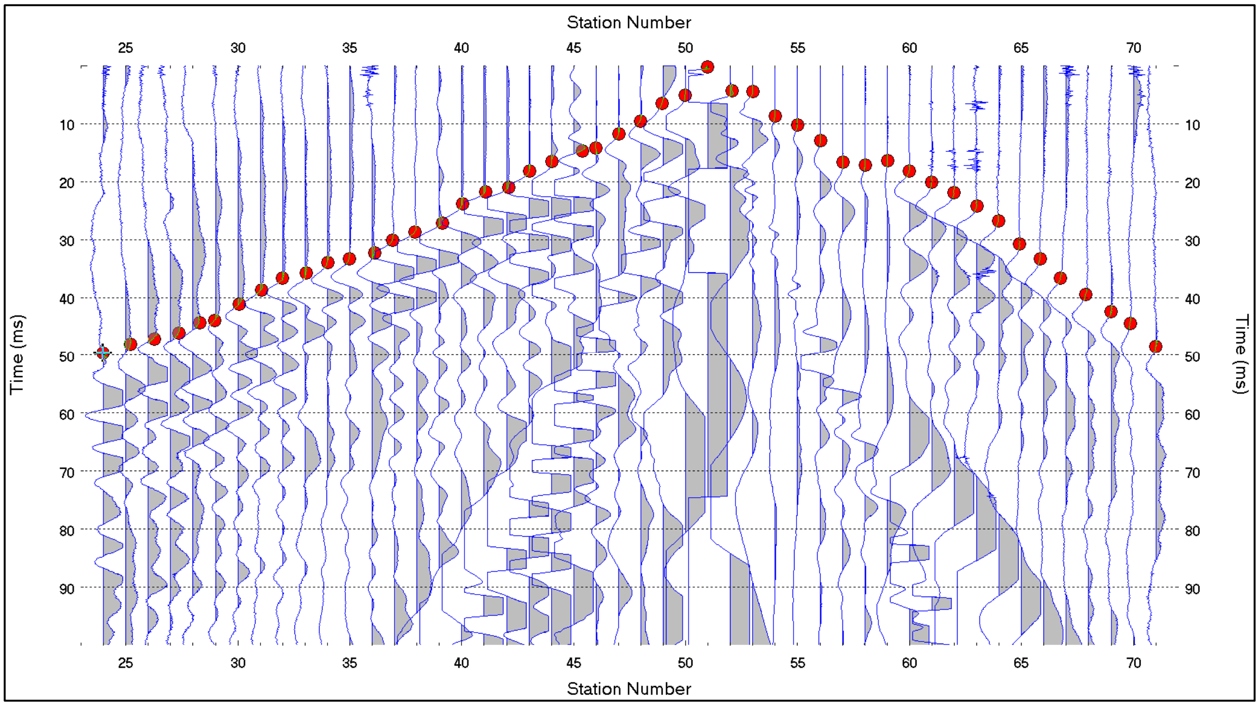


Figure 3: Example first arrival picking (red circles) of a sample SRT record from this investigation.

Results and Discussion

The 2D interpretive geophysical results for the SRT lines are presented in Figure 4 at the end of this report; the figure is 11x17 inches. The Vp profiles are presented with ‘cool’ colors (e.g., blue) representing lower velocity values and ‘warm’ colors (e.g., red) representing higher velocity values. The horizontal (distance) and vertical (elevation) dimensions (as measured by GPS) are shown in feet, at 2x vertical exaggeration. In the lower left corner of the figure is a location map showing the seismic lines (red; see also Figure 2). Note that no results are presented from Line 4, as the SRT data from this line proved to be unusable. This is most likely because this line was collected on top of a cement slab on the downstream side of the dam. Although MASW can often image through concrete slabs, SRT often cannot.

Lithologic logs from the boreholes, provided to Olson by RJH, are overlain on the profiles at their approximate horizontally-projected positions along each line. Elevation data for the boreholes were provided by TZA. The borehole log for B-101 is not included on the seismic profile, as the borehole was drilled too far away from the seismic line for the borehole log to be of any correlative/interpretive use. The projected location of B-102 is included on the profile of Lines 3 and 5. As noted on Figure 4, the borehole is located approximately 100 feet off-line.

The Vp models are interpreted based on velocity gradient analysis and correlation to the borehole logs. A high velocity gradient is indicated by a rapid change in seismic velocity over a short depth range. Velocity gradients are indicative of transitions to harder layers, although not necessarily indicative of geologically distinct layering. It is important to note that refraction tomography will always produce a gradient at a velocity transition or geologic/layer interface, no matter how sharp the interface is physically. The 2D Vp profiles have been annotated to highlight two interpretive velocity contours; the dashed line represents a Vp of approximately 4,000 feet per second (ft/s), and the solid line represents a Vp of approximately 6,000 ft/s.

Seismic results and borehole logs from on the south side of the river are indicative of two geologic interfaces. The logs from B-104 and B-105 indicate that the alluvial sand layer is underlain by a layer of soft clayey sandstone. This uppermost soft bedrock layer overlies a thin layer of hard sandstone. Below the hard sandstone is a layer of soft clayey/silty sandstone grading to sandy claystone. On Line 2, the 4,000 ft/s contour correlates well with the top of the upper soft bedrock layer, and the 6,000 ft/s contour correlates with depth of the thin hard sandstone layer. On Line 1, the 4,000 ft/s contour is shallower than the top of the soft bedrock encountered by B-104. The heavily saturated soils observed on Line 1 likely resulted in an apparent velocity increase of the sand, as the Vp contour appears to correlate more closely with the water table depth at this location.

On the north side of the river, however, only one geologic interface appears to have been resolved due to a lateral change in bedrock composition. B-102 and B-103 indicate that there is no soft bedrock overlying the thin hard sandstone layer. In B-102, the hard sandstone layer is at the top of the borehole log. Comparison of these logs with the seismic results from Lines 3 and 5 indicates that the 4,000 ft/s contour again correlates with the top of bedrock, regardless of the change in bedrock composition from Line 2. As a result, the 6,000 ft/s contour does not to correlate to any geologic interfaces encountered by the boreholes. It thus does not appear to have any interpretive value on the north side of the river, but is shown on the results from Line 3, 5, and 6 for consistency.

Closure

The geophysical methods and field procedures defined in this report were applicable to the project objectives and have been successfully applied by Olson to investigations of similar size and nature. However, sometimes field or subsurface conditions are different from those anticipated and the resultant data may not achieve the project objectives. Olson warrants that our services were performed within the limits prescribed for this project, with the usual thoroughness and competence of the geophysical profession. Olson conducted this project using the current standards of the geophysical industry and utilized in-house quality control standards to produce a precise geophysical survey.

The overall quality of the SRT data collected around the Upper Platte site was good, with minimal to moderate interference from the river. The SRT results correlate well to the borehole logs provided by RJH. The quality of the geophysical data and the good correlations to proximal borehole logs yields a high degree of confidence in the SRT results obtained and interpretations presented in this report. If you have any questions regarding the field procedures, data analyses, or the interpretive results presented herein, please do not hesitate to contact us. We appreciate working with you and look forward to providing TZA Water Engineers with geophysical and nondestructive testing (NDT) services in the future.

Respectfully,

Paul

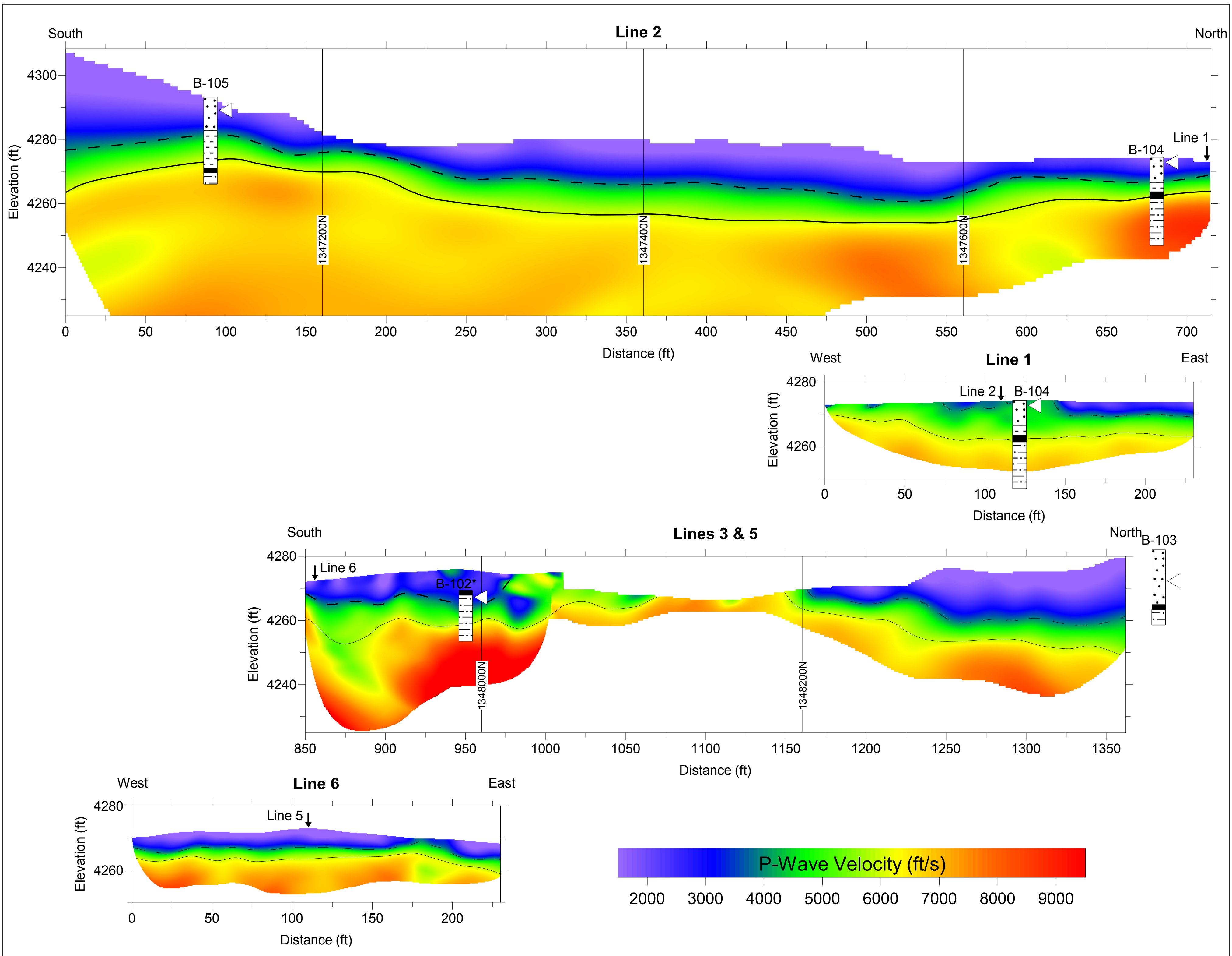
Paul Schwering
Geophysicist

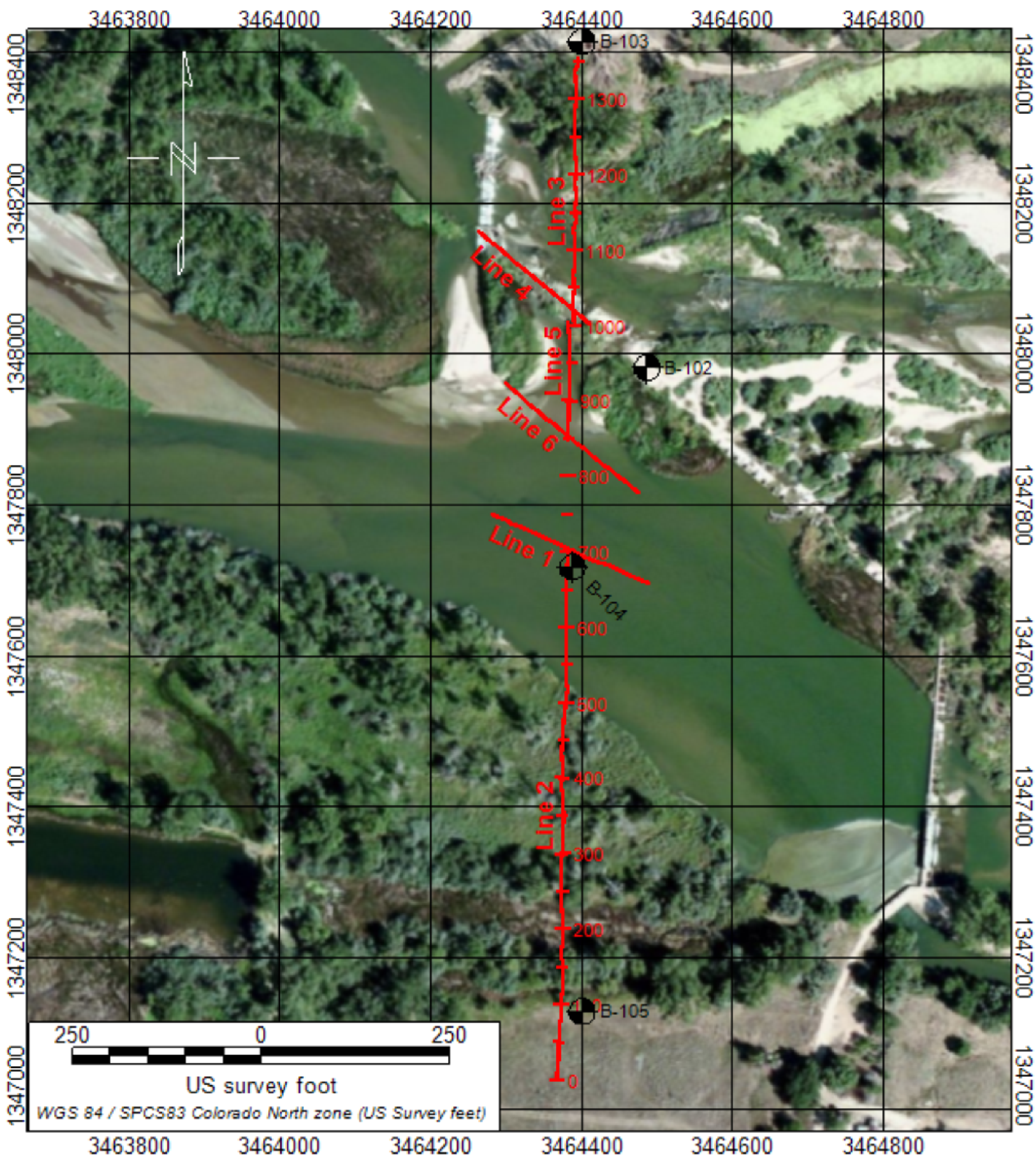
Reviewed by:

Jacob Sheehan

Jacob Sheehan
Senior Geophysicist

(1 copy e-mailed PDF format)





*Borehole B-102 is located approximately 100 ft east of Line 5.

Legend

⁘ Sand

⁘ Soft to very soft clayey sandstone

■ Hard sandstone

▤ Soft to very soft clayey or silty sandstone grading to sandy claystone

◁ Water table

~4,000 ft/s interpretive velocity contour

~6,000 ft/s interpretive velocity contour

◕ Borehole Location

TZA Water Engineers
12596 W Bayaud Ave., Ste. 330
Lakewood, CO 80228

Olson
ENGINEERING

Upper Platte & Beaver / Deuel & Snyder SRT Results

Job 5203A
February 2016

Figure 4

Appendix D Geotechnical Investigation

GEOTECHNICAL AND
WATER RESOURCES ENGINEERING

GEOTECHNICAL DATA REPORT

UPPER PLATTE AND BEAVER/DEUEL AND SNYDER FEASIBILITY STUDY

MORGAN COUNTY, COLORADO

Submitted to
TZA Water Engineers
12596 W. Bayaud Avenue, Suite 330
Lakewood, CO 80228

Submitted by
RJH Consultants, Inc.
9800 Mt. Pyramid Court, Suite 330
Englewood, Colorado 80112
303-225-4611
www.rjh-consultants.com

June 2016
Project 15140

Rodney W. Eisenbraun, P.E.
Project Manager

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APPENDICES

SECTION 1 - INTRODUCTION

1.1 Background

An existing diversion dam spans the South Platte River (River) approximately 1.75 miles upstream of Fort Morgan, Colorado. The diversion structure is located in Section 26 and 35 of Township 4 North, Range 58 West of the 6th Principal Meridian. The area of interest for this Geotechnical Data Report (Report) includes an area extending along the River from the existing diversion structure approximately 1.5 miles upstream to the confluence with Bijou Creek (Site) as shown on Figure 1.1.

The existing diversion structure enables the Upper Platte and Beaver Canal Company (UP&B) and the Deuel and Snyder Canal Company (D&S) to divert water into their respective intake structures. Portions of the existing structure were constructed over 80 years ago, and UP&B and D&S have modified and repaired the structure throughout its history to make it useable for both companies. Based on information from UP&B and D&S, the bedrock foundation immediately under the structure has eroded and this erosion has resulted in structural damage. This damage needs to be addressed to reduce the potential for the diversion structure to fail and to provide efficient operation of UP&B's and D&S's irrigation systems.

We understand that the objective of the Upper Platte and Beaver/Deuel and Snyder Feasibility Study (Project) being implemented by TZA Water Engineers (TZA) is to evaluate the existing diversion structure, its associated diversion components, and the foundation of the structure to develop and evaluate concept-level designs to repair or replace the structure.

1.2 Objectives of the Geotechnical Data Report

This Report presents geologic and geotechnical data collected and compiled by RJH Consultants, Inc. (RJH) and is intended to provide geotechnical information to support concept designs being developed by TZA. Additional geotechnical data will likely be needed for final design of the selected design concept.

1.3 Scope of Work

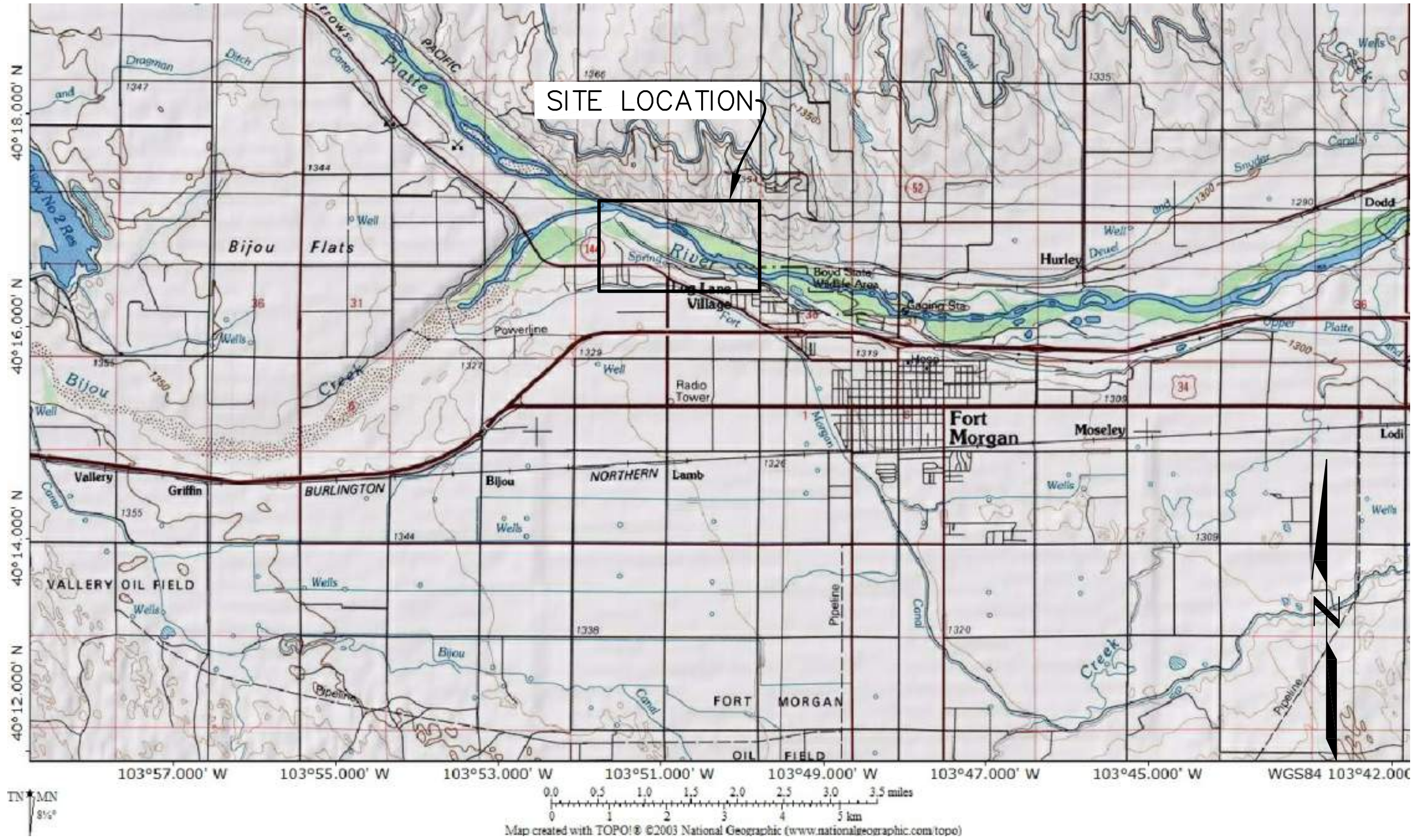
RJH performed the following services:

- Reviewed published and relevant geotechnical data and geologic maps pertaining to the vicinity of the Project.
- Participated in a Site visit on December 9, 2015.
- Reviewed available construction drawings of the existing structure.
- Drilled, logged, and sampled five exploratory boreholes.
- Collected shallow samples of River alluvium at three locations upstream of the existing structure.
- Performed laboratory tests on selected samples of soil and bedrock collected during subsurface exploration.
- Reviewed results of a geophysical investigation performed at the Site.
- Prepared this Report to present and summarize the geotechnical data.

1.4 Authorization and Project Personnel

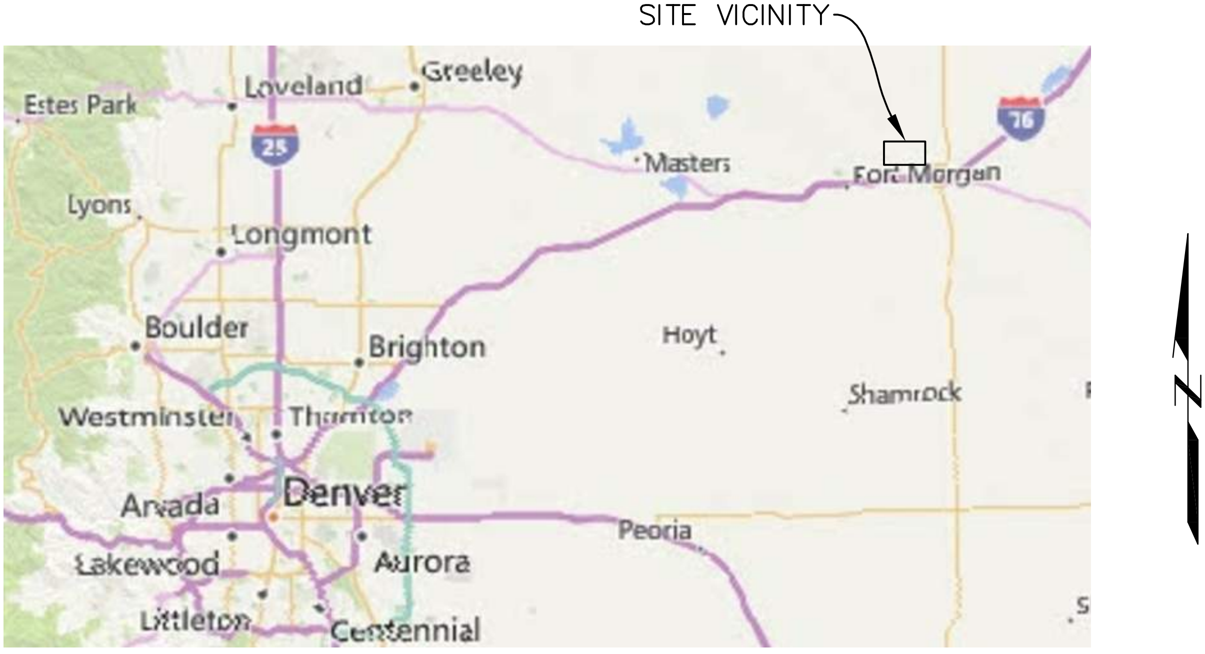
The work described in this Report was performed in accordance with the Sub-Consulting Agreement between TZA and RJH executed December 4, 2015. RJH personnel responsible for the execution of this work included:

Project Manager	Rodney W. Eisenbraun, P.E., PMP
Project Engineer	Kevin T. Mininger, P.G.
Technical Reviewer	Robert J. Huzjak, P.E.



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

LOCATION MAP



VICINITY MAP

NOT TO SCALE

RJH CONSULTANTS, INC.

UPPER PLATTE AND BEAVER/
DEUEL AND SNYDER
FEASIBILITY STUDY

SITE VICINITY MAP

PROJECT NO. 15140

June 2016

Figure 1.1

P:\15140 – UPPER PLATTE AND BEAVER FEASIBILITY\CAD\FIGURES\VICINITY MAP.DWG 6/16/2016 1:43 PM

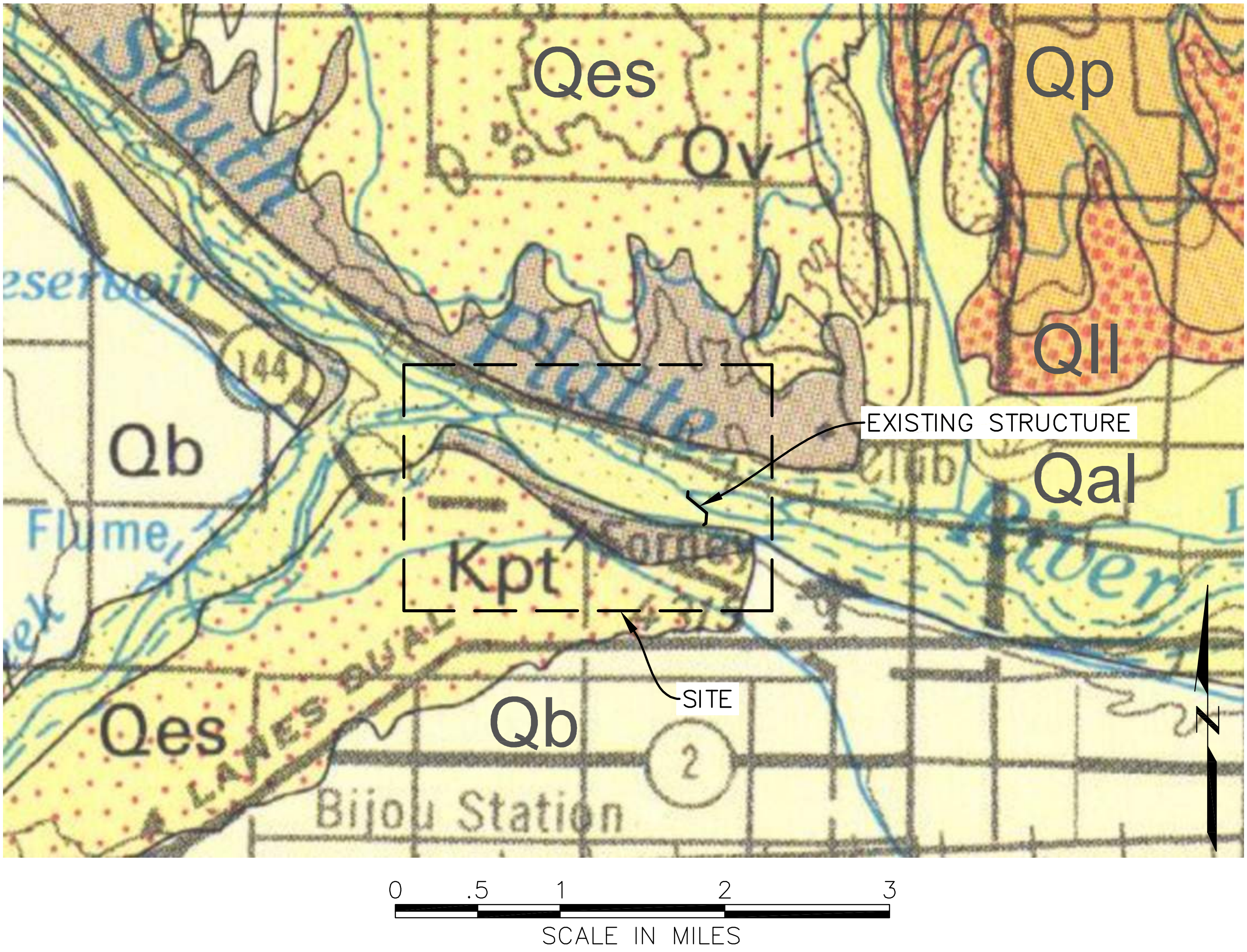
SECTION 2 - GEOLOGY

2.1 Regional Geology

The Site is located within the Great Plains Physiographic Province, which is characterized by broad gently east sloping uplands dissected by generally east flowing streams that form broad, shallow, steep sided valleys (Hunt, 1967). Bedrock within the Great Plains province consists of relatively flat-lying Mesozoic and Cenozoic formations (less than 254 million years old). The Site is situated along the River, a major drainage within the Great Plains province.

2.2 Site Geology

The geologic units identified at the Site consisted of colluvium, alluvium, and bedrock of the Upper Transition Member of the Pierre Shale (Pierre Shale). Colluvium and alluvium were Holocene-age (younger than approximately 10,000 years) and the Pierre Shale was Cretaceous age (between 145 million and 65 million years old). Figure 2.1 shows a portion of the mapped geology in the Site vicinity (Scott, 1978). Additional information on the geologic units identified at the Site is presented in Section 5 of this Report.



EXPLANATION

Qal	ALLUVIUM (HOLOCENE)	Qll	LOVELAND LOESS (PLEISTOCENE)
Qes	EOLIAN SAND (HOLOCENE AND PLEISTOCENE)	Qv	VERDOS ALLUVIUM (PLEISTOCENE)
Qb	BROADWAY ALLUVIUM (PLEISTOCENE)	Kpt	UPPER TRANSITION MEMBER OF PIERRE SHALE (UPPER CRETACEOUS)
Qp	PEORIA LOESS (PLEISTOCENE)		

NOTE:

1. PUBLISHED GEOLOGICAL MAPPING FROM SCOTT (1978).

RJH CONSULTANTS, INC.

UPPER PLATTE AND BEAVER/
DEUEL AND SNYDER
FEASIBILITY STUDY

GEOLOGY MAP

PROJECT NO. 15140

June 2016

Figure 2.1

P:\15140 – UPPER PLATTE AND BEAVER FEASIBILITY\CAD\FIGURES\GEOLOGY MAP.DWG 6/16/2016 1:50 PM

SECTION 3 - SUBSURFACE EVALUATION

3.1 General

The subsurface conditions at the Site were evaluated by drilling boreholes, collecting shallow samples, and performing laboratory testing on selected samples. RJH advanced a total of five boreholes for this exploration program. Two boreholes were located along the existing structure and three were located along an alignment for a proposed new structure, which is generally upstream of the existing structure. RJH collected alluvium samples at three locations along the River upstream of the structure. The locations of the subsurface explorations are shown on Figure 3.1.

Additionally, RJH reviewed the results of a geophysical investigation obtained by TZA. Locations of the geophysical survey lines are shown on Figure 3.1.

3.2 Exploratory Boreholes

RJH engaged Elite Drilling Services (Elite) of Denver, Colorado to advance five boreholes between December 21 and 29, 2015. Elite utilized a buggy-mounted CME 550 drill rig and advanced boreholes through surficial soils and into the top of bedrock using hollow-stem augers with an inside diameter (I.D.) of 4.25 inches and an outside diameter (O.D.) of approximately 7.5 inches. Within bedrock, boreholes were generally advanced with continuous wireline coring using HQ-sized (3.79-inch O.D., 2.375-inch I.D.) tooling. A summary of the exploratory drilling program is provided in Table 3.1.

TABLE 3.1
SUMMARY OF SUBSURFACE INVESTIGATIONS

Investigation Location	Northing(1) (ft)	Easting(1) (ft)	Ground Surface Elevation(2) (ft)	Depth to Bedrock (ft)	Depth to Groundwater (ft)	Total Depth (ft)
B-101	1347687.9(3)	3464904.9(3)	4274.8(3)	4.5	6.0	21.0
B-102	1347981.7(3)	3464497.0(3)	4269.7(3)	0.0	0.9	15.6
B-103	1348420.0(3)	3464402.3(3)	4286.0(3)	17.0	9.3	23.5
B-104	1347720(4)	3464390(4)	4277.5(3,5)	8.0	0.8	25.5
B-105	1347128.3(3)	3464394.0(3)	4293.8(3)	10.0	4.0	27.0
SS-101	1350810(4)	3457830(4)	4287(6)	N/E	0.0	1.0
SS-102	1349640(4)	3461090(4)	4285(6)	N/E	0.3	1.0
SS-103	1348800(4)	3463170(4)	4283(6)	N/E	0.3	1.0

Notes:
1. The horizontal coordinate system is Colorado Northern State Plan.

2. The vertical datum is NAVD 88.
3. Survey data provided by TZA.
4. Coordinates measured in the field by hand-held GPS unit accurate to about 10 feet.
5. Boring location was submerged at time of survey. The elevation was surveyed at the closest point on the bank.
6. Elevations estimated from River elevation in Google Earth Pro.
7. N/E signifies not encountered.

Samples of surficial soils were collected ahead of the augers at approximately 5.0-foot intervals. A sample was also collected at the top of bedrock. Samples were obtained using a standard split-spoon sampler (2-inch O.D.) or a California sampler (2.0-inch I.D. and 2.5-inch O.D.) that contained 3-inch-long brass liners. The standard split-spoon and California samplers were driven with an automatic-trip, 140-pound hammer dropped 30 inches.

Recovered samples were packaged and transported in general accordance with ASTM D 4220. Samples obtained from the standard spilt-spoon were placed in sealed plastic bags. Samples obtained with the California sampler were in brass liners and the liners were sealed with plastic caps to help preserve the natural moisture content of the material. Brass California liners were stored and transported in an upright position, in temperature-controlled environments, and in padded boxes to reduce sample disturbance.

An RJH engineer observed drilling procedures, visually classified soil and rock samples, prepared a field log of each borehole, photographed recovered samples, and observed and recorded relevant drilling information. Collected soil samples were classified in the field in general accordance with ASTM D 2488 (visual-manual classification). Soil classifications and field borehole logs were reviewed by an experienced geotechnical engineer for quality control. Following laboratory testing, field sample descriptions were revised where appropriate based on laboratory data and final logs were prepared. If laboratory test results of index properties were available, samples were classified in general accordance with ASTM D 2487 (the Unified Soil Classification System (USCS)). Rock core samples were identified and classified in general accordance with the United States Bureau of Reclamation (USBR) *Engineering Geology Field Manual* (USBR, 2001). Additional explanation of the terms and descriptors used on the borehole logs is included in Appendix A.1. Final logs are in Appendix A.2. Photographs of selected samples and selected site photographs are provided in Appendix B.

3.3 South Platte River Alluvium Samples

RJH collected shallow samples of alluvium at three locations as requested by Bob Simons of Simons and Associates (Figure 3.1). Three general sample locations were selected to be roughly equally spaced between the existing structure and the confluence between the River and Bijou Creek, which is about 1.5 miles upstream of the existing structure. Specific sample locations were generally selected on sandbars adjacent to the River channel. Generally, sandy material was selected; areas with fine grained deposits or areas with gravel armoring were not sampled. However, sample SS-101 was collected from alluvium submerged by less than 4 inches of water immediately downstream of a concrete foundation of an old diversion structure because no sand bars were accessible in that reach of the River on the day of sampling. Approximately 30 to 50 pounds of sample was collected from the top 1 foot of alluvium at each location using a hand shovel. Material descriptions were developed for each sample as described in Section 3.2.

3.4 Field Testing

Within the boreholes, Standard Penetration Tests (SPTs) were performed using the standard split-spoon sampler in general accordance with ASTM D 1586 (the sampler was unlined and retainer baskets were used as needed). The hammer blows required to advance the sampler 6 inches were recorded on the borehole logs and uncorrected N-values were developed by summing the blows required to advance the sampler beyond the first 6-inch interval. A summary of the SPT results is presented in Table 3.2. N-values presented in Table 3.2 neither include hammer blows from driving the California sampler nor from SPTs that extended through two different geologic units.

TABLE 3.2
UNCORRECTED N-VALUES

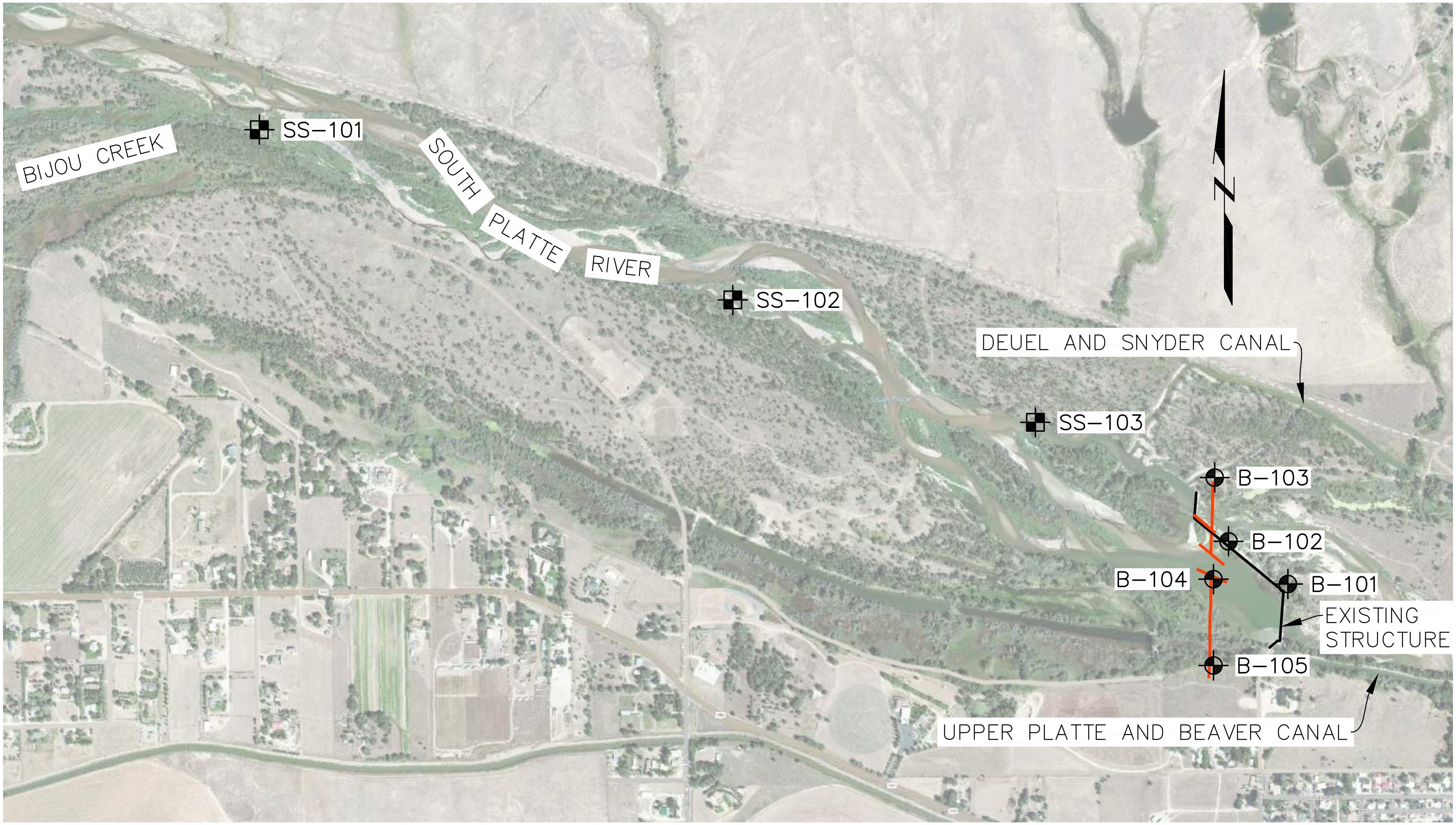
Geologic Unit	No. of Tests	Maximum	Minimum	Average
Colluvium	1	2	2	2
Alluvium	8	12	4	6
Pierre Shale				
Hard Sandstone	1	50 blows for 3 inches	50 blows for 3 inches	50 blows for 3 inches
Silty Sandstone and Clayey Sandstone	2	50 blows for 6 inches	88	(1)

Note:
1. An average N-value is not applicable because one test reached refusal before the sampler was driven 18 inches.

3.5 Geophysical Investigation

TZA engaged Olson Engineering, Inc. (Olson) to perform a geophysical investigation on December 3 and 4, 2015. The purpose of the geophysical investigation was to evaluate the depth to top of bedrock across the valley bottom, where accessible. Collecting geophysical data below the River channel was not possible because of the speed of the current.

The investigation consisted of six seismic lines totaling 1,860 linear feet. The orientation of the seismic lines is shown on Figure 3.2. Seismic energy was produced using a sledge hammer striking a plastic strike plate on the ground. Seismic data was processed using the multichannel analysis of surface waves (MASW) method and the Seismic Refraction Tomography (SRT) method. The MASW method produced inconclusive results and were not reported. The SRT method produced usable results that were correlated with logs from boreholes B-102 through B-105 to produce velocity profiles along the survey lines, as shown on Figure 3.2. No results are presented for line 4 on Figure 3.2 because the SRT data from this line was unusable. The profiles display lower velocities with a blue color and high velocities with a red color. In general, based on the seismic data, the top of bedrock is relatively flat across the valley bottom. The geophysical investigation report by Olson is provided in Appendix C.



NOTE: AERIAL IMAGE DOES NOT REFLECT CURRENT RIVER ALIGNMENT.

EXPLANATION

⊕ BOREHOLE

▨ SHALLOW SAMPLE

— GEOPHYSICAL SURVEY LINE

0 500 1000 2000 3000

SCALE IN FEET

RJH CONSULTANTS, INC.

UPPER PLATTE AND BEAVER/
DEUEL AND SNYDER
FEASIBILITY STUDY

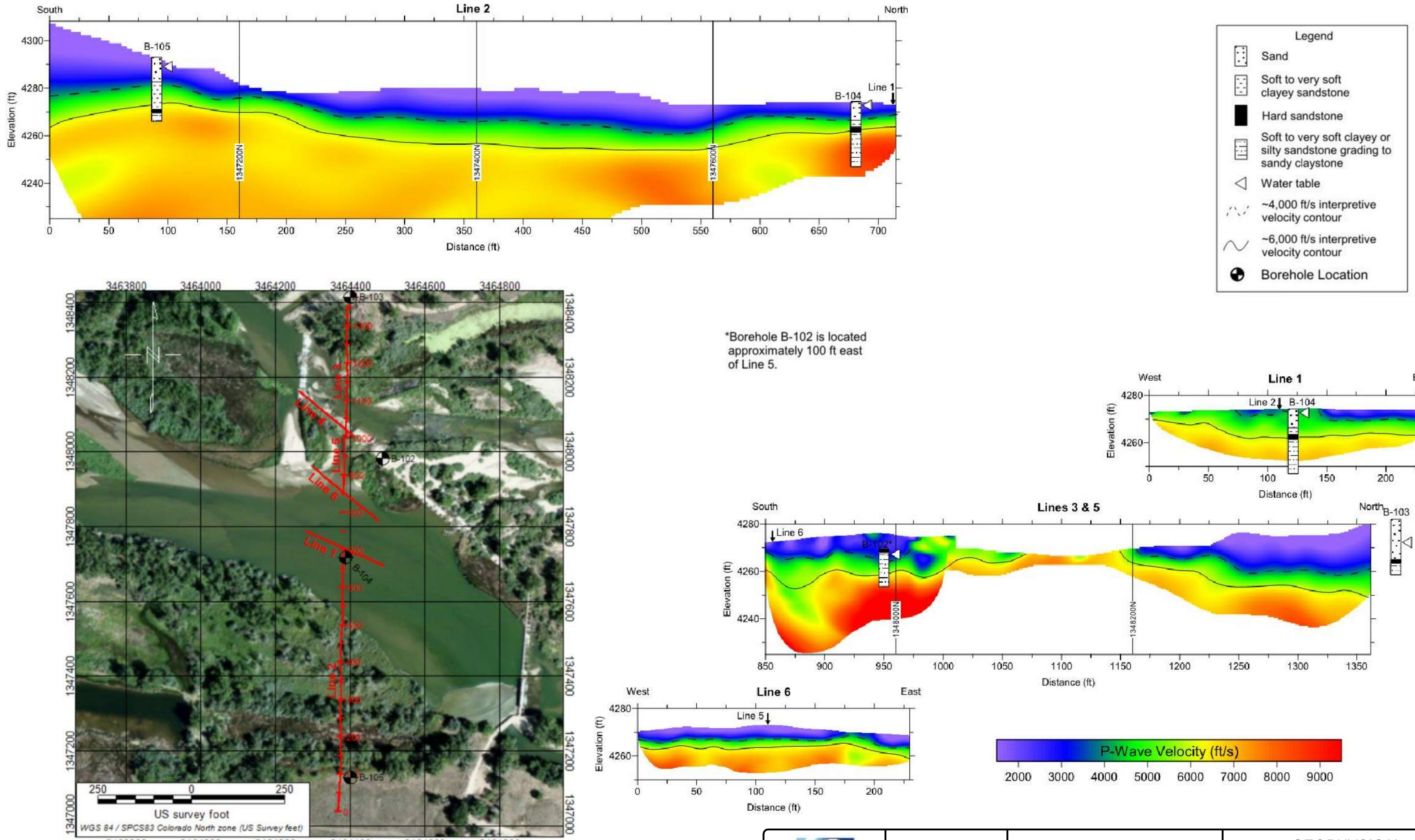
SUBSURFACE INVESTIGATION
LOCATIONS

PROJECT NO. 15140

June 2016

Figure 3.1

P:\15140 – UPPER PLATTE AND BEAVER FEASIBILITY\CAD\FIGURES\BORING LOCATIONS.DWG 6/16/2016 1:56 PM



*Borehole B-102 is located approximately 100 ft east of Line 5.

NOTE:

1. FIGURE REPRODUCED FROM OLSON'S GEOPHYSICAL INVESTIGATION REPORT (APPENDIX C).

Olson ENGINEERING

RJH CONSULTANTS, INC.

UPPER PLATTE AND BEAVER/ DEUEL AND SNYDER FEASIBILITY STUDY

PROJECT NO. 15140

GEOPHYSICAL INVESTIGATION RESULTS

June 2016

Figure 3.2

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SECTION 4 - LABORATORY TESTING

4.1 Index Testing

Index tests were performed on samples of alluvium and bedrock. The moisture content tests were used to evaluate the in-situ water content of the soil or rock sample. Dry density tests were used to measure the in-situ density of the soil or rock sample. Grain-size analyses (including minus No. 200 sieve tests) provided data on the individual particle sizes of the soil or rock samples and the distribution of these particle sizes. Atterberg limits tests approximated the relationship between the moisture content of a soil or bedrock sample and its liquid and plastic behaviors. The results of all of the laboratory testing is included in Appendix D. The following index tests were performed:

- Eleven moisture content tests (ASTM D 2216).
- Eleven dry unit weight tests (ASTM D 2937).
- Seven Atterberg limit 5-point tests (ASTM D 4318).
- Five minus No. 200 sieve analysis (ASTM D 1140).
- Four grain-size analysis (ASTM D 6913).

The results are summarized in Table 4.1.

4.2 Consolidation Testing

Two consolidation tests were performed on samples of bedrock in general accordance with Method B of ASTM D 4546. Consolidation testing was used to evaluate the potential for the foundation to swell or consolidate when saturated and loaded by the overlying structure. Samples were saturated at a vertical confining stress of 5,000 pounds per square foot (psf). Consolidation test results are summarized in Table 4.1.

4.3 Strength Testing

Three unconfined compressive strength tests with stress-strain curves were performed on selected bedrock samples in general accordance with ASTM D 2166 (soft rock and soil) and one unconfined compressive strength test was performed in general accordance with ASTM D 7012, Method C (hard rock). Unconfined compressive strength tests were used to evaluate the compressive strength of a rock sample without the confining stresses that would be present in-situ. Three consolidated undrained triaxial shear strength tests were performed on samples of bedrock in general accordance with ASTM D 4767. Triaxial shear strength tests were used to evaluate the shear strength of a rock or soil sample with varying confining stresses. Samples were tested at confining stresses of 800, 1,800, and 3,800 psf. Strength testing results are summarized in Table 4.1.

TABLE 4.1
SUMMARY OF INDEX, CONSOLIDATION, AND STRENGTH LABORATORY TEST RESULTS

Boring/ Test Pit ID	Sample ID	Sample Depth Interval (ft)	General Material Description	Natural Moisture Content (%)	Dry Unit Weight (pcf)	Gradation			Atterberg Limits		Swell/Consolidation (-) = Collapse Consolidation (%)	Unconfined Compressive Strength (psf)	Effective Strength		Total Strength	
						% Gravel (>No. 4)	% Sand (No. 4 to No. 200)	% Fines (>No. 200)	Liquid Limit (%)	Plasticity Index (%)			φ' (deg)	c' (psf)	φ (deg)	c (psf)
Alluvium																
SS-101	Bu-1 A & B	0.0 - 1.0	Poorly Graded Sand			6.3	90.9	2.8								
SS-102	Bu-1 A & B	0.0 - 1.0	Poorly Graded Sand with Gravel			28.3	71.4	0.3								
SS-103	Bu-1 A & B	0.0 - 1.0	Poorly Graded Sand			4.4	95.1	0.5								
B-104	Bu-4	0.0 - 8.0	Poorly Graded Sand with Gravel			27.4	71.6	1.0								
Pierre Shale																
B-102	HQ-1	2.0 - 2.9	Sandy Claystone	16.3$^{(2)}$	115.4$^{(2)}$			52.7	40	25		61,573				
B-102	HQ-3	5.6-6.5	Sandy Claystone	16.9	115.4			68.6	37	19						
B-102	HQ-3	9.7-10.6	Sandy Claystone	16.2$^{(1)}$	114.8$^{(1)}$				38	23	0.00	73,607				
				15.9$^{(2)}$	116.8$^{(2)}$											
B-102	HQ-4	14.8-15.6	Sandy Claystone	16.3	116.5				41	26						
B-104	HQ-1	9.8 - 10.5	Sandstone	5.7	151.0							835,200				
B-104	HQ-4	18.5 - 19.1	Sandy Claystone	16.6$^{(3)}$	114.8$^{(3)}$								39	0	69	8,800
B-104	HQ-4	19.1 - 19.7	Sandy Claystone	16.2$^{(3)}$	116.0$^{(3)}$											
B-104	HQ-4	19.7 - 20.5	Sandy Claystone	17.0$^{(3)}$	115.2$^{(3)}$			79.3	38	22						
B-104	HQ-5	21.4-22.0	Sandy Claystone	16.6$^{(1)}$	114.9$^{(1)}$			74.3	41	26	-0.02					
B-105	HQ-2	17.2 - 17.9	Clayey Sandstone	17.5$^{(2)}$	112.9$^{(2)}$			42.7	35	17		35,956				

Notes:
1. Moisture and dry density values from swell/consolidation test results.
2. Moisture and dry density values from unconfined compressive strength test results.
3. Moisture and dry density values from triaxial shear test results.

4.4 Corrosivity Testing

A suite of soil corrosivity tests were performed on a sample of bedrock. Corrosivity tests can be used to evaluate the potential for corrosion of concrete or steel structures and components that would be in contact with the bedrock. Corrosivity testing evaluated water soluble chloride (AASHTO T291-91/ASTM D 4327), electrical conductivity (ASA2 10-3.3), pH (AASHTO T289-91), resistivity (AASHTO T288-91), water soluble sulfate (AASHTO T290-91/ASTM D 4327), and sulfides (AWWA C105). Results are summarized in Table 4.2.

TABLE 4.2
CORROSIVITY TESTING RESULTS

Boring ID	Sample ID	Sample Depth Interval (ft)	General Material Description	Water Soluble Chloride (%)	Electrical Conductivity (mmhos/cm)	pH	Resistivity (ohm-cm)	Water Soluble Sulfate (%)	Sulfide
Pierre Shale									
B-102	HQ-3	5.6-6.5	Sandy Claystone	0.0010	1.2	7.6	812	0.054	Positive

SECTION 5 - SUBSURFACE CONDITIONS

5.1 General

The information in this section is based on the results of the subsurface investigations conducted by RJH, laboratory testing, and the geophysical investigation conducted by Olson. The stratigraphy generally consisted of alluvium overlying bedrock of the Pierre Shale. Colluvium was also identified on the slope south of the River.

5.2 Colluvium

Colluvium was identified at the ground surface on the slope south of the River in borehole B-105. The thickness was about 2.8 feet. Colluvium consisted of poorly graded sand with clay and the Unified Soil Classification System (USCS) group symbol was SP-SC. Sand content ranged from 85 to 95 percent and fines contents ranged from 5 to 15 percent. The plasticity ranged from low to medium plasticity. The density was very loose based on one SPT test, with an N-value of 2. The moisture content was moist. No laboratory testing was performed on samples of colluvium.

5.3 Alluvium

Alluvium was identified at the ground surface in the River channel and north of the River channel and below colluvium south of the River channel. Alluvium was identified in all borings and shallow sample locations except borehole B-102, where bedrock was identified at the ground surface. In the boreholes where the full thickness of the alluvium was penetrated, the thickness ranged from 4.5 to 17.0 feet and averaged 9.2 feet. Alluvium in the River channel (borings B-101, B-102, and B-104 and shallow samples SS-101, SS-102, and SS-103) consisted of poorly graded sand, poorly graded sand with gravel, poorly graded sand with silt, and silt with sand. The USCS group symbols were SP, SP-SM, and ML. Outside the River channel (borings B-103 and B-105), alluvium consisted of well-graded sand, poorly graded sand with clay, clayey sand, well graded gravel with sand, well graded sand with silt and gravel, and well graded sand with clay. The USCS group symbols were SW, SP-SC, SC, GW, SW-SM, and SW-SC. Gravel contents ranged from 0 to 70 percent but were typically less than 15 percent, sand contents ranged from 30 to 95 percent, and fines content ranged from 0 to 70 percent, but were typically less than 15 percent. The plasticity ranged from non-plastic to low plasticity and was typically non-plastic to low plasticity. The density ranged from very loose to medium dense and was typically very loose to loose. SPT N-values ranged from

4 to 12 and averaged 6. The moisture content ranged from dry to wet and was typically moist to wet. Grain-size analyses were performed on four samples of alluvium collected adjacent to the River in shallow sample locations SS-101, SS-102, and SS-103, and borehole B-104. These samples classified as poorly graded sand and poorly graded sand with gravel with fines content ranging from 0.3 to 2.8 percent.

5.4 Pierre Shale

Pierre Shale was identified below alluvium in all borings except B-102, where it was identified at the ground surface. Bedrock was not encountered at the shallow sample locations. The depth to the top of bedrock ranged from 0.0 to 17.0 feet. The approximate elevation of the top of bedrock ranged from elevation (El.) 4269.0 to El. 4283.8, but was generally between El. 4269.0 and El. 4270.3. The full thickness of the Pierre Shale was not penetrated during this investigation; however, published mapping reports a thickness of up to about 6,000 feet (Scott, 1978).

Rock types identified within the Pierre Shale are described in two groups, hard sandstone, and soft rock. Hard sandstone was identified at the top of bedrock in borings B-101, B-102, and B-103, and below 1.7 and 12.0 feet of soft rock in borings B-104 and B-105, respectively. The elevation of the top of the hard sandstone layer was relatively consistent across the site ranging from about El. 4267.8 to El. 4271.8. The sand contents of the hard sandstone ranged from 80 to 100 percent and the fines contents ranged from 0 to 20 percent. The plasticity ranged from non-plastic to low plasticity. The degree of weathering in the recovered samples ranged from fresh to moderately weathered and the degree of fracturing ranged from unfractured to intensely fractured. However, the degree of fracturing ranged from slightly to very slightly fractured in outcrops at various locations along the downstream toe of the existing structure. The hardness ranged from hard to moderately hard. Augering through approximately 1 foot of hard sandstone required about 15 minutes. The moisture content ranged from dry to moist. The moisture content of one sample of the hard sandstone was 5.7 percent and the dry unit weight was 151.0 pounds per cubic foot (pcf). The unconfined compressive strength of one sample of the hard sandstone was 835,200 psf.

The second group of rock types within the Pierre Shale consisted of soft sandy claystone, clayey sandstone, and silty sandstone and is referred to as soft rock. Soft rock was identified below the hard sandstone in all borings and above the hard sandstone in borings B-104 and B-105. The thickness of the soft rock above the hard sandstone was from 1.7 to 12 feet. The sand contents of soft rock ranged from 20 to 80 percent and the fines content ranged from 20 to 80 percent. The plasticity ranged from non-plastic to medium plasticity and typically ranged from low to medium plasticity. The degree of weathering ranged from fresh to intensely weathered and the degree of fracturing ranged from slightly to moderately fractured. The hardness ranged from soft to very soft. Advancing the augers through 5 feet of soft rock required 1 to 2 minutes. The moisture content ranged from moist to wet. The moisture content of ten samples of soft rock that were tested ranged from 15.9 to 17.5 percent and averaged 16.6 percent. The dry unit weight of the same samples ranged from 112.9 to 116.8 pcf and averaged 115.3 pcf. The liquid limit of seven samples ranged from 35 to 41 and averaged 39. The plasticity index ranged from 17 to 26 and average 23.

In general, a 2- to 4-foot-thick weathered zone existed at the top of the soft rock. Weathered soft rock was commonly poorly cemented and slightly to intensely weathered. The soft rock below the weathered zone was better cemented and the degree of weathering ranged from fresh to slightly weathered. Soft rock within the weathered zone could generally be crumbled relatively easily between thumb and finger. The rock below the weathered zone required significant effort to crumble with thumb and finger and at times required a rock hammer to break. Consolidation and strength testing were performed on samples collected below the weathered zone.

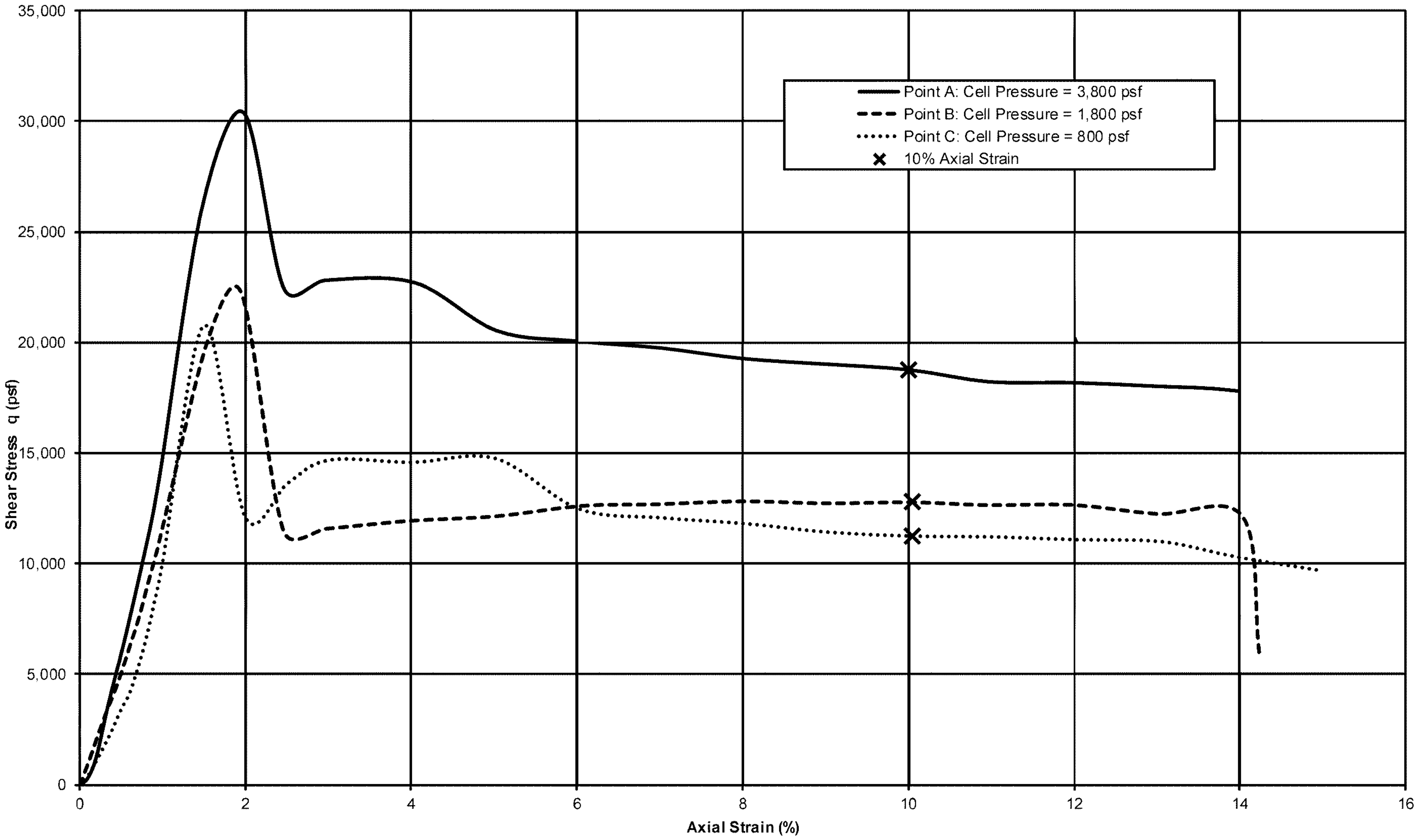
Two samples of sandy claystone exhibited 0.00 and 0.02 percent consolidation after the samples were saturated under 5,000 psf of vertical stress. The unconfined compressive strength of two sample of sandy claystone were 61,573 and 73,607 psf. The unconfined compressive strength of one sample of clayey sandstone was 35,956 psf.

Three consolidated undrained triaxial shear strength tests were performed on samples of sandy claystone at confining stresses of 800, 1,800, and 3,800 psf. As shown on Figure 5.1, the samples have a high peak strength and break in a brittle manner as would be expected for intact rock. As strain continues, the samples developed a softened strength, which is considered to be representative to the inter-particle strength along a joint or bedding plain. The shear strengths at 10 percent strain were selected as representative of the softened strength and were used to develop the drained and undrained strength envelopes shown on Figures 5.2 and 5.3. The drained strength was an effective friction angle of 39 degrees with 0 psf of effective cohesion. The undrained strength was a friction angle of 69 degrees with 8,800 psf of cohesion.

5.5 Groundwater

Groundwater was encountered in all boreholes and shallow sample locations. Water levels were estimated based on retrieval of samples that appeared to have free water through the sample. The depth to groundwater within the River channel ranged from about 0.0 to 6.0 feet below the ground surface (bgs) and was typically less than 1.0 foot bgs. Outside the River channel, groundwater was encountered about 4.0 and 9.3 feet bgs.

P:\15140 – UPPER PLATTE AND BEAVER FEASIBILITY\CAD\FIGURES\GRAPHS.DWG 6/16/2016 2:03 PM



RJH CONSULTANTS, INC.

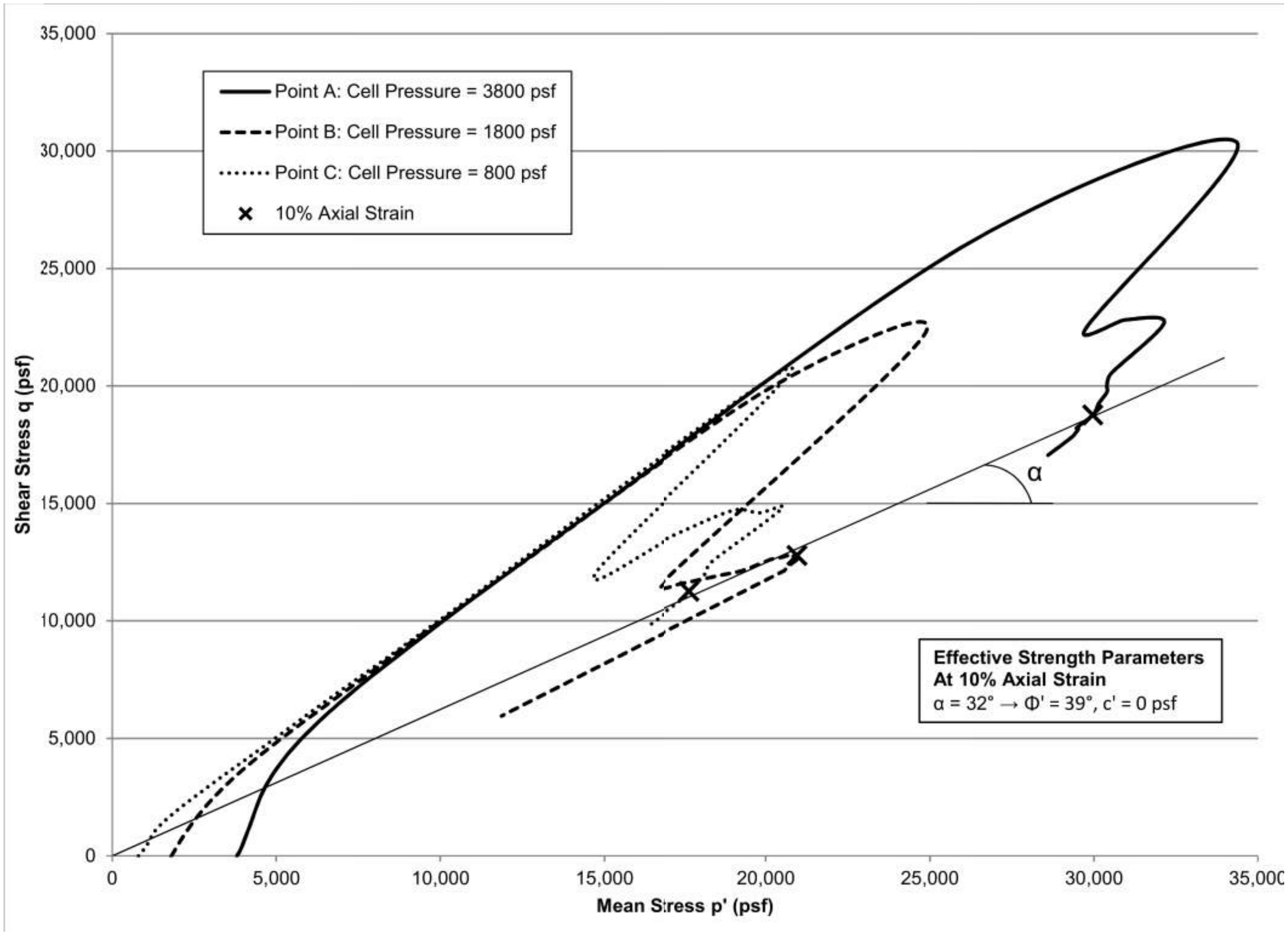
UPPER PLATTE AND BEAVER/
DEUEL AND SNYDER
FEASIBILITY STUDY

PROJECT NO. 15140

SHEAR STRESS VERSUS AXIAL STRAIN

June 2016

Figure 5.1



Effective Strength Parameters
At 10% Axial Strain
α = 32° → Φ' = 39°, c' = 0 psf

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UPPER PLATTE AND BEAVER/
DEUEL AND SNYDER
FEASIBILITY STUDY

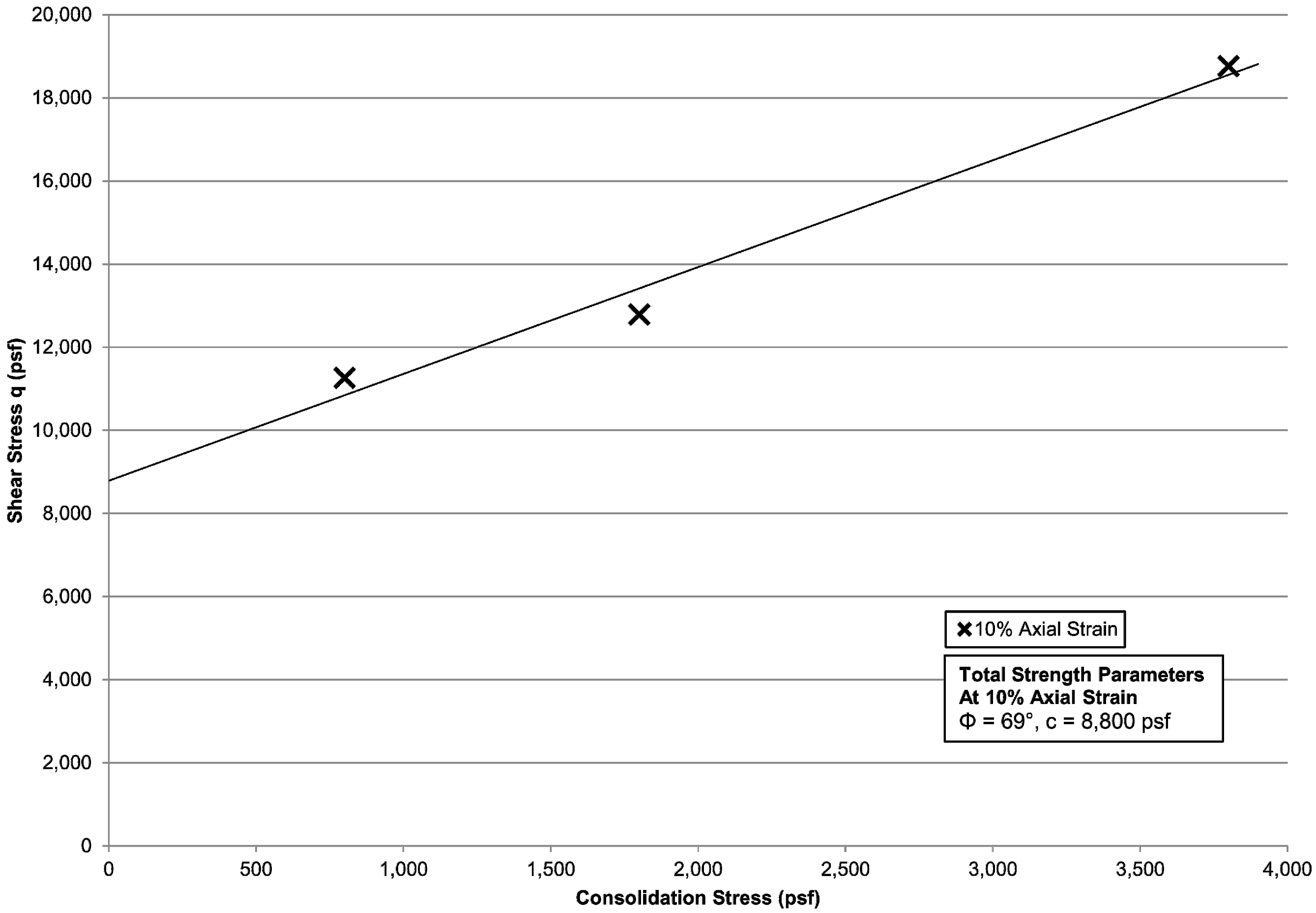
DRAINED STRENGTH

PROJECT NO. 15140

June 2016

Figure 5.2

P:\15140 – UPPER PLATTE AND BEAVER FEASIBILITY\CAD\FIGURES\GRAPHS.DWG 6/16/2016 2:04 PM



UPPER PLATTE AND BEAVER/
DEUEL AND SNYDER
FEASIBILITY STUDY

UNDRAINED STRENGTH

RJH CONSULTANTS, INC.

PROJECT NO. 15140

June 2016

Figure 5.3

SECTION 6 - RECOMMENDATIONS FOR FUTURE INVESTIGATIONS

Concepts for the replacement and/or repair of the existing structure are being developed by TZA. RJH understands that at least one concept includes an earthen embankment extending from the right abutment into the river channel.

RJH recommends the following future phases of design and investigation based on our geotechnical and dam design experience:

1. The concept design should be advanced sufficiently to establish the embankment alignment, the necessary embankment height, and the configuration of gates, canals, and other appurtenant structures.
2. Conceptual embankment cross sections should be developed to evaluate how best to incorporate the concept with the site conditions described in this Report.
3. A geotechnical investigation should be developed to collect information needed to advance the design. The investigation would likely include:
    - Perform a detailed survey of the site, including UP&B and D&S property, on the right and left abutments, which may be used as borrow and/or staging areas.
    - Advance additional borings along the proposed embankment alignment to a depth of at least 15 feet below the hard sandstone.
    - Perform water pressure tests (Packer tests) within bedrock to characterize the foundation permeability.
    - Perform erodibility and dispersivity testing on the bedrock foundation.
    - Advance borings and excavate test pits within UP&B property above the right abutment to evaluate quantity and suitability of potential embankment fill borrow material.
    - Collect additional bulk samples of alluvium within the River channel to evaluate suitability for potential filter and drain borrow material.
    - Perform index, compaction, strength, and permeability testing of potential embankment fill borrow materials.

SECTION 7 - LIMITATIONS

This report has been prepared for the exclusive use of TZA Water Engineers, Upper Platte and Beaver Canal Company, and the Deuel and Snyder Canal Company. RJH is not responsible for technical interpretations of this data by others. RJH has endeavored to conduct our professional services for this Project in a manner consistent with a level of care and skill ordinarily exercised by members of the engineering profession currently practicing in Colorado under similar conditions as this project. RJH makes no other warranty, expressed or implied.

The methods used in this study indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect variations in subsurface conditions that may exist between sampling locations.

The nature and extent of variations between boreholes and test pits may not become evident until excavation during construction. Timely and comprehensive observation and evaluation of actual subsurface conditions, supported by appropriate field and laboratory testing, will be critical during construction as variations from anticipated subsurface conditions may be encountered.

SECTION 8 - REFERENCES

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APPENDIX A

SUBSURFACE INVESTIGATION LOGS

APPENDIX A.1

EXPLANATION OF SOIL AND ROCK DESCRIPTORS

SOIL CLASSIFICATION FLOWCHARTS AND DESCRIPTION CRITERIA

TABLE 1.1
CRITERIA FOR DESCRIBING SOIL STRUCTURE(1)

Description	Criteria
Stratified	Alternating layers of varying material or color with layers greater than or equal to 1/4 inch thick (6 mm)
Laminated	Alternating layers of varying material or color with layers less than 1/4 inch thick (6 mm)
Fissured	Breaks along definite plates of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Homogeneous	Same color and appearance throughout

Note:
1. Modified from ASTM D 2488 *Description and Identification of Soils (Visual-Manual Procedure)* and differ from the U.S. Bureau of Reclamation *Engineering Geology Field Manual* (2001).

TABLE 1.2
RELATIVE DENSITY OF SANDS ACCORDING TO RESULTS OF STANDARD PENETRATION TEST(1)

Number of Blows N	Relative Density
0-4	Very Loose
5-10	Loose
11-30	Medium
31-50	Dense
Over 50	Very Dense

Note:
1. Modified from Terzaghi, Peck, and Mesri (1996).

TABLE 1.3
GUIDE FOR STIFFNESS OF FINE-GRAINED SOILS(1)

Description	Criteria	Estimated Unconfined Compressive Strength (TSF)
Very Soft	Extrudes between fingers when squeezed	<0.25
Soft	Molded by light finger pressure	0.25-0.50
Medium	Molded by strong finger pressure	0.50-1.00
Stiff	Readily indented by thumb or penetrated with great effort	1.00-2.00
Very Stiff	Readily indented by thumbnail	2.00-4.00
Hard	Indented with difficulty by thumbnail	>4.00

Note:
1. Reproduced from NAVFAC (1986).

TABLE 1.4
CRITERIA FOR DESCRIBING SOIL MOISTURE CONDITION(1)

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below the water table

Note:

1. Reproduced from ASTM 2488 *Description and Identification of Soils (Visual-Manual Procedure)*.

TABLE 1.5
CRITERIA FOR DESCRIBING SOIL CEMENTATION(1)(2)

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Notes:

1. Reproduced from ASTM 2488 *Description and Identification of Soils (Visual-Manual Procedure)*.
2. The absence of cementation was not recorded on boring logs.

TABLE 1.6
CRITERIA FOR DESCRIBING SOIL REACTION WITH HCL(1)

Description	Criteria
None(2)	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Notes:

1. Reproduced from ASTM 2488 Description and Identification of Soils (Visual-Manual Procedure).
2. The absence of a reaction was not recorded on boring logs.

SEDIMENTARY ROCK CLASSIFICATION AND CRITERIA FOR DESCRIPTIONS

TABLE 2.1
GENERAL SEDIMENTARY ROCK TYPES

Rock Type	General Description
Conglomerate	Mostly gravel, cobbles, or boulders; grains are rounded to subrounded.
Breccia	Mostly gravel, cobbles, or boulders; grains are angular to subangular.
Sandstone	Mostly sand sized particles.
Siltstone	Mostly silt sized particles that are generally non to low plastic.
Claystone	Mostly clay sized particles that are generally low to high plastic fines.
Mudstone	Mostly clay sized particles that are generally low to high plastic fines. Generally less competent and more friable than claystone.
Shale	Mostly clay sized particles that are generally low to high plastic fines; more competent than claystone; fissile along bedding planes.

TABLE 2.2
BEDDING, FOLIATION, OR FLOW TEXTURE DESCRIPTIONS(1)(2)

Descriptor	Thickness/Spacing
Massive	Greater than 10 ft. (3 m)
Very Thickly (Bedded, Foliated, or Banded)	3 to 10 ft. (1 to 3 m)
Thickly	1 to 3 ft. (300 mm to 1 m)
Moderately	0.3 to 1 ft. (100 to 300 mm)
Thinly	0.1 to 0.3 ft. (30 to 100 mm)
Very Thinly	0.03 [3/8-in.] to 0.1 ft. (10 to 30 mm)
Laminated (Intensely Foliated or Banded)	Less than 0.03 ft. [3/8-in] (10 mm)

Notes:

1. The dip of the bedding noted on the logs is measured from horizontal for vertical boreholes and normal to the axis on angled boreholes.
2. Reproduced from U.S. Bureau of Reclamation, *Engineering Geology Field Manual* (2001).

TABLE 2.3
WEATHERING DESCRIPTORS

	Diagnostic Features				
	Chemical Weathering – Discoloration and/or Oxidation		**Mechanical Weathering (Grain boundary conditions-use with granitics and coarse grained sediments)**		
Weathering Descriptor	**Body of Rock**	**Fracture Surfaces(2)**		**Texture**	**Solutioning**
Fresh	No discoloration, not oxidized	No discoloration or oxidation	No separation, intact (tight)	No change	No Solutioning
Slightly weathered to fresh (1)					
Slightly weathered	Discoloration or oxidation is limited to surface or short distance from, fractures: some feldspar crystals are dull	Minor to complete discoloration or oxidation of most surfaces	No visible separation, intact (tight)	Preserved	Minor leaching of some soluble minerals may be noted
Moderately to slightly weathered (1)					
Moderately weathered	Discoloration or oxidation extends from fractures, usually throughout: Fe-Mg minerals are “rusty”, feldspar crystals are “cloudy”	All fracture surfaces are discolored or oxidized	Partial separation of boundaries visible	Generally Preserved	Soluble minerals may be mostly leached
Intensely to moderately weathered (1)					
Intensely weathered	Discoloration or oxidation throughout; all feldspars and Fe-Mg minerals are altered to clay to some extent; or chemical alteration produces in-situ disaggregation, see grain boundaries conditions	All fracture surfaces are discolored or oxidized, surfaces friable	Partial separation, rock is friable; in semi-arid conditions granitics are disaggregated	Texture altered by chemical disintegration (hydration, argillation)	Leaching of soluble minerals may be complete
Very intensely weathered (1)					
Decomposed	Discolored or oxidized throughout, but resistant minerals such as quartz may be unaltered; all feldspars and Fe-Mg minerals are completely altered to clay		Complete separation of grain boundaries (disaggregated)	Resembles a soil, partial, or complete remnant rock structure may be preserved; leaching of soluble minerals usually complete	

Notes:

This chart and its horizontal categories are most readily applied to rocks with feldspars and mafic minerals. Weathering in various sedimentary rocks, particularly limestones and poorly indurated sediments, will not always fit the categories established. This chart and weathering categories may have to be modified for particular site conditions or alteration such as hydrothermal effects; however, the basic framework and similar descriptors are to be used.

1. Combination descriptors are permissible where equal distribution of both weathering characteristics are present over significant intervals or where characteristics present are “in between” the diagnostic feature. However, dual descriptors should not be used where significant, identifiable zones can be delineated. When given as a range, only two adjacent terms may be combined (i.e., decomposed to slightly weathered or moderately weathered to fresh are not acceptable).
2. Does not include directional weathering along shears or faults and their associated features. For example, a shear zone that carried weathering to great depths into a fresh rock mass would not require the rock mass to be classified as weathered.
3. Reproduced from U.S. Bureau of Reclamation, *Engineering Geology Field Manual* (2001).

TABLE 2.4
FRACTURE DENSITY DESCRIPTORS(1)

Descriptor	Criteria (Excludes Mechanical Breaks)
Unfractured	No observed fractures.
Very Slightly Fractured	Core recovered mostly in lengths greater than 3 feet (1 m).
Slightly to Very Slightly Fractured (2)	
Slightly Fractured	Core recovered mostly in lengths from 1 to 3 feet (300 to 1,000 mm) with few scattered lengths less than 1 foot (300 mm) or greater than 3 feet (1,000 mm).
Moderately to Slightly Fractured (2)	
Moderately Fractured	Core recovered mostly in lengths from 0.33 to 1.0 foot (100 to 300 mm) lengths with most lengths about 0.67 foot (200 mm).
Intensely to Moderately Fractured (2)	
Intensely Fractured	Lengths average from 0.1 to 0.33 foot (30 to 100 mm) with scattered fragmented intervals. Core recovered mostly in lengths less than 0.33 foot (100 mm).
Very Intensely to Intensely Fractured (2)	
Very Intensely Fractured	Core recovered mostly as chips and fragments with a few scattered short core lengths.

Notes:

1. Reproduced from U.S. Bureau of Reclamation*, Engineering Geology Field Manual* (2001).
2. Combinations of fracture densities are permissible (e.g., very intensely to intensely fractured or moderately to slightly fractured) where equal distribution of both fracture density characteristics are present over a significant core interval or exposure, or where characteristics are “in between” the descriptor definitions.

TABLE 2.5
ROCK HARDNESS / STRENGTH DESCRIPTORS(1)

Alphanumeric Descriptor	Descriptor	Criteria
H1	Extremely Hard	Core, fragment, or exposure cannot be scratched with knife or sharp pick; can only be chipped with repeated heavy hammer blow.
H2	Very Hard	Cannot be scratched with knife or sharp pick. Core or fragment breaks with repeated heavy hammer blow.
H3	Hard	Can be scratched with knife or sharp pick with difficulty (heavy pressure). Heavy hammer blow required to break specimen.
H4	Moderately Hard	Can be scratched with knife or sharp pick with light or moderate pressure. Core or fragment breaks with moderate hammer blow.
H5	Moderately Soft	Can be grooved 1/16 inch (2 mm) deep by knife or sharp pick with moderate or heavy pressure. Core or fragment breaks with light hammer blow or heavy manual pressure.
H6	Soft	Can be grooved or gouged easily by knife or sharp pick with light pressure. Can be scratched with fingernail. Breaks with light to moderate manual pressure.
H7	Very Soft	Can be readily indented, grooved, or gouged with fingernail, or carved with a knife. Breaks with light manual pressure.

Note:

1. Reproduced from U.S. Bureau of Reclamation*, Engineering Geology Field Manual* (2001).

TABLE 2.6
FRACTURE OPENNESS DESCRIPTORS(1)

Alphanumeric Descriptor	Descriptor	Openness
O0	Tight	No visible separation
O1	Slightly Open	Less than 0.003 ft [1/32 in] (< 1 mm)
O2	Moderately Open	0.003 to 0.01 ft [1/32 to 1/8 in] (1 to 3 mm)
O3	Open	0.01 to 0.03 ft [1/8 to 3/8 in] (3 to 10 mm)
O4	Moderately Wide	0.03 to 0.1 ft [3/8 to 1.2 in] (10 to 30 mm)
O5	Wide	Greater than 0.1 ft [1.2 in] (> 30 mm)

Note:

1. Reproduced from U.S. Bureau of Reclamation, *Engineering Geology Field Manual* (2001).

TABLE 2.7
FRACTURE ROUGHNESS DESCRIPTORS(1)

Alphanumeric Descriptor	Roughness Descriptor	Criteria
R1	Stepped	Near-normal steps and ridges occur on the fracture surface.
R2	Rough	Large angular asperities can be seen.
R3	Moderately Rough	Asperities are clearly visible and fracture surface feels abrasive.
R4	Slightly Rough	Small asperities on the fracture surface are visible and can be felt.
R5	Smooth	No asperities, smooth to the touch.
R6	Polished/ Slickensided	Extremely smooth and shiny. A polished fault surface, often with a lineation parallel to the displacement direction.

Note:

1. Reproduced from U.S. Bureau of Reclamation, *Engineering Geology Field Manual* (2001).

TABLE 2.8
FRACTURE FILLING THICKNESS DESCRIPTORS(1)

Alphanumeric Descriptor	Fracture Filling Descriptor	Thickness
T0	Clean	No film or coating
T1	Very Thin	Less than 0.003 ft [1/32 in] (< 1 mm)
T2	Moderately Thin	0.003 to 0.01 ft [1/32 to 1/8 in] (1 to 3 mm)
T3	Thin	0.01 to 0.03 ft [1/8 to 3/8 in] (3 to 10 mm)
T4	Moderately Thick	0.03 [3/8 in] to 0.1 ft (10 to 30 mm)
T5	Thick	Greater than 0.1 ft (> 30 mm)

Note:

1. Reproduced from U.S. Bureau of Reclamation, *Engineering Geology Field Manual* (2001).

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APPENDIX A.2

BOREHOLE LOGS

LOG OF SOIL BORING

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347687.9, E 3464904.9 ft
Ground El: 4274.8 ft Total Depth: 21.0 ft
Groundwater El: 4268.8 ft On Date: 12-21-2015

Start Date: 12-21-2015 End Date: 12-22-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 4.5 ft Checked By: JPK
Drilling Rig: CME 550 Buggy Rig
Equipment: 4.25" ID, 7.5" OD Hollow Stem Augers

Borehole ID:
B-101
Sheet 1 of 2

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
	1	S - 1	0/2/2	1.5	1.3			S-1: Poorly Graded Sand Mostly sand, fine to coarse grained, mostly fine to medium grained; less than 10% gravel, fine grained; less than 5% fines, nonplastic; maximum particle size = 0.5 inches; very loose; moist; light brown; (SP); [Alluvium] *0.6-0.7 ft: organic rich silt layer; (ML);*
	2							
4271.8	3	CA - 2	3/5	1.0	1.0	Driller felt stiffer material so drove CA sampler.		CA-2: Poorly Graded Sand with Silt Mostly sand, fine to coarse grained, mostly fine to medium grained; 5-15% fines, nonplastic to low plasticity; less than 10% gravel, fine grained; maximum particle size = 0.5 inches; loose; dry to moist; light brown; (SP-SM); [Alluvium]
	4							
4270.3		CA - 3	50 for 3 inches	0.2	0.0	Top of bedrock at 4.5 feet.		CA-3, S-4: Sandstone A few 1/4-1/2" pieces of silty sandstone fell out of the shoe; dry to moist; [PIERRE SHALE]
4269.7	5	S - 4	50 for 3 inches	0.4	0.0			
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							

Continued on next sheet

Notes Contacts are approximate. Auger to 4.5 feet, switch to HQ wireline coring. No water observed above bedrock. Backfilled to ground surface with grout.

LOG OF ROCK CORE

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347687.9, E 3464904.9 ft
Ground El: 4274.8 ft Total Depth: 21.0 ft
Groundwater El: 4268.8 ft On Date: 12-21-2015

Start Date: 12-21-2015 End Date: 12-22-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 4.5 ft Checked By: JPK
Plunge: 90.0 Bearing:
Drilling Rig: CME 550 Buggy Rig
Equipment: HQ Wireline Coring

Borehole ID:
B-101
Sheet 2 of 2

Elevation	Depth (ft)	Notes: Groundwater, Drilling, Conditions, Circulation etc	Interval (ft)	Penetration (ft)	Recovery ft, (%)	RQD, ft (%)	Coring Time (min)	No. of Pieces	Longest (ft)	Shortest (ft)	Hardness	In Situ Testing	Joint Description	Joint Symbol	Lithology	Description and Classification of Materials
	5	Return water leaking around augers at top of bedrock.	4.5 to 6.0	1.5	0.3 (20)	0.0 (0)	5	3	0.1	<0.1	H3					4.5 to 6.0 ft: Sandstone Laminated to very thinly bedded, undulating; mostly sand, fine grained; less than 20% fines, nonplastic to low plasticity; slightly weathered; intensely fractured; moist; dark gray; H3; strong reaction with HCl; [PIERRE SHALE]
4268.8	6 7 8 9 10	Groundwater at 6.0 feet. No return water through augers, but flowing through sand to ground surface. After removing drill steel, water level in augers does not drop. Low permeability rock.	6.0 to 11.0	5.0	2.2 (44)	1.2 (24)	12	0	0.7	<0.1	H6 to H7		rubble			6.0 to 16.0 ft: Clayey Sandstone Laminated, undulating; poorly cemented; mostly sand, fine grained, subangular to subrounded; 25-35% fines, low to medium plasticity, increasing fines content with depth; slightly weathered; moderately fractured; moist; dark gray; H6-H7; weak reaction with HCl; [PIERRE SHALE]
	11 12 13 14 15	Full circulation. Changed bit to improve recovery. Smooth drilling.	11.0 to 16.0	5.0	5.0 (100)	4.1 (82)	12	10	1.3	0.1	H6 to H7		Moderately open, moderately rough Mechanical break Slightly open, slightly rough 10 degrees Mechanical break Slightly open, slightly rough			*Similar to 6.0-11.0 ft Except: better cemented; 40-50% fines; slightly to moderately fractured;*
4258.8	16 17 18 19 20		16.0 to 21.0	5.0	5.0 (100)	5.0 (100)	16	4	2.6	1	H6		Slightly open, slightly rough Tight, rough Slightly open, slightly rough, 10 degrees Mechanical break			16.0 to 21.0 ft: Sandy Claystone Laminated, undulating; mostly fines, low to medium plasticity; 30-40% sand, fine grained; fresh to slightly weathered; slightly fractured; moist; dark gray; H6; gradational change from clayey sandstone above; [PIERRE SHALE]
4253.8	21 22 23 24															End of rock core log at 21.00 ft

Notes Contacts are approximate. Auger to 4.5 feet, switch to HQ wireline coring. No water observed above bedrock. Backfilled to ground surface with grout.

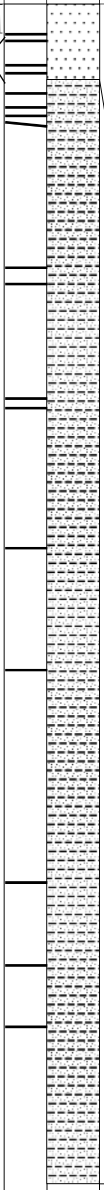
LOG OF ROCK CORE

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347981.7, E 3464497.0 ft
Ground El: 4269.7 ft   Total Depth: 15.6 ft
Groundwater El: 4268.8 ft   On Date: 12-22-2015

Start Date: 12-22-2015   End Date: 12-22-2015
Driller: Elite Drilling - Dan   Logged By: KTM
Bedrock Depth: 0.0 ft   Checked By: JPK
Plunge: 90.0   Bearing:
Drilling Rig: CME 550 Buggy Rig
Equipment: HQ Wireline Coring

Borehole ID:
B-102
Sheet 1 of 1

Elevation	Depth (ft)	Notes: Groundwater, Drilling, Conditions, Circulation etc	Interval (ft)	Penetration (ft)	Recovery ft, (%)	RQD, ft (%)	Coring Time (min)	No. of Pieces	Longest (ft)	Shortest (ft)	Hardness	In Situ Testing	Joint Description	Joint Symbol	Lithology	Description and Classification of Materials
4268.7	1 2 3 4	Full circulation. Groundwater at 0.9 feet Smooth drilling.	0.0 to 5.0	5.0	4.5 (90)	3.2 (64)	16	9	1.9	<0.1	H3 to H7		No Recovery: 0.0-0.4 feet Open, moderately rough Mechanical break Slightly open, rough Mechanical break 5 degrees Open, rough Mechanical break			0.0 to 1.0 ft: Sandstone Laminated, undulating; mostly sand, fine grained, subangular to subrounded; less than 20% fines, nonplastic to low plasticity; slightly weathered; moderately to intensely fractured; moist; gray; H3 to H4; strong reaction with HCl; [PIERRE SHALE] 1.0 to 15.6 ft: Sandy Claystone Laminated, undulating; mostly fines, low to medium plasticity, increasing plasticity with depth; 30-50% sand, fine grained, subangular to subrounded, decreasing sand content with depth; slightly weathered; slightly to moderately fractured; moist; dark gray; H6 to H7; top 3 to 4 feet are poorly cemented; ; weak reaction with HCl; [PIERRE SHALE]
	5		5.0 to 5.6	0.6	0.4 (67)	0.0 (0)	7	2	0.1	<0.1	H6 to H7		Slightly open, slightly rough Mechanical break			
	6 7 8 9 10		5.6 to 10.6	5.0	5.0 (100)	5.0 (100)	13	3	1.8	1.6	H6 to H7		Slightly open, moderately rough Open, moderately rough			
4254.1	11 12 13 14 15		10.6 to 15.6	5.0	5.0 (100)	5.0 (100)	13	4	2	1	H6 to H7		Open, slightly rough Open, slightly rough Slightly open, moderately rough			End of rock core log at 15.60 ft
	16 17 18 19 20															



Notes Contacts are approximate. Hard sandstone at surface is about 8-10 inches thick based on edge of outcrop which is about 25 feet downstream of hole. Backfilled to ground surface with grout.

RJH CONSULTANTS, INC.

LOG OF SOIL BORING

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1348420.0, E 3464402.3 ft
Ground El: 4286.0 ft Total Depth: 23.5 ft
Groundwater El: 4276.7 ft On Date: 12-29-2015

Start Date: 12-29-2015 End Date: 12-29-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 17.0 ft Checked By: JPK
Drilling Rig: CME 550 Buggy Rig
Equipment: 4.25" ID, 7.5" OD Hollow Stem Augers

Borehole ID:
B-103
Sheet 1 of 2

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
	1	S - 1	10/8/2	1.5	1.5		▨	S-1: Well Graded Sand with Clay Mostly sand, fine to coarse grained, subangular to subrounded; 5-15% gravel, fine grained, subrounded to rounded; 5-15% fines, low to medium plasticity; maximum particle size = 0.5 inches; very loose; moist; light brown; (frozen); (SW-SC); [Alluvium]
4285.1	2						▨	S-1: Clayey Sand Mostly sand, fine to medium grained, subangular to subrounded; 15-25% fines, low plasticity; very loose; moist; brown; (SC); [Alluvium]
4283.2	3 4 5 6 7	S - 2	7/6/6	1.5	1.5	Bu-9: auger cuttings collected from 0.0-8.0 feet.	▨	S-2: Poorly Graded Sand with Clay Mostly sand, fine grained, subangular to subrounded; 5-15% fines, nonplastic to low plasticity; medium dense; moist; brown; decomposing roots at 4.4 and 5.2 feet; up to 1 inch in diameter pockets of clayey sand and poorly graded sand with clay throughout; (SP-SC); [Alluvium]
4278.7	8 9	S - 3	2/3/4	1.5	1.4	Groundwater at 9.3 feet.	▨	S-3: Well Graded Sand with Silt and Gravel Mostly sand, fine to coarse grained, subangular to subrounded; 15-25% gravel, fine to coarse grained, subrounded to rounded; 5-15% fines, nonplastic; maximum particle size = 1 inch; loose; wet; brown; (SW-SM); [Alluvium]
4276.5							▨	S-3: Clayey Sand Mostly sand, fine grained, subangular to subrounded; 20-30% fines, low plasticity; loose; wet; brown; iron staining common; slight organic odor; decomposing roots at 9.5 feet; (SC); [Alluvium]
4276.0	10 11 12						▨	S-3: Well Graded Gravel with Sand Mostly gravel, fine to coarse grained, subrounded to rounded; 30-40% sand, fine to coarse grained, subangular to subrounded; less than 5% fines, nonplastic; maximum particle size = 1 inch; loose; wet; brown; (GW); [Alluvium]
4273.7	13 14 15 16	S - 4	4/3/4	1.5	1.2		▨	S-4: Well Graded Sand Mostly sand, fine to coarse grained, subangular to subrounded; less than 15% gravel, fine grained, subangular to subrounded; less than 5% fines, nonplastic; loose; wet; brown; (SW); [Alluvium]
4269.0	17	CA - 5	50 for 1 inch	0.1	0.0	Top of bedrock at 17.0 feet. Sample CA-5 at 17.0 feet: 50 for 1 inch, sandstone fragments in shoe.	▨	CA-5: Sandstone Mostly sand, fine grained, subangular to subrounded; less than 20% fines, nonplastic to low plasticity; slightly to moderately weathered; moist; gray; H4; [PIERRE SHALE]
4268.0	18 19 20	CA - 6 S - 7	27/50 for 4 inches 50 for 6 inches	0.8 0.5	0.8 0.6		▨	CA-6, S-7: Silty Sandstone Laminated, undulating; poorly cemented; mostly sand, fine grained, subangular to subrounded; 20-30% fines, nonplastic to low plasticity; fresh to slightly weathered; moist; dark gray; fractures not apparent; H7; weak reaction with HCl;

Continued on next sheet

Notes Contacts are approximate. Backfilled to 5 feet below ground surface with grout. Remaining hole filled with cuttings.

RJH CONSULTANTS, INC.

LOG OF SOIL BORING

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1348420.0, E 3464402.3 ft
Ground El: 4286.0 ft Total Depth: 23.5 ft
Groundwater El: 4276.7 ft On Date: 12-29-2015

Start Date: 12-29-2015 End Date: 12-29-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 17.0 ft Checked By: JPK
Drilling Rig: CME 550 Buggy Rig
Equipment: 4.25" ID, 7.5" OD Hollow Stem Augers

Borehole ID:
B-103
Sheet 2 of 2

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
								[PIERRE SHALE]
4265.4								S-8: Clayey Sandstone Laminated, undulating; mostly sand, fine grained, subangular to subrounded; 30-40% fines, low plasticity; fresh to slightly weathered; moist; dark gray; fractures not apparent; H7; strong reaction with HCl; [PIERRE SHALE]
	21							
	22					Augers stopped advancing at 22 feet.		
		S - 8	21/38/50	1.5	1.7			
	23							
4262.5								End of boring log at 23.50 ft
	24							
	25							
	26							
	27							
	28							
	29							
	30							
	31							
	32							
	33							
	34							
	35							
	36							
	37							
	38							
	39							
	40							

Notes Contacts are approximate. Backfilled to 5 feet below ground surface with grout. Remaining hole filled with cuttings.

LOG OF SOIL BORING

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347720.0, E 3464390.0 ft
Ground El: 4277.5 ft Total Depth: 25.5 ft
Groundwater El: 4276.7 ft On Date: 12-28-2015

Start Date: 12-28-2015 End Date: 12-28-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 8.0 ft Checked By: JPK

Borehole ID:
B-104
Sheet 1 of 2

Drilling Rig: CME 550 Buggy Rig
Equipment: 4.25" ID, 7.5" OD Hollow Stem Augers

Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
4277.1								S-1: Silt with Sand Mostly fines, nonplastic; 30-40% sand, fine to medium grained, subangular to subrounded; very soft; wet; (frozen); (ML); [Alluvium]
	1	S - 1	7/3/2/2	2.0	1.3	Groundwater at 0.8 feet. Bottom 0.7 feet fell out.		S-1, S-2, Bu-4: Poorly Graded Sand with Gravel Mostly sand, fine to coarse grained, coarser with depth; 20-30% gravel, fine grained, subrounded; less than 5% fines, nonplastic; maximum particle size = 1 inch; loose; moist to wet; light brown; (SP); [Alluvium]
	2							
	3							
	4					Sample fell out of barrel, re-drove sample with catcher. Blow counts from original SPT drive.		*Sand is coarser; less than 10% gravel; wet;*
	5	S - 2	2/2/2	1.5	0.6			*Piece of clayey sandstone; Mostly sand, fine grained, subangular to subrounded; 30-40% fines, low plasticity; wet; dark gray;*
	6					Bu-4: auger cuttings collected from 0.0-8.0 feet.		
	7							
4269.5	8	CA - 3	20/30	1.0	1.0	Top of Bedrock at 8.0 feet.		CA-3: Clayey Sandstone Laminated, undulating; poorly cemented; mostly sand, fine grained, subangular to subrounded; 35-45% fines, low plasticity; slightly to moderately weathered; moist; dark gray; fractures not apparent; H7; [PIERRE SHALE]
4268.5	9							
	10							
	11							
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							

Continued on next sheet

Notes Contacts are approximate. Auger to 9.0 feet, switch to HQ wireline coring. River level is 16 inches below ground surface, 20 feet north of hole. Backfilled to ground surface with grout.

LOG OF ROCK CORE

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347720.0, E 3464390.0 ft
Ground El: 4277.5 ft Total Depth: 25.5 ft
Groundwater El: 4276.7 ft On Date: 12-28-2015

Start Date: 12-28-2015 End Date: 12-28-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 8.0 ft Checked By: JPK
Plunge: 90.0 Bearing:
Drilling Rig: CME 550 Buggy Rig
Equipment: HQ Wireline Coring

Borehole ID:
B-104
Sheet 2 of 2

Elevation	Depth (ft)	Notes: Groundwater, Drilling, Conditions, Circulation etc	Interval (ft)	Penetration (ft)	Recovery ft, (%)	RQD, ft (%)	Coring Time (min)	No. of Pieces	Longest (ft)	Shortest (ft)	Hardness	In Situ Testing	Joint Description	Joint Symbol	Lithology	Description and Classification of Materials
4267.8	10	Full circulation.	9.0 to 10.5	1.5	1.5 (100)	0.8 (53)	12	<10	0.7	<0.1	H4 to H7		Mechanical break			9.0 to 9.7 ft: Clayey Sandstone Laminated, undulating; poorly cemented; mostly sand, fine grained, subangular to subrounded; 30-40% fines, low to medium plasticity; moderately to intensely weathered; wet; dark gray; fractures not apparent; H7; weak reaction with HCl; [PIERRE SHALE]
4265.6	11 12 13		10.5 to 13.8	3.3	3.3 (100)	3.0 (91)	12	7	1	0.2	H3 to H7		Mechanical break Mechanical break Open, slightly rough Mechanical break Slightly open, moderately rough Open, rough			9.7 to 11.9 ft: Sandstone Laminated to very thinly bedded, undulating; mostly sand, fine grained, subangular to subrounded; less than 20% fines, nonplastic to low plasticity; slightly to moderately weathered; unfractured; moist; gray; H3 to H4; weak reaction with HCl; [PIERRE SHALE] 11.9 to 25.5 ft: Sandy Claystone Laminated, undulating; mostly fines, medium plasticity; 20-40% sand, fine grained, subangular to subrounded, decreasing sand content with depth; slightly weathered; moderately fractured; moist; dark gray; H6 to H7; weak reaction with HCl; [PIERRE SHALE]
	14 15	Barrel plugged at 13.8 feet, pulled core.	13.8 to 15.5	1.7	1.6 (94)	1.6 (94)	6	1	1.6	1.6	H6 to H7					
	16 17 18 19 20		15.5 to 20.5	5.0	5.0 (100)	5.0 (100)	12	5	3.5	1	H6 to H7		Mechanical break Slightly open, moderately rough Slightly open, moderately rough, 10 degrees Mechanical break			*15.5-20.5 ft; fresh to slightly weathered; slightly to moderately fractured;*
4252.0	21 22 23 24 25		20.5 to 25.5	5.0	4.8 (96)	4.8 (96)	13	3	1.9	1.4	H6		Open, rough, 15 degrees Slightly open, slightly rough			*20.5-25.5 ft; fresh to slightly weathered; slightly fractured; H6;* End of rock core log at 25.50 ft
	26 27 28 29															

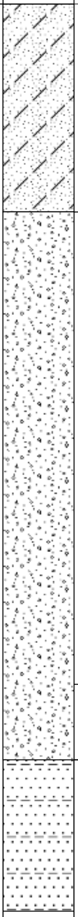
Notes Contacts are approximate. Auger to 9.0 feet, switch to HQ wireline coring. River level is 16 inches below ground surface, 20 feet north of hole. Backfilled to top of bedrock with grout. Remaining hole filled with cuttings.

LOG OF SOIL BORING

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347128.3, E 3464394.0 ft
Ground El: 4293.8 ft Total Depth: 27.0 ft
Groundwater El: 4289.8 ft On Date: 12-28-2015

Start Date: 12-28-2015 End Date: 12-29-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 10.0 ft Checked By: JPK
Drilling Rig: CME 550 Buggy Rig
Equipment: 4.25" ID, 7.5" OD Hollow Stem Augers

Borehole ID:
B-105
Sheet 1 of 2



Elevation	Depth (ft)	Type - No	Blows per 6 inch	Penetration (ft)	Recovery (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
	1	S - 1	2/1/1	1.5	1.4			S-1: Poorly Graded Sand with Clay Mostly sand, fine grained, subangular to subrounded; 5-15% fines, low to medium plasticity; very loose; moist; brown; roots and plant matter in top 0.2 inches; top 0.3 inches frozen; (SP-SC); [Colluvium]
	2							
4291.0	3							S-2, S-3: Well Graded Sand Mostly sand, fine to coarse grained; less than 5% fines, nonplastic; very loose; wet; light brown; (SW); [Alluvium]
	4 5	S - 2	1/2/2	1.5	0.9	Groundwater in augers at 4.0 feet. Sample fell out, re-drove with catcher. Blow counts from original SPT drive.		
	6 7 8							
	9	S - 3	3/4/10	1.5	1.5			*Similar to 2.75-9.0 ft Except: loose; (SW);*
4283.8	10					Top of bedrock at 10.0 feet.		S-3, CA-4: Clayey Sandstone Laminated, undulating; poorly cemented; mostly sand, fine grained, subangular to subrounded; 25-35% fines, low to medium plasticity; intensely weathered; moist to wet; brown with iron staining; iron staining decreases with depth; H7; fracturees not apparent; weak reaction with HCl; [PIERRE SHALE]
	11	CA - 4	17/33	1.0	0.9			
4281.8	12							
	13 14 15 16 17 18 19 20							

Continued on next sheet

Notes Contacts are approximate. Auger to 11.5 feet, switch to HQ wireline coring. Backfilled to 3.0 feet below ground surface with grout. Remaining hole filled with cuttings.

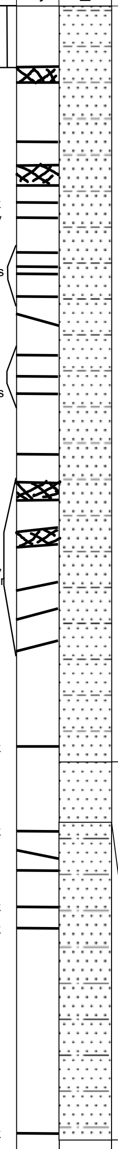
LOG OF ROCK CORE

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1347128.3, E 3464394.0 ft
Ground El: 4293.8 ft Total Depth: 27.0 ft
Groundwater El: 4289.8 ft On Date: 12-28-2015

Start Date: 12-28-2015 End Date: 12-29-2015
Driller: Elite Drilling - Dan Logged By: KTM
Bedrock Depth: 10.0 ft Checked By: JPK
Plunge: 90.0 Bearing:
Drilling Rig: CME 550 Buggy Rig
Equipment: HQ Wireline Coring

Borehole ID:
B-105
Sheet 2 of 2

Elevation	Depth (ft)	Notes: Groundwater, Drilling, Conditions, Circulation etc	Interval (ft)	Penetration (ft)	Recovery ft, (%)	RQD, ft (%)	Coring Time (min)	No. of Pieces	Longest (ft)	Shortest (ft)	Hardness	In Situ Testing	Joint Description	Description and Classification of Materials
	12.0 to 17.0	Full circulation. Sample fell out of barrel.	12.0 to 17.0	5.0	4.2 (84)	3.2 (64)	13	<10	0.5	<0.1	H6 to H7		No Recovery: 12.0-12.8 feet Open, rough Mechanical break Open, moderately rough Mechanical breaks Moderately open, rough	12.0 to 22.0 ft: Clayey Sandstone Laminated, undulating; mostly sand, fine grained, subangular to subrounded; 25-45% fines, low to medium plasticity; intensely weathered, slightly to moderately weathered below 13.8 feet; slightly to moderately fractured; moist to wet; gray to brown; H6-H7; iron stained throughout from 12.8-13.8 and occasionally below 13.8 ft; weak reaction with HCl; [PIERRE SHALE]
	17.0 to 22.0	Core broken because over packed.	17.0 to 22.0	5.0	5.0 (100)	4.6 (92)	10	12	1.2	0.2	H6 to H7		Mechanical breaks Moderately open, slightly rough Moderately open, moderately rough, fractures from over packed core Mechanical break	
4271.8 4271.0	22.0 to 27.0		22.0 to 27.0	5.0	4.9 (98)	4.6 (92)	19	7	2.7	1	H3 to H7		Mechanical break Open, rough Open, rough Mechanical break Mechanical break Mechanical break	22.0 to 22.8 ft: Sandstone Laminated to very thinly bedded, undulating; mostly sand, fine grained, subangular to subrounded; less than 20% fines, nonplastic to low plasticity; fresh; unfractured; moist; light gray; H3 to H4; [PIERRE SHALE] 22.8 to 27.0 ft: Silty Sandstone Laminated, undulating; mostly sand, fine grained, subangular to subrounded; 25-35% fines, nonplastic to low plasticity; fresh; slightly fractured; moist; dark gray; H6 to H7; weak reaction with HCl; [PIERRE SHALE]
4266.8	27													End of rock core log at 27.00 ft



Notes Contacts are approximate. Auger to 11.5 feet, switch to HQ wireline coring. Backfilled to 3.0 feet below ground surface with grout. Remaining hole filled with cuttings.

APPENDIX A.3

SHALLOW SAMPLE LOGS

LOG OF SAMPLE

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1350810.0, E 3457830.0 ft
Ground El: 4287.0 ft
Total Depth: 1.0 ft
Groundwater El: 4287.0 ft
On Date: 12-17-2015

Start Date: 12-17-2015
Logged By: KTM
End Date: 12-17-2015
Checked By: JPK

Borehole ID:
SS-101
Sheet 1 of 1

Bedrock Depth: Not Encountered
Bearing:

Dimensions in ft
Length:2.0
Width:2.0

Contractor: RJH
Equipment:

Elevation	Depth (ft)	Type - No	Depth Interval (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
		Bu - 1	0.0 - 1.0	Groundwater at the ground surface.		Bu-1: Poorly Graded Sand Mostly sand, fine to coarse grained, angular to subrounded; less than 10% gravel, fine grained, subangular to rounded; less than 5% fines, nonplastic to low plasticity, fines occur as very thin lenses of silty fine grained sand; maximum particle size = 0.75 inches; wet; brown; (SP); [Alluvium]
4286.0	1					End of test pit at 1.00 ft
	2					
	3					
	4					
	5					
	6					
	7					
	8					

Notes Sample collected by hand shovel.

RJH CONSULTANTS, INC.

LOG OF SAMPLE

Start Date: 12-17-2015
End Date: 12-17-2015
Logged By: KTM
Checked By: JPK

Borehole ID:

SS-102

Sheet 1 of 1

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1349640.0, E 3461090.0 ft
Ground El: 4285.0 ft
Total Depth: 1.0 ft
Bedrock Depth: Not Encountered
Groundwater El: 4284.7 ft
On Date: 12-17-2015
Bearing:

Dimensions in ft
Length:2.0
Width:2.0

Contractor: RJH

Equipment:

Elevation	Depth (ft)	Type - No	Depth Interval (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
4284.0	1	Bu - 1	0.0 - 1.0	Groundwater at 0.3 feet.		Bu-1: Poorly Graded Sand with Gravel Mostly sand, fine to coarse grained, angular to subrounded, mostly coarse grained; 25-35% gravel, fine to coarse grained, subangular to rounded; less than 5% fines, nonplastic; maximum particle size = 1.5 inches; wet; brown; (SP); [Alluvium] End of test pit at 1.00 ft
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					

Notes Sample collected by hand shovel.

RJH CONSULTANTS, INC.

LOG OF SAMPLE

Project name: Upper Platte and Beaver Feasibility Project
Project No: 15140
Boring Location: N 1348800.0, E 3463170.0 ft
Ground El: 4283.0 ft Total Depth: 1.0 ft
Groundwater El: 4282.7 ft On Date: 12-21-2015

Start Date: 12-21-2015 Logged By: KTM
End Date: 12-21-2015 Checked By: JPK

Borehole ID:
SS-103
Sheet 1 of 1

Bedrock Depth: Not Encountered
Bearing:

Dimensions in ft
Length:2.0
Width:2.0

Contractor: RJH
Equipment:

Elevation	Depth (ft)	Type - No	Depth Interval (ft)	Remarks	Graphic Lithology	Description and Classification of Materials
		Bu - 1	0.0 - 1.0	Groundwater at 0.3 feet.	⁘	Bu-1: Poorly Graded Sand Mostly sand, fine to coarse grained, angular to subrounded; less than 10% gravel, fine grained, subangular to rounded; less than 5% fines, nonplastic; maximum particle size = 0.75 inches; wet; brown; (SP); [Alluvium]
4282.0	1					End of test pit at 1.00 ft
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					

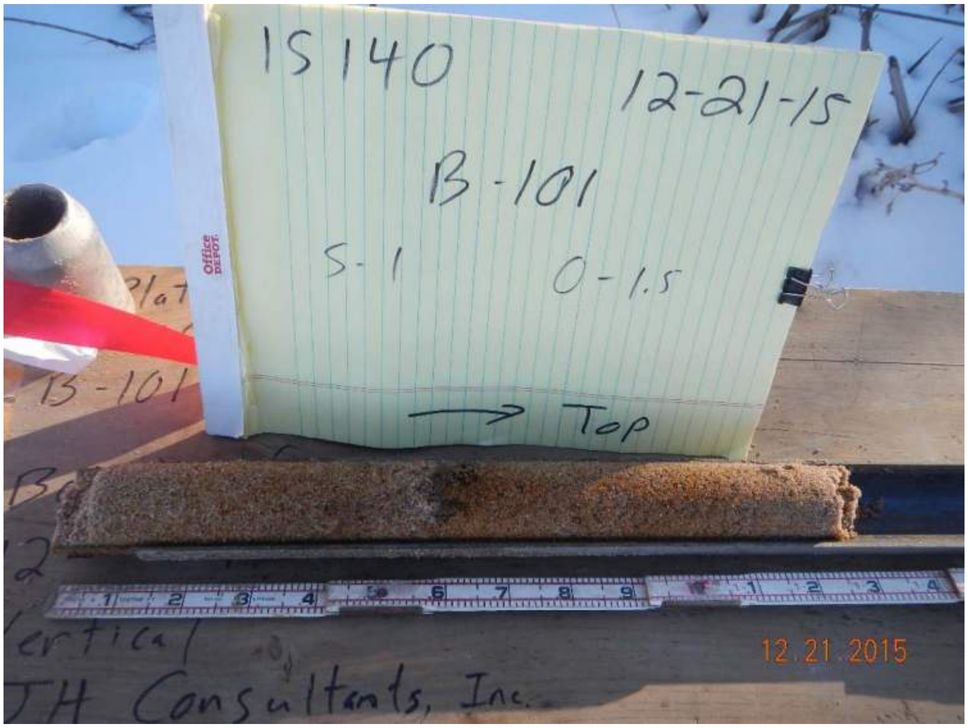
Notes Sample collected by hand shovel.

CONSULTANTS, INC.

APPENDIX B

PHOTOGRAPHS

APPENDIX B
PHOTOGRAPHS



Photograph 1: Typical sample of alluvium from boring B-101.

Photograph 2: Typical sample of alluvium from boring B-104. The portion on the left side that appears dry is frozen.

Photograph 3: Alluvium bedrock contact from boring B-105. Bedrock consists of intensely weathered soft rock.

Photograph 4: Hard sandstone outcrop at boring B-102 is about 1 foot thick. The underlying soft rock is not visible in this photograph.

Photograph 5: Looking east at an outcrop of hard sandstone overlying soft rock located at the downstream toe of the existing structure.

Photograph 6: Typical core sample of hard sandstone (left) with soft rock below (right). Soft rock is easily gauged with a knife, note marks on core at right of photograph.

Photograph 7: Typical core sample of soft rock between about 5 and 10 feet below the hard sandstone. Note minimal fractures and no discoloration due to weathering.

Photograph 8: Soft rock (left) above hard sandstone (right) in boring B-104.


12.21.2015

Photograph 9: Looking west at location of boring B-101. The diagonal structure is in the background and left abutment wing wall of the south structure is on the left side of the image.


12.22.2015

Photograph 10: Looking southeast at location of boring B-102.

Photograph 11: Looking southwest along the Deuel and Snyder Canal at the location of boring B-103. The drill rig and support truck obscure the control house for the canal head gate.

Photograph 12: Looking south east at the location of boring B-104. The existing gate structure is visible in the background.

Photograph 13: Looking east at the location of boring B-105 at the toe of the right bank. An out building adjacent to the dam tenders residence is visible in the upper right side of the photograph.

Photograph 14: Looking north at shallow sample location SS-101. The sample location marked by shovel, immediately downstream of a concrete foundation of a former diversion structure. The main channel of the South Platte River is visible in the background.

Photograph 15: Looking west, upstream, at shallow sample location SS-102.

Photograph 16: Alluvium at ground surface at shallow sample location SS-102.

Photograph 17: Looking west, upstream, at shallow sample location SS-103.

Photograph 18: Alluvium at ground surface at shallow sample location SS-103.

APPENDIX C

GEOPHYSICAL SURVEY REPORT

INFRASTRUCTURE IMAGING AND NDE
ASSESSMENT, MONITORING AND REPAIR

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February 17, 2016

TZA Water Engineers
12596 W Bayaud Ave., Ste. 330
Lakewood, CO 80228

Attn: John Allis Jr., P.E.
Office: 303.971.0030
Email: jallis@tza4water.com

Re: Geophysical investigation on the Upper Platte & Beaver / Deuel & Snyder Feasibility Study, Morgan County, CO
Olson Project No. 5203A

Olson Engineering, Inc. (Olson) conducted a geophysical investigation for TZA Water Engineers (TZA) as part of the Upper Platte & Beaver / Deuel & Snyder Feasibility Study located in Morgan County, CO (Figure 1). The objectives of the investigation were to determine the thickness of unconsolidated alluvial sediments overlying the shale bedrock, and to determine the lateral and vertical variability of stiffness in the overburden and the shale bedrock. Olson initially planned to meet these objectives by using multichannel analysis of surface waves (MASW). It was anticipated that the shallow ground water on the site would make MASW more effective than Seismic Refraction Tomography (SRT) due to the effect soil saturation can have on SRT. However, data were collected in a manner that allows for MASW and/or SRT processing. In the data processing stage, it was determined that SRT was more effective than MASW, and therefore SRT was used to generate all of the results and interpretations presented in this report.

A total of six seismic lines, totaling 1,860 linear feet of geophysical coverage, were collected (Figure 2). The seismic survey was performed based on the scope of work outlined in Olson Proposal No. P2015334.1PG. Field work was conducted December 3rd and 4th, 2015 by Olson geophysicists Paul Schwering, Jacob Sheehan, and Miriam Moller. The following report presents results from the investigation and summarizes the site conditions, data acquisition, processing procedures, and interpretation approach. For further information regarding the intricacies of the MASW or SRT methods used for this investigation, Olson can submit a method addendum, per method, to this report upon request.

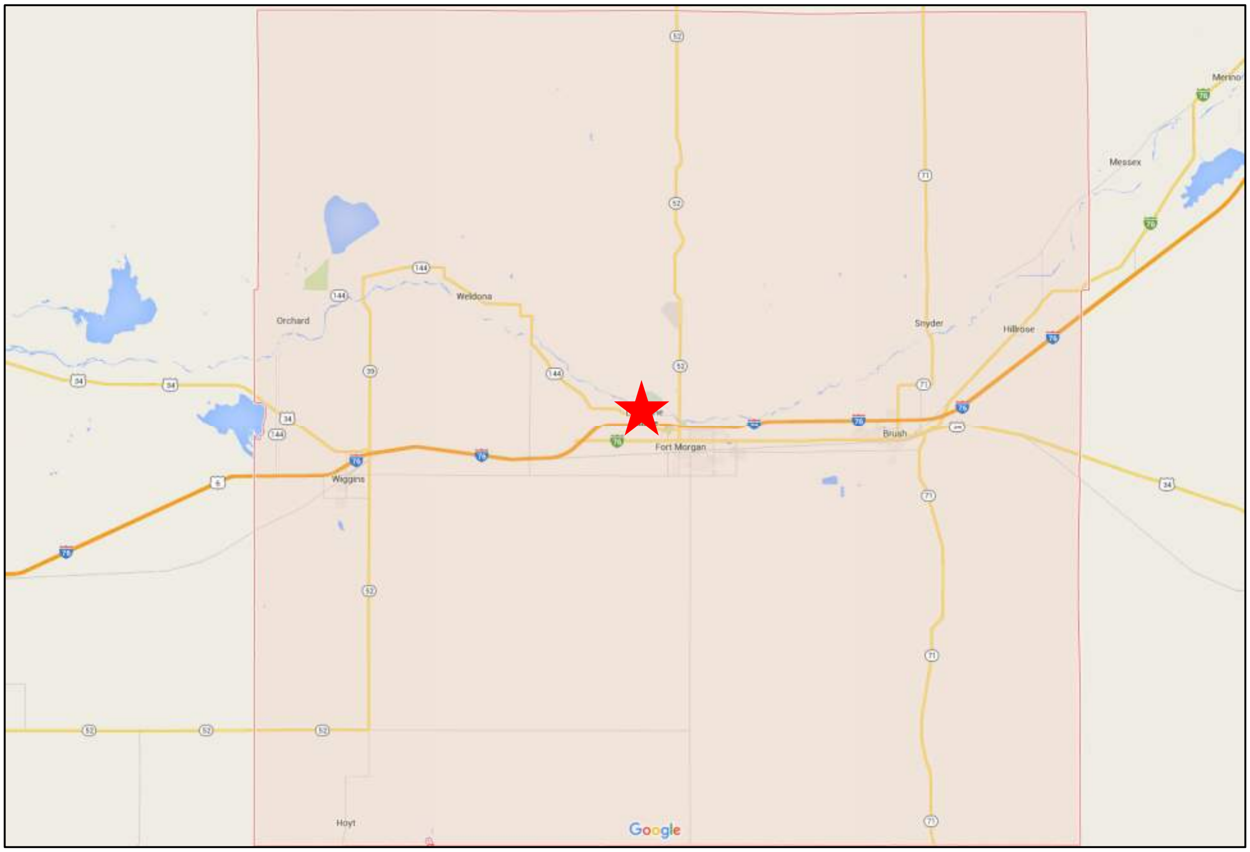

Figure 1: Map of Morgan County (outlined in red) showing approximate location of the investigation area (red star).

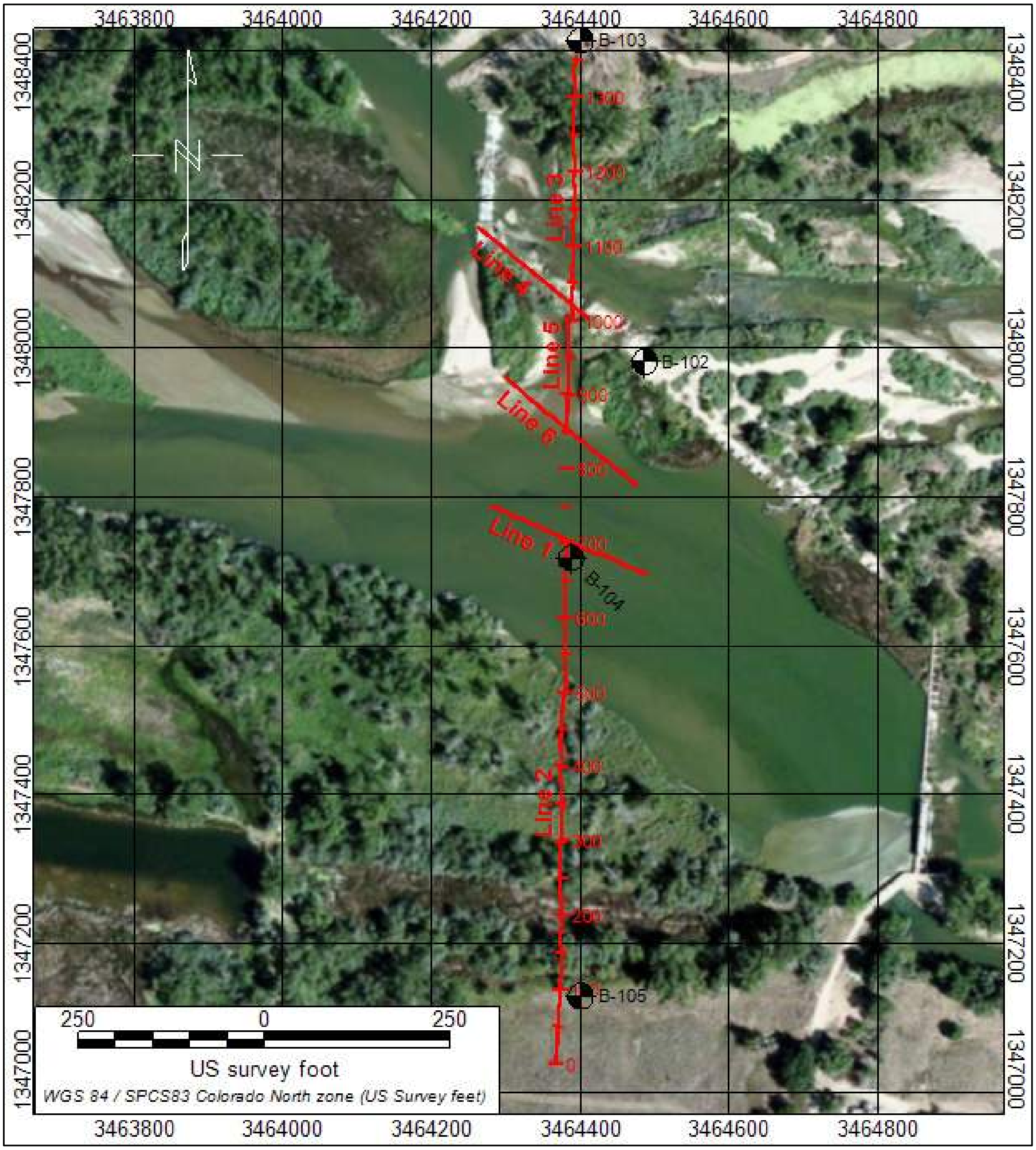

Figure 2: Aerial view of the six seismic line locations (red lines) and proximal borehole locations (black crosshairs). Note the aerial imagery (courtesy Bing Maps) does not reflect the conditions encountered during the investigation.

Site Conditions

The site ranged from minimally- to heavily-vegetated. The terrain was generally mild/rolling except for the dam crossing between Lines 3 and 5. The South Platte River was being drained/diverted such that the river channel was flowing between Lines 1 and 6 at the time of the investigation. The recent lowering of the water level combined with recent precipitation made large portions of site very muddy and difficult to traverse (*inset photo from this investigation at right*). Line 4 was positioned on the concrete along the downstream toe of the dam. RJH Consultants, Inc. (RJH) supplied Olson with lithologic data from four boreholes located proximal to the seismic lines (Figure 2). The general geologic composition at the site is overburden on bedrock. The overburden is comprised primarily of sandy alluvium. Bedrock at the site is generally flat-lying sandstone and/or siltstone.

Method

In a SRT survey, an impulse (shot) is imparted to the ground (e.g., via a sledge hammer) and the seismic waves generated by the impulse are detected along an array of receivers (geophones). The propagation of seismic waves is governed by the stiffness of the soils or the hardness of rock formations. The variability of the soil deposits can be mapped laterally, and depth to competent bedrock can be imaged, with a modeling process called tomographic inversion. For this project, P-wave energy was used for the analysis.

Data Acquisition

Initially, the data were collected and processed for both passive- and active-source MASW. However, the passive-source MASW data was unusable at this particular site and the active-source MASW results proved inconclusive as stand-alone results. Therefore, the same seismic data was also processed using the SRT approach. The SRT results proved to be more useful for interpretation and presentation.

Seismic data were acquired using one (Lines 1, 4, 5, and 6) or two (Lines 2 and 3) Geometrics Geode 24-channel seismographs (*inset photo from this investigation at left*) with up to forty-eight 4.5 Hz vertical component geophones spaced at a 10 foot interval. Data were recorded on a Panasonic Toughbook laptop. Acquisition parameters of the seismic system consisted of 2 second records sampled at a 0.125 millisecond (ms) rate. Shot points were located every 30 feet. A sledge hammer impacting a plastic strike plate was used to generate seismic energy.

The six seismic lines were positioned and oriented in the field based on recommendations of TZA personnel and accessibility/safety constraints. The location and orientation of each line was measured with a Trimble GeoHX 6000 series GPS unit capable of sub-meter spatial precision. Lines were numbered sequentially in the order they were acquired.

Data Processing

The refraction data from this project were processed using Rayfract, version 3.33, by Intelligent Resources, Inc. The two major processing steps involved with SRT are first arrival picking and data inversion. The first arrival picking step consists of picking the time for each trace (signal) where the first arrival of wave energy is observed at that geophone position. Figure 3 illustrates the picking approach used for SRT records, with an example acquired during this investigation. After picking is completed, a two-dimensional (2D) P-wave velocity (Vp) model is generated that best fits the first arrival picks by iteratively modifying a Vp grid model until the misfit between the modeled and real travel time values is minimized, subject to smoothing constraints.

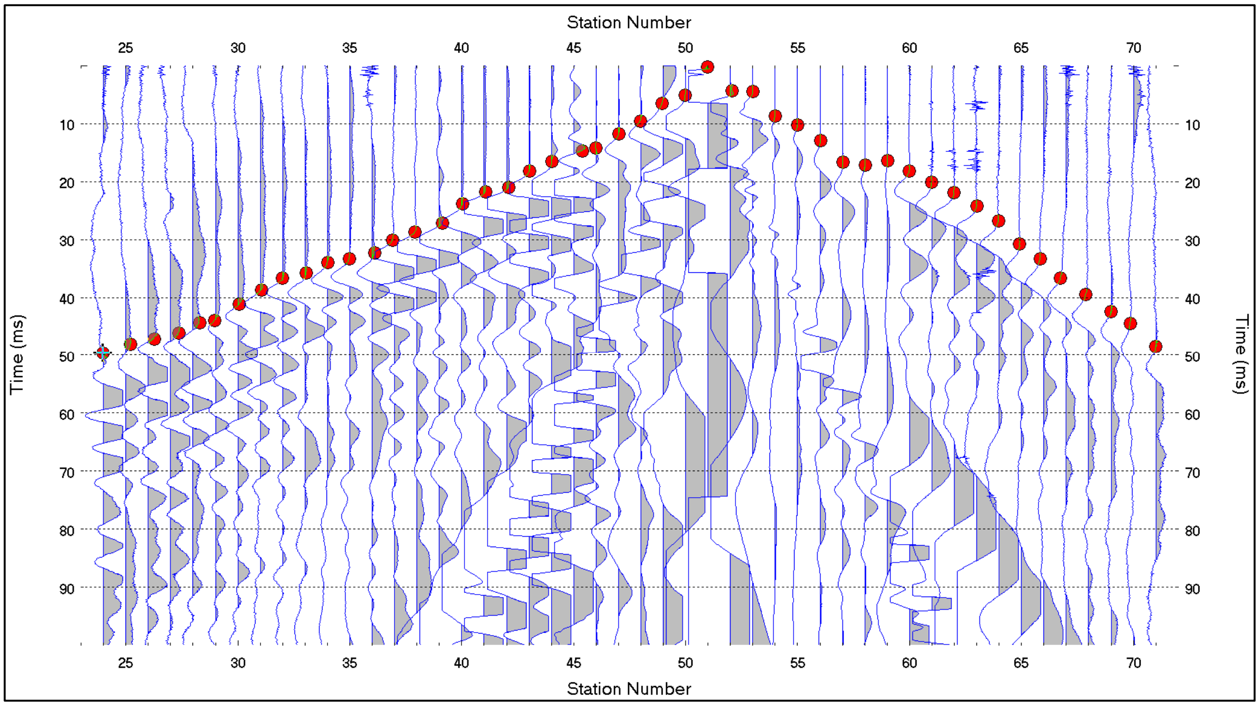

Figure 3: Example first arrival picking (red circles) of a sample SRT record from this investigation.

Results and Discussion

The 2D interpretive geophysical results for the SRT lines are presented in Figure 4 at the end of this report; the figure is 11x17 inches. The Vp profiles are presented with 'cool' colors (e.g., blue) representing lower velocity values and 'warm' colors (e.g., red) representing higher velocity values. The horizontal (distance) and vertical (elevation) dimensions (as measured by GPS) are shown in feet, at 2x vertical exaggeration. In the lower left corner of the figure is a location map showing the seismic lines (red; see also Figure 2). Note that no results are presented from Line 4, as the SRT data from this line proved to be unusable. This is most likely because this line was collected on top of a cement slab on the downstream side of the dam. Although MASW can often image through concrete slabs, SRT often cannot.

Lithologic logs from the boreholes, provided to Olson by RJH, are overlain on the profiles at their approximate horizontally-projected positions along each line. Elevation data for the boreholes were provided by TZA. The borehole log for B-101 is not included on the seismic profile, as the borehole was drilled too far away from the seismic line for the borehole log to be of any correlative/interpretive use. The projected location of B-102 is included on the profile of Lines 3 and 5. As noted on Figure 4, the borehole is located approximately 100 feet off-line.

The Vp models are interpreted based on velocity gradient analysis and correlation to the borehole logs. A high velocity gradient is indicated by a rapid change in seismic velocity over a short depth range. Velocity gradients are indicative of transitions to harder layers, although not necessarily indicative of geologically distinct layering. It is important to note that refraction tomography will always produce a gradient at a velocity transition or geologic/layer interface, no matter how sharp the interface is physically. The 2D Vp profiles have been annotated to highlight two interpretive velocity contours; the dashed line represents a Vp of approximately 4,000 feet per second (ft/s), and the solid line represents a Vp of approximately 6,000 ft/s.

Seismic results and borehole logs from on the south side of the river are indicative of two geologic interfaces. The logs from B-104 and B-105 indicate that the alluvial sand layer is underlain by a layer of soft clayey sandstone. This uppermost soft bedrock layer overlies a thin layer of hard sandstone. Below the hard sandstone is a layer of soft clayey/silty sandstone grading to sandy claystone. On Line 2, the 4,000 ft/s contour correlates well with the top of the upper soft bedrock layer, and the 6,000 ft/s contour correlates with depth of the thin hard sandstone layer. On Line 1, the 4,000 ft/s contour is shallower than the top of the soft bedrock encountered by B-104. The heavily saturated soils observed on Line 1 likely resulted in an apparent velocity increase of the sand, as the Vp contour appears to correlate more closely with the water table depth at this location.

On the north side of the river, however, only one geologic interface appears to have been resolved due to a lateral change in bedrock composition. B-102 and B-103 indicate that there is no soft bedrock overlying the thin hard sandstone layer. In B-102, the hard sandstone layer is at the top of the borehole log. Comparison of these logs with the seismic results from Lines 3 and 5 indicates that the 4,000 ft/s contour again correlates with the top of bedrock, regardless of the change in bedrock composition from Line 2. As a result, the 6,000 ft/s contour does not to correlate to any geologic interfaces encountered by the boreholes. It thus does not appear to have any interpretive value on the north side of the river, but is shown on the results from Line 3, 5, and 6 for consistency.

Closure

The geophysical methods and field procedures defined in this report were applicable to the project objectives and have been successfully applied by Olson to investigations of similar size and nature. However, sometimes field or subsurface conditions are different from those anticipated and the resultant data may not achieve the project objectives. Olson warrants that our services were performed within the limits prescribed for this project, with the usual thoroughness and competence of the geophysical profession. Olson conducted this project using the current standards of the geophysical industry and utilized in-house quality control standards to produce a precise geophysical survey.

The overall quality of the SRT data collected around the Upper Platte site was good, with minimal to moderate interference from the river. The SRT results correlate well to the borehole logs provided by RJH. The quality of the geophysical data and the good correlations to proximal borehole logs yields a high degree of confidence in the SRT results obtained and interpretations presented in this report. If you have any questions regarding the field procedures, data analyses, or the interpretive results presented herein, please do not hesitate to contact us. We appreciate working with you and look forward to providing TZA Water Engineers with geophysical and nondestructive testing (NDT) services in the future.

Respectfully,

Paul

Paul Schwering
Geophysicist

Reviewed by:

Jacob Sheehan

Jacob Sheehan
Senior Geophysicist

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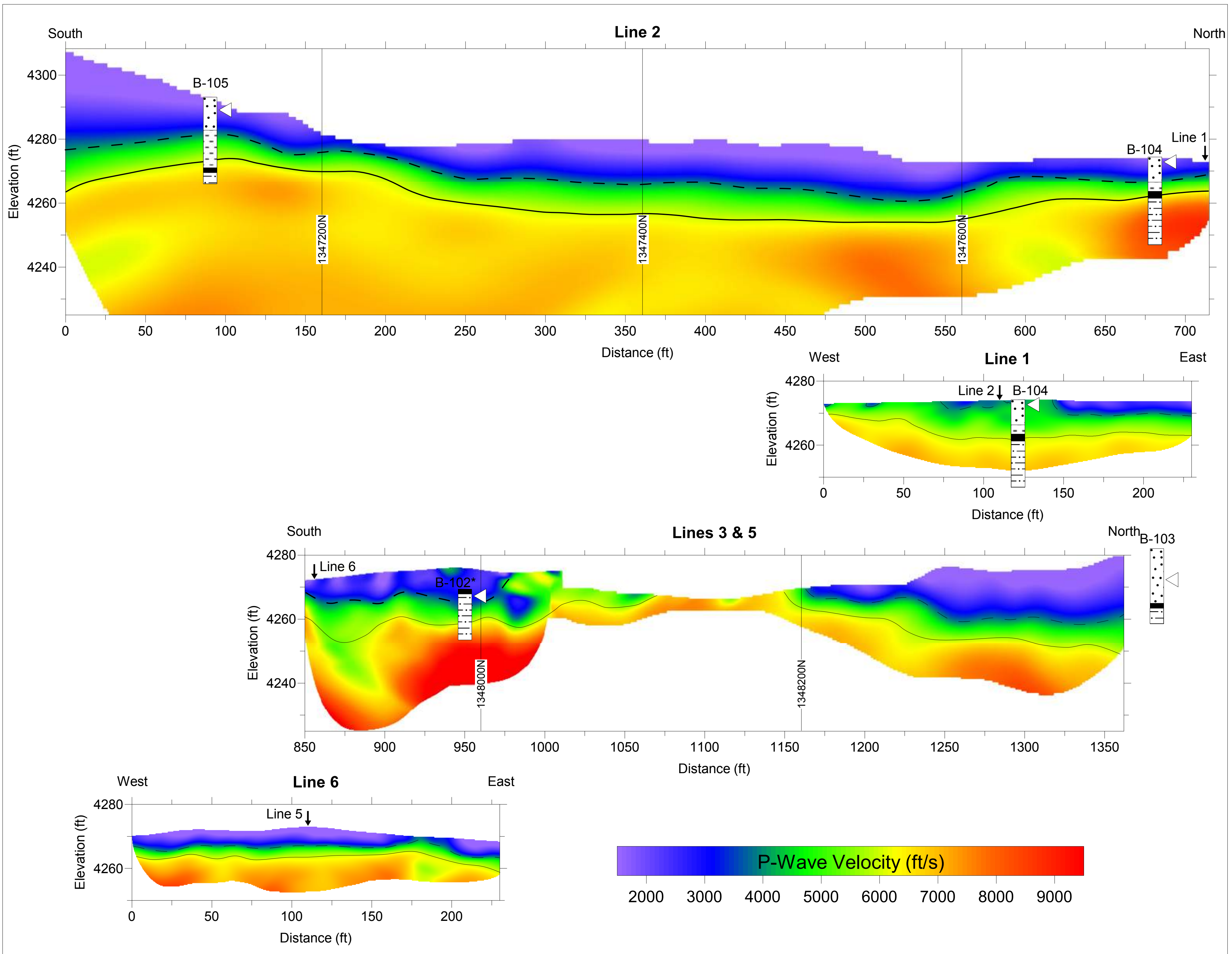

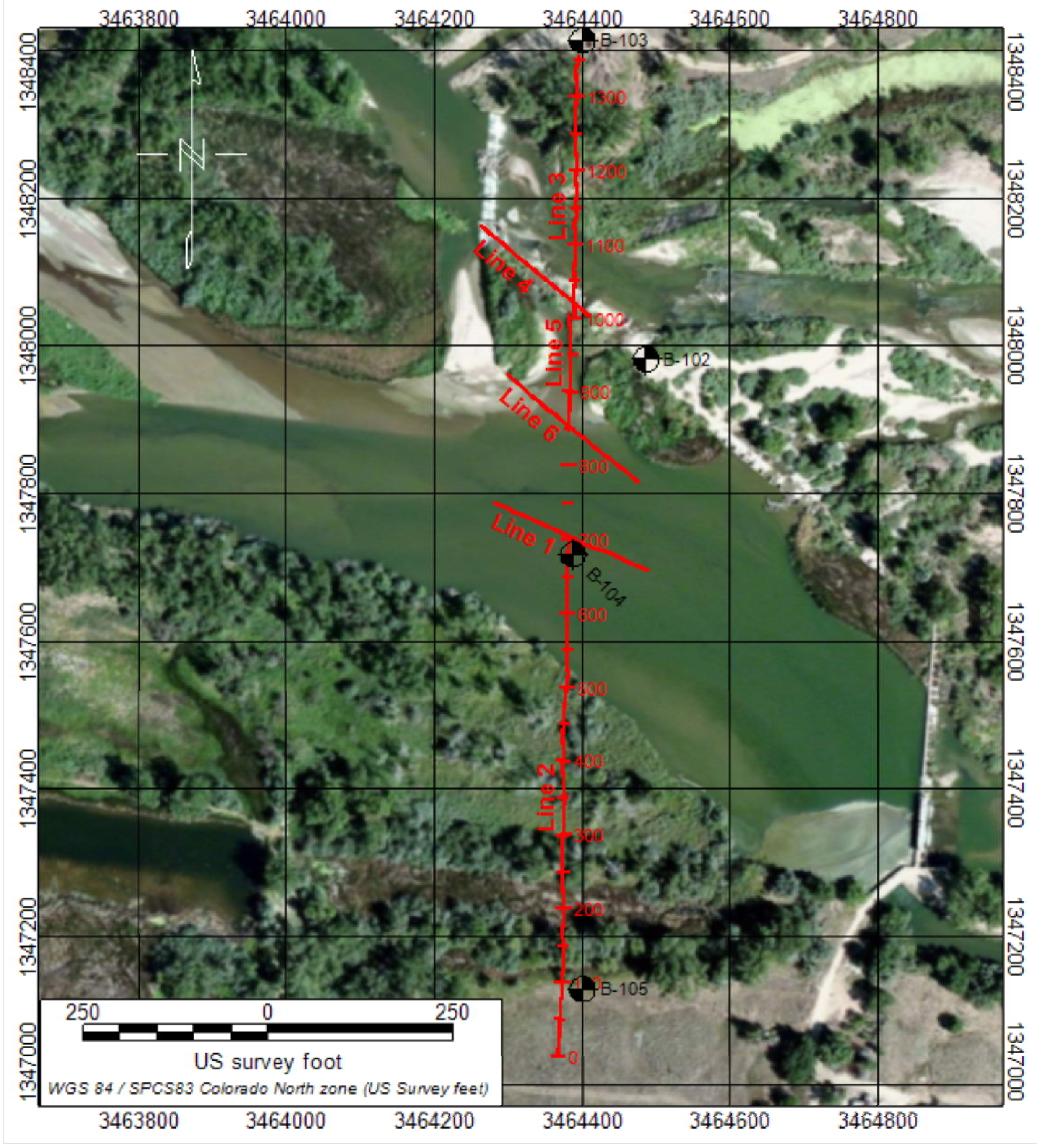

*Borehole B-102 is located approximately 100 ft east of Line 5.

Legend

⁙	Sand
⁘	Soft to very soft clayey sandstone
■	Hard sandstone
▤	Soft to very soft clayey or silty sandstone grading to sandy claystone
◁	Water table
╌	~4,000 ft/s interpretive velocity contour
∼	~6,000 ft/s interpretive velocity contour
◕	Borehole Location

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Olson
ENGINEERING

Upper Platte & Beaver / Deuel & Snyder SRT Results

Job 5203A
February 2016

Figure 4

APPENDIX D

LABORATORY TEST RESULTS

Moisture & Density

ASTM D 2216 & 2937

ADVANCED TERRA TESTING

Moisture & Density Determinations
ASTM D 2216 & D 2937

CLIENT:	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	LOCATION	--
PROJECT NO.	15140		

BORING NO.	B-102	B-102
SAMPLE NO.	HQ-4	HQ-3
DEPTH	14.8-15.6'	5.6-6.5'
DATE SAMPLED	12/24/2015	12/22/2015
DATE TESTED	1/25/2016	1/25/2016
TECHNICIAN	DPM	DPM
SOIL DESCRIPTION	--	--
DENSITY DETERMINATIONS		
Sample Height (in)	2.993	3.002
Sample Diameter (in)	2.390	2.372
Wt of Wet Soil & Rings	477.690	469.930
Wt of Rings	0.000	0.000
Wt of Wet Soil (gms)	477.69	469.93
Sample Volume (CU Ft)	0.00777	0.00768
WET DENSITY (PCF)	135.5	135.0
DRY DENSITY (PCF)	116.5	115.4
MOISTURE DETERMINATIONS		
Wt. of Wet Soil & Dish (gms)	264.32	294.92
Wt. of Dry Soil & Dish (gms)	228.17	253.27
Net Loss of Moisture (gms)	36.15	41.65
Wt. of Dish (gms)	6.95	6.92
Wt. of Dry Soil (gms)	221.22	246.35
Moisture Content (%)	16.3	16.9

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Moisture & Density Determinations
ASTM D 2216 & D 2937

CLIENT: RJH Consultants
PROJECT: Upper Platte and Beaver Diversion

JOB NO.: 2679-91

BORING	B-104
SAMPLE DEPTH	9.8-10.5
SAMPLE NO.	HQ-1
DATE SAMPLED	
DATE TESTED	1/21/16 BL
ROCK DESCRIPTION	
DENSITY DETERMINATIONS	
Sample Height (IN)	5.151
Sample Diameter (IN)	2.386
Wt of Wet Rock (GMs)	965.30
Sample Volume (CU Ft)	0.01333
WET DENSITY (PCF)	159.7
DRY DENSITY (PCF)	151.0
MOISTURE DETERMINATIONS	
Wt. of Wet Rock & Dish (gms)	420.31
Wt. of Dry Rock & Dish (gms)	397.92
Net Loss of Moisture (gms)	22.39
Wt. of Dish (gms)	6.60
Wt. of Dry Rock (gms)	391.32
Moisture Content (%)	5.7

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Atterberg Limits

ASTM D 4318

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-102
Depth: 2-2.9'
Sample Number: HQ-1
Test Date: 1/25/2016
Technician: BDF
Sampled Date: 12/22/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

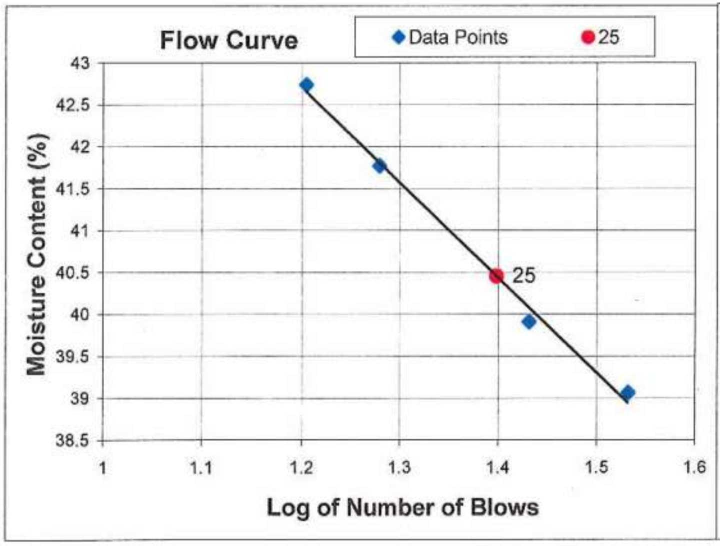
	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.460	6.399	6.429
Weight of Dry Soil & Pan (g):	5.750	5.694	5.731
Weight of Water (g):	0.710	0.705	0.698
Weight of Pan (g):	1.133	1.137	1.126
Moisture Content (%):	15.4	15.5	15.2

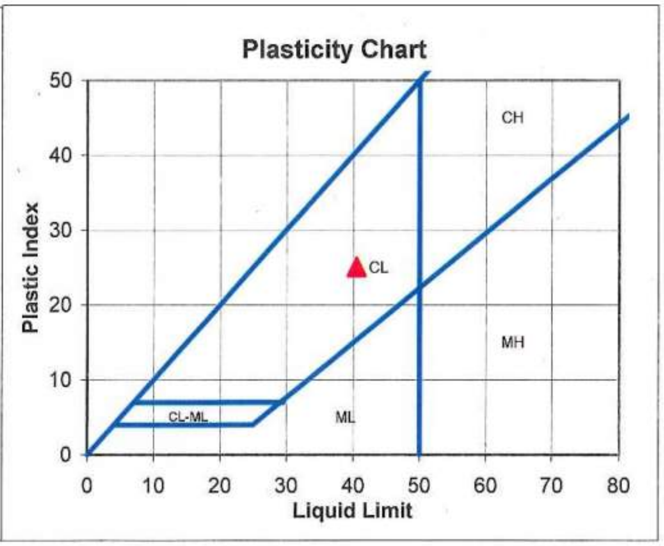
Average: 15.3%
Standard Deviation: 0.2%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4
Number of Blows:	16	19	34	27
Weight of Wet Soil & Pan (g):	7.926	8.317	10.322	11.343
Weight of Dry Soil & Pan (g):	5.894	6.189	7.743	8.434
Weight of Water (g):	2.032	2.128	2.579	2.909
Weight of Pan (g):	1.139	1.094	1.141	1.145
Moisture Content (%):	42.7	41.8	39.1	39.9

Plastic Limit: 15
Liquid Limit: 40
Plastic Index: 25
Atterberg Classification CL





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ADVANCED TERRA TESTING

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-102
Depth: 5.6-6.5'
Sample Number: HQ-3
Test Date: 1/28/2015
Technician: BDF
Sampled Date: 12/22/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.802	6.643	6.739
Weight of Dry Soil & Pan (g):	5.943	5.816	5.885
Weight of Water (g):	0.859	0.827	0.854
Weight of Pan (g):	1.136	1.129	1.125
Moisture Content (%):	17.9	17.6	17.9

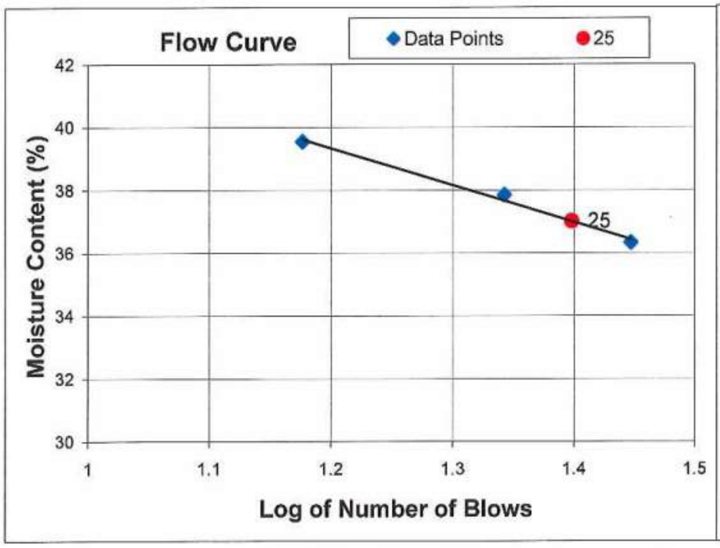
Average: 17.8%

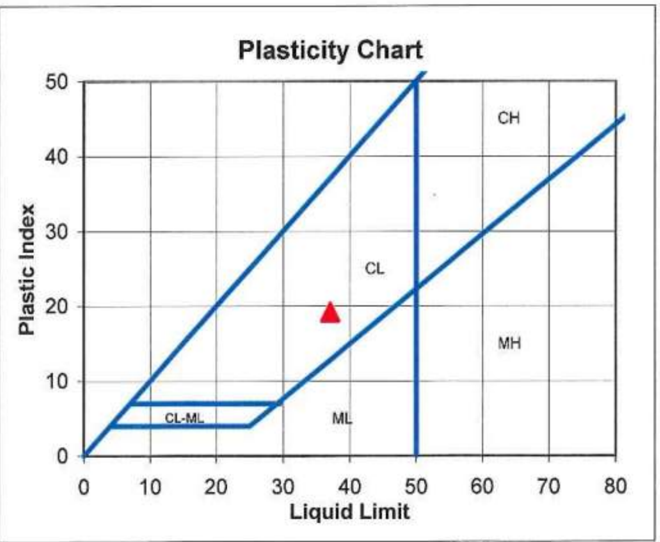
Standard Deviation: 0.2%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4
Number of Blows:	22	25	28	15
Weight of Wet Soil & Pan (g):	8.253	8.983	9.807	8.470
Weight of Dry Soil & Pan (g):	6.284	6.862	7.485	6.395
Weight of Water (g):	1.969	2.121	2.322	2.075
Weight of Pan (g):	1.081	1.131	1.091	1.148
Moisture Content (%):	37.8	37.0	36.3	39.5

Plastic Limit: 18
Liquid Limit: 37
Plastic Index: 19
Atterberg Classification CL





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ADVANCED TERRA TESTING

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-102
Depth: 9.7-10.6'
Sample Number: HQ-3
Test Date: 1/26/2016
Technician: BDF
Sampled Date: 12/22/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

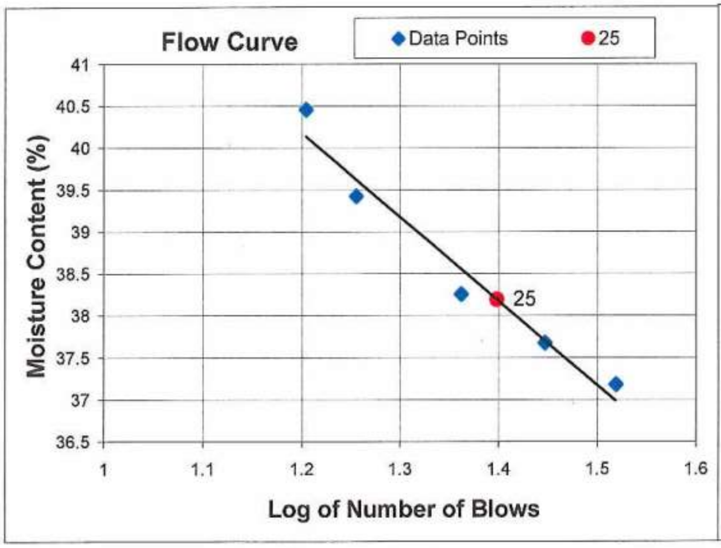
	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.498	6.380	6.226
Weight of Dry Soil & Pan (g):	5.793	5.694	5.539
Weight of Water (g):	0.705	0.686	0.687
Weight of Pan (g):	1.129	1.126	1.086
Moisture Content (%):	15.1	15.0	15.4

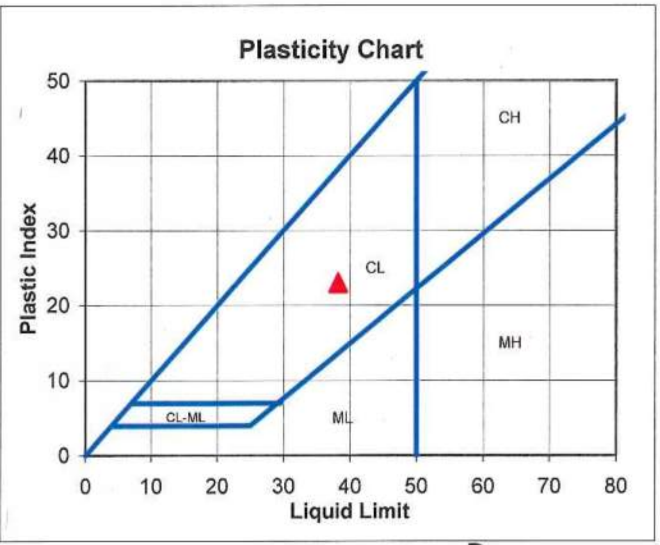
Average: 15.2%
Standard Deviation: 0.2%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Number of Blows:	23	28	16	18	33
Weight of Wet Soil & Pan (g):	8.872	9.666	8.893	8.457	8.449
Weight of Dry Soil & Pan (g):	6.743	7.336	6.658	6.375	6.459
Weight of Water (g):	2.129	2.330	2.235	2.082	1.990
Weight of Pan (g):	1.178	1.152	1.134	1.094	1.107
Moisture Content (%):	38.3	37.7	40.5	39.4	37.2

Plastic Limit: 15
Liquid Limit: 38
Plastic Index: 23
Atterberg Classification CL





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Date: 1/28/16

ADVANCED TERRA TESTING

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-102
Depth: 14.8-15.6'
Sample Number: HQ-4
Test Date: 1/27/2016
Technician: BDF
Sampled Date: 12/22/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

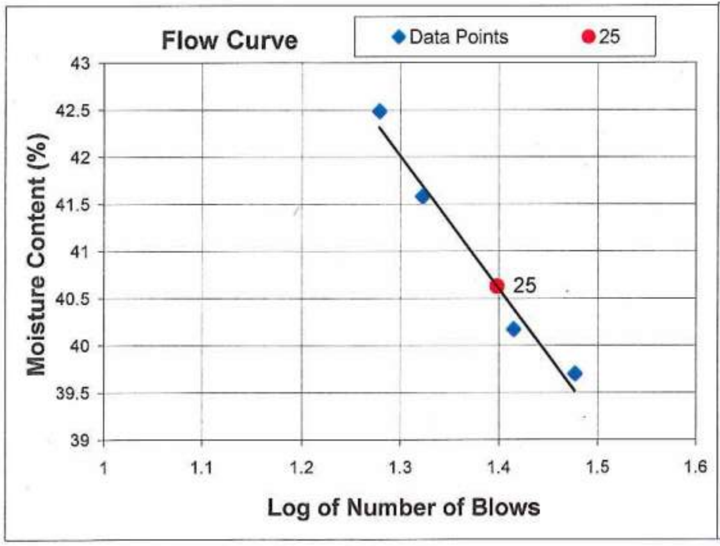
	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.409	6.332	6.423
Weight of Dry Soil & Pan (g):	5.742	5.663	5.735
Weight of Water (g):	0.667	0.669	0.688
Weight of Pan (g):	1.148	1.096	1.134
Moisture Content (%):	14.5	14.6	15.0

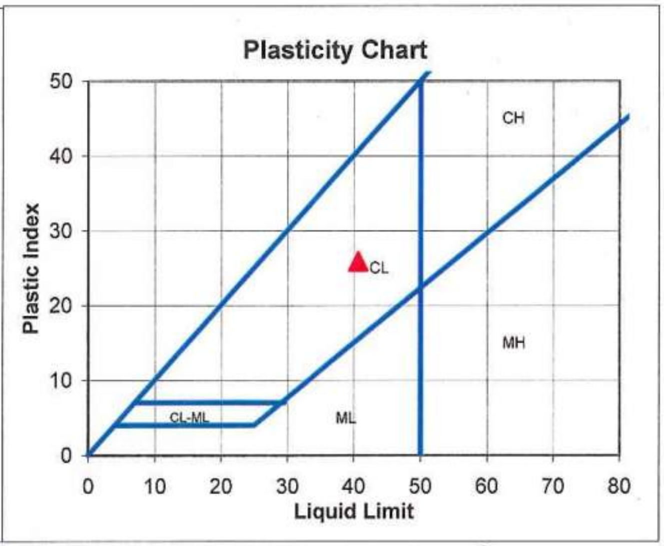
Average: 14.7%
Standard Deviation: 0.2%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4
Number of Blows:	26	21	30	19
Weight of Wet Soil & Pan (g):	9.164	8.440	8.855	8.347
Weight of Dry Soil & Pan (g):	6.855	6.309	6.662	6.195
Weight of Water (g):	2.309	2.131	2.193	2.152
Weight of Pan (g):	1.106	1.183	1.137	1.129
Moisture Content (%):	40.2	41.6	39.7	42.5

Plastic Limit: 15
Liquid Limit: 41
Plastic Index: 26
Atterberg Classification CL





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Date: 1/28/16

ADVANCED TERRA TESTING

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-104
Depth: 19.7-20.5'
Sample Number: HQ-4
Test Date: 1/26/2016
Technician: BDF
Sampled Date: 12/28/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

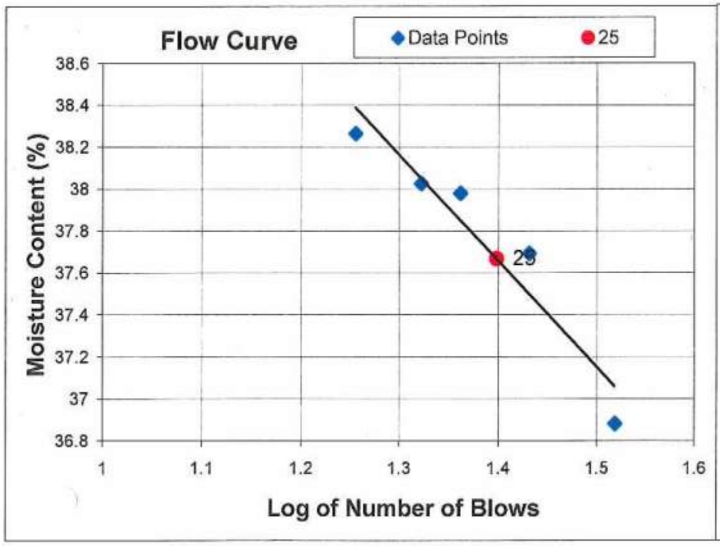
	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.517	6.592	6.565
Weight of Dry Soil & Pan (g):	5.777	5.861	5.834
Weight of Water (g):	0.740	0.731	0.731
Weight of Pan (g):	1.144	1.164	1.148
Moisture Content (%):	16.0	15.6	15.6

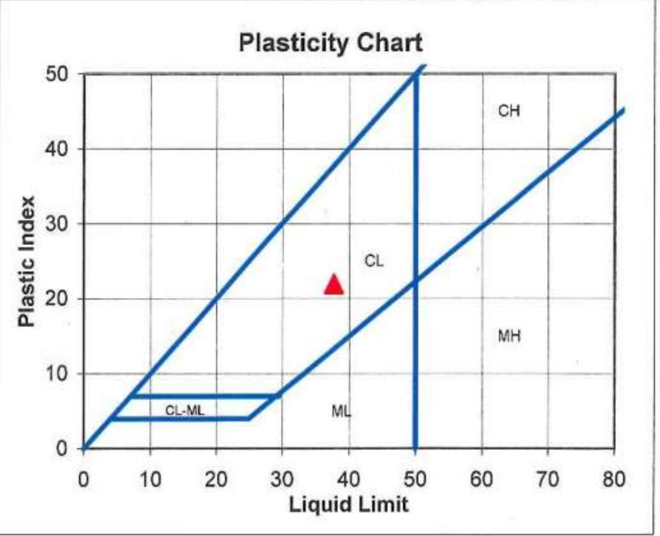
Average: 15.7%
Standard Deviation: 0.2%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Number of Blows:	18	27	21	33	23
Weight of Wet Soil & Pan (g):	8.718	7.686	7.903	8.792	9.563
Weight of Dry Soil & Pan (g):	6.610	5.867	6.039	6.717	7.236
Weight of Water (g):	2.108	1.819	1.864	2.075	2.327
Weight of Pan (g):	1.101	1.041	1.137	1.091	1.109
Moisture Content (%):	38.3	37.7	38.0	36.9	38.0

Plastic Limit: 16
Liquid Limit: 38
Plastic Index: 22
Atterberg Classification CL





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Date: 1/28/16

ADVANCED TERRA TESTING

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-104
Depth: 21.4-22'
Sample Number: HQ-5
Test Date: 1/27/2016
Technician: BDF
Sampled Date: 11/28/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

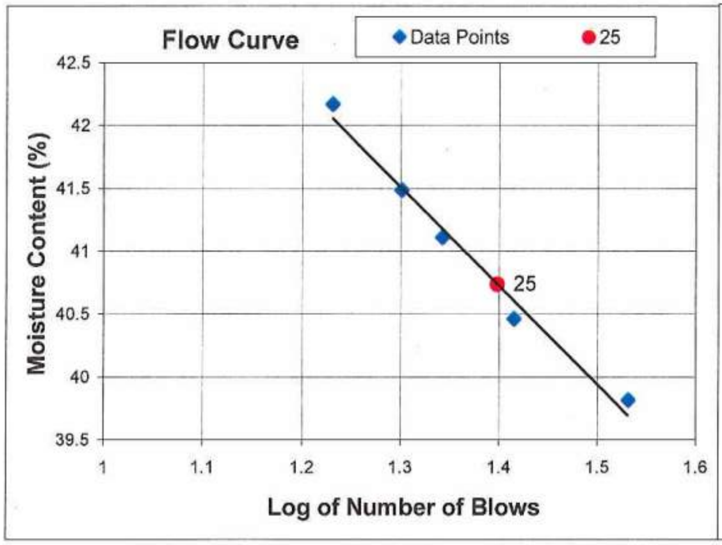
	Sample 1	Sample 2
Weight of Wet Soil & Pan (g):	6.605	6.621
Weight of Dry Soil & Pan (g):	5.908	5.856
Weight of Water (g):	0.697	0.765
Weight of Pan (g):	1.149	1.092
Moisture Content (%):	14.6	16.1

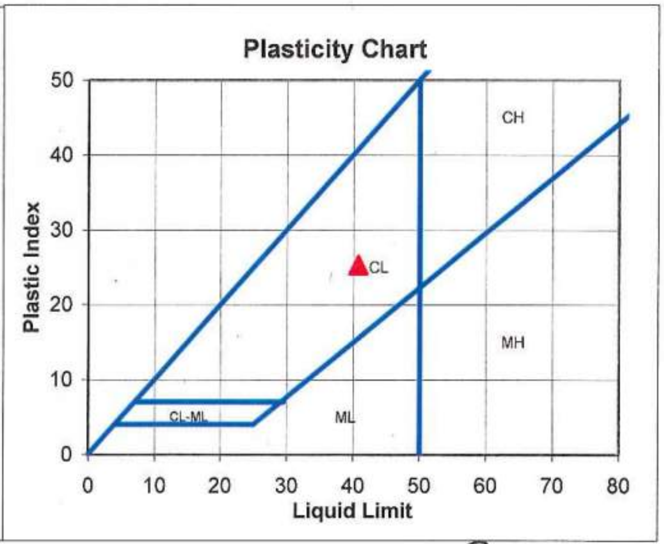
Average: 15.4%
Standard Deviation: 1.0%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Number of Blows:	20	22	17	26	34
Weight of Wet Soil & Pan (g):	8.565	8.254	11.070	8.590	10.743
Weight of Dry Soil & Pan (g):	6.390	6.190	8.128	6.444	8.012
Weight of Water (g):	2.175	2.064	2.942	2.146	2.731
Weight of Pan (g):	1.147	1.169	1.151	1.140	1.152
Moisture Content (%):	41.5	41.1	42.2	40.5	39.8

Plastic Limit: 15
Liquid Limit: 41
Plastic Index: 26
Atterberg Classification CL





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File Name: 2679_91_atterberg-ASTMD-4318-R8_4.xls

Data Checked By: CKP
Date: 1/28/16

ADVANCED TERRA TESTING

Atterberg Limits Test
ASTM D 4318

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-105
Depth: 17.2-17.9'
Sample Number: HQ-2
Test Date: 1/25/2016
Technician: BDF
Sampled Date: 12/28/2015
Sampled By: --
Method: Method A

Test Configuration

Liquid Limits Device: 1080
Material Size of Fines: -#40

Plastic Limits

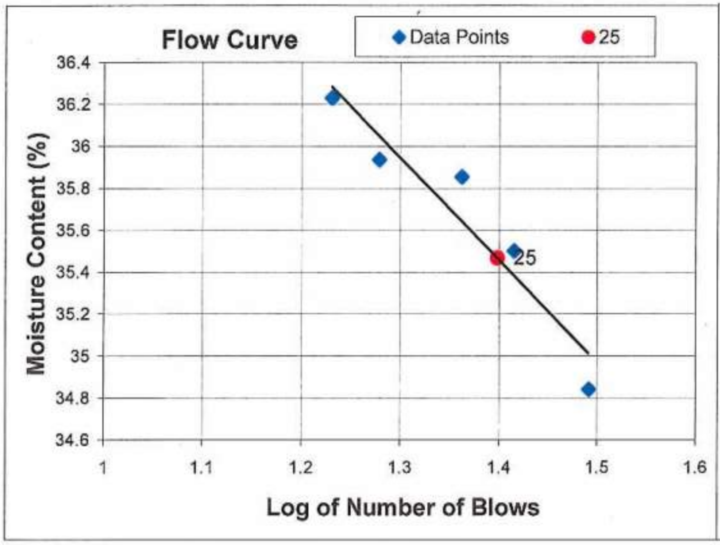
	Sample 1	Sample 2	Sample 3
Weight of Wet Soil & Pan (g):	6.527	6.601	6.596
Weight of Dry Soil & Pan (g):	5.713	5.746	5.795
Weight of Water (g):	0.814	0.855	0.801
Weight of Pan (g):	1.068	1.062	1.137
Moisture Content (%):	17.5	18.3	17.2

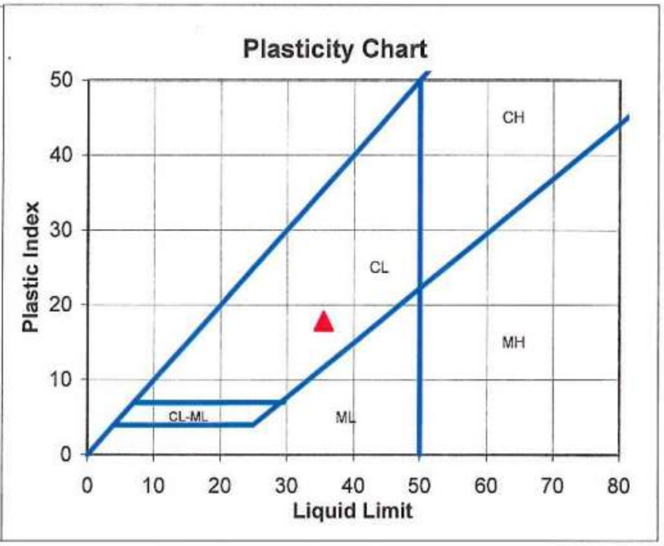
Average: 17.7%
Standard Deviation: 0.5%

Liquid Limits

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Number of Blows:	17	26	19	31	23
Weight of Wet Soil & Pan (g):	8.840	10.829	8.226	9.249	10.899
Weight of Dry Soil & Pan (g):	6.795	8.277	6.355	7.155	8.307
Weight of Water (g):	2.045	2.552	1.871	2.094	2.592
Weight of Pan (g):	1.151	1.089	1.149	1.145	1.078
Moisture Content (%):	36.2	35.5	35.9	34.8	35.9

Plastic Limit: 18
Liquid Limit: 35
Plastic Index: 17
Atterberg Classification CL





Data Entered By: NN
Date: 1/26/2016
File Name: 2679_91_atterberg-ASTMD-4318-R8_0.xls

Data Checked By: CAL
Date: 1-26-16

ADVANCED TERRA TESTING

GRAIN SIZE ANALYSIS

PERCENT FINES, -200 SEIVE ONLY

ASTM D 1140

Amount of Material in Soils Finer than #200
ASTM D 1140

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-102
Depth: 2-2.9'
Sample Number: HQ-1
Sampled Date: 12/22/15
(+) Wash Date: --
(-) Wash Date: 1/22/16

Sampled By: --
Technician: --
Technician: DPM

Grain Size Data

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
#200	**0.075**	951.29	855.65	95.64	95.64	52.7

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 1062.60
Weight of Dry Soil & Pan (g): 1057.78
Weight of Water (g): 4.82
Weight of Pan (g): 855.65
Weight of Dry Soil (g): 202.13
Moisture (%): 2.4

Total Wet Weight of Sample (g): 206.95
Total Dry Weight of Sample (g): 202.13
Calculated Weight Plus #200 (g): 95.64
Moisture of Total Sample (%): 2.4
Percent Retained #200 Sieve (%): 47.3

Wet Weight of Soil (g): 206.95
Dry Weight of Soil (g): 202.13

Data Entered By: NN
Date: 1/25/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_4.xls

Checked By: ca
Date: 1-25-16

ATT
ADVANCED TERRA TESTING

Amount of Material in Soils Finer than #200
ASTM D 1140

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-102
Depth: 5.6-6.5'
Sample Number: HQ-3
Sampled Date: 12/22/15
(+) Wash Date: --
(-) Wash Date: 1/28/16

Sampled By: --
Technician: --
Technician: DPM

Grain Size Data

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
#200	**0.075**	917.50	840.20	77.30	77.30	68.6

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 1086.18
Weight of Dry Soil & Pan (g): 1086.18
Weight of Water (g): 0.00
Weight of Pan (g): 840.20
Weight of Dry Soil (g): 245.98
Moisture (%): 0.0

Total Wet Weight of Sample (g): 245.98
Total Dry Weight of Sample (g): 245.98
Calculated Weight Plus #200 (g): 77.30
Moisture of Total Sample (%): 0.0
Percent Retained #200 Sieve (%): 31.4

Wet Weight of Soil (g): 245.98
Dry Weight of Soil (g): 245.98

Data Entered By: CAL
Date: 1/29/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_7.xls

Checked By: DPM
Date: 2/3/16

ADVANCED TERRA TESTING

Amount of Material in Soils Finer than #200
ASTM D 1140

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-104
Depth: 19.7-20.5'
Sample Number: HQ-4
Sampled Date: 12/28/15
(+) Wash Date: --
(-) Wash Date: 1/29/16

Sampled By: --
Technician: --
Technician: BDF

Grain Size Data

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
#200	**0.075**	829.41	782.55	46.86	46.86	79.3

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 1010.53
Weight of Dry Soil & Pan (g): 1009.21
Weight of Water (g): 1.32
Weight of Pan (g): 782.55
Weight of Dry Soil (g): 226.66
Moisture (%): 0.6

Total Wet Weight of Sample (g): 227.98
Total Dry Weight of Sample (g): 226.66
Calculated Weight Plus #200 (g): 46.86
Moisture of Total Sample (%): 0.6
Percent Retained #200 Sieve (%): 20.7

Wet Weight of Soil (g): 227.98
Dry Weight of Soil (g): 226.66

Data Entered By: NN
Date: 2/1/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_8.xls

Checked By: DPm
Date: 2/3/16

ATT
ADVANCED TERRA TESTING

Amount of Material in Soils Finer than #200
ASTM D 1140

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-104
Depth: 21.4-22'
Sample Number: HQ-5
Sampled Date: 12/28/15
(+) Wash Date: --
(-) Wash Date: 1/27/16

Sampled By: --
Technician: --
Technician: NN

Grain Size Data

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
#200	**0.075**	827.54	792.61	34.93	34.93	74.3

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 930.37
Weight of Dry Soil & Pan (g): 928.32
Weight of Water (g): 2.05
Weight of Pan (g): 792.61
Weight of Dry Soil (g): 135.71
Moisture (%): 1.5

Total Wet Weight of Sample (g): 137.76
Total Dry Weight of Sample (g): 135.71
Calculated Weight Plus #200 (g): 34.93
Moisture of Total Sample (%): 1.5
Percent Retained #200 Sieve (%): 25.7

Wet Weight of Soil (g): 137.76
Dry Weight of Soil (g): 135.71

Data Entered By: NN
Date: 1/28/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_6.xls

Checked By: BDF
Date: 01/28/16

ATT
ADVANCED TERRA TESTING

Amount of Material in Soils Finer than #200
ASTM D 1140

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-105
Depth: 17.2-17.9'
Sample Number: HQ-2
Sampled Date: 12/28/15
(+) Wash Date: --
(-) Wash Date: 1/26/16

Sampled By: --
Technician: --
Technician: NN

Grain Size Data

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
#200	**0.075**	952.32	856.24	96.08	96.08	42.7

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 1024.74
Weight of Dry Soil & Pan (g): 1023.95
Weight of Water (g): 0.79
Weight of Pan (g): 856.24
Weight of Dry Soil (g): 167.71
Moisture (%): 0.5

Total Wet Weight of Sample (g): 168.50
Total Dry Weight of Sample (g): 167.71
Calculated Weight Plus #200 (g): 96.08
Moisture of Total Sample (%): 0.5
Percent Retained #200 Sieve (%): 57.3

Wet Weight of Soil (g): 168.50
Dry Weight of Soil (g): 167.71

Data Entered By: NN
Date: 1/27/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_5.xls

Checked By: BDF
Date: 01/28/16

ATT
ADVANCED TERRA TESTING

Mechanical Analysis

ASTM D 6931

Particle Size Distribution (Gradation) of Soil Using Sieve Analysis
ASTM D 6913

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: B-104
Depth: 0-8'
Sample Number: Bu-4
Sampled Date: 12/28/15
(+) Wash Date: 1/19/16
(-) Wash Date: 1/20/16

Sampled By: --
Technician: CKP
Technician: NN

Grain Size Data

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 243.77
Weight of Dry Soil & Pan (g): 243.47
Weight of Water (g): 0.30
Weight of Pan (g): 7.06
Weight of Dry Soil (g): 236.41
Moisture (%): 0.1

Total Wet Weight of Sample (g): 21,215.00
Total Dry Weight of Sample (g): 21,195.48
Calculated Weight Plus #200 (g): 20,977.31
Moisture of Total Sample (%): 0.1
Percent Retained #200 Sieve (%): 99.0

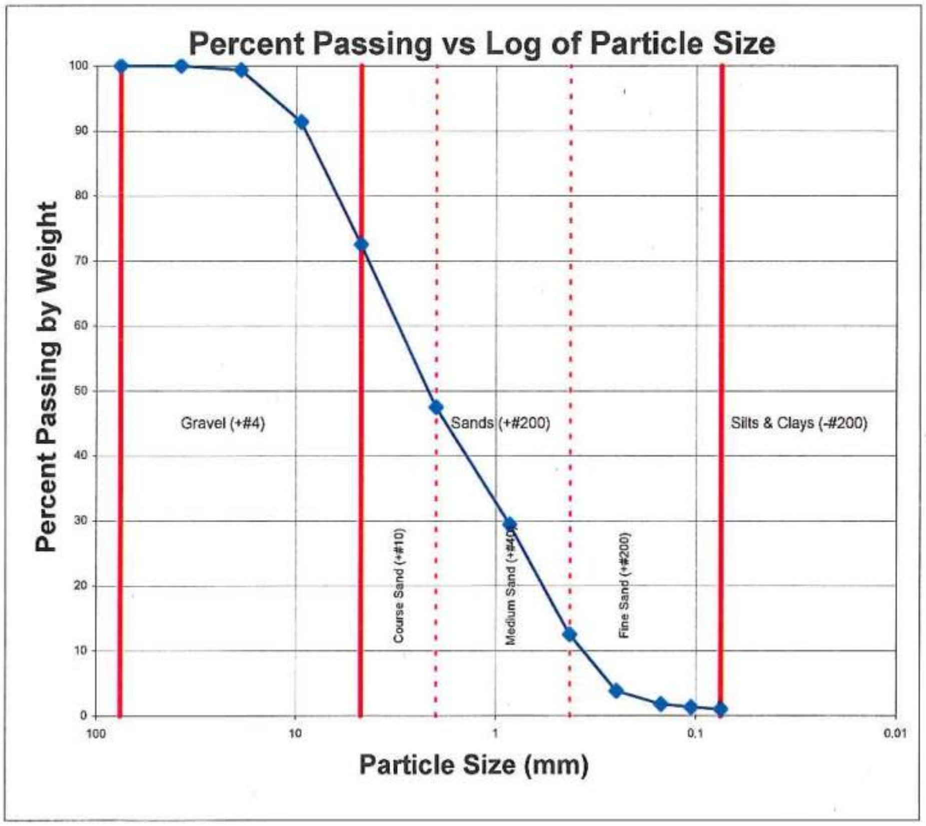
Plus Split Data

Original Weight of +#4 (g): 5,901.00
Calculated Weight of +#4 (g): 5,816.57

Minus Split Data

Original Weight of -#4 (g): 15,314.00
Calculated Dry Weight of -#4 (g): 15,378.91

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
3"	**76.2**	0.00	0.00	0.00	0.00	100.0
1.5"	**38.10**	0.00	0.00	0.00	0.00	100.0
3/4"	**19.05**	132.97	0.00	132.97	132.97	99.4
3/8"	**9.525**	1696.70	0.00	1696.70	1696.70	91.4
#4	**4.750**	3986.90	0.00	3986.90	3986.90	72.6
247.21g split out of -#4 material.						
#10	**2.000**	88.57	3.13	85.44	5322.09	47.4
#20	**0.850**	64.69	3.17	61.52	3831.70	29.4
#40	**0.425**	60.57	3.02	57.54	3584.29	12.5
#60	**0.250**	32.52	3.12	29.39	1830.92	3.8
#100	**0.150**	10.04	3.11	6.94	432.22	1.8
#140	**0.106**	4.66	3.11	1.55	96.67	1.3
#200	**0.075**	4.20	3.19	1.01	62.85	1.0



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Date: 1/22/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_1.xls

Checked By:
Date: 1-26-16

ATT
ADVANCED TERRA TESTING

Particle Size Distribution (Gradation) of Soil Using Sieve Analysis
ASTM D 6913

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: SS-101
Depth: 0-1'
Sample Number: Bu-1 (A+B)
Sampled Date: 12/17/15
(+) Wash Date: 1/19/16
(-) Wash Date: 1/22/16

Sampled By: --
Technician: BDF
Technician: DPM

Grain Size Data

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 270.53
Weight of Dry Soil & Pan (g): 269.99
Weight of Water (g): 0.54
Weight of Pan (g): 14.50
Weight of Dry Soil (g): 255.49
Moisture (%): 0.2

Total Wet Weight of Sample (g): 25,271.89
Total Dry Weight of Sample (g): 25,221.95
Calculated Weight Plus #200 (g): 24,512.28
Moisture of Total Sample (%): 0.2
Percent Retained #200 Sieve (%): 97.2

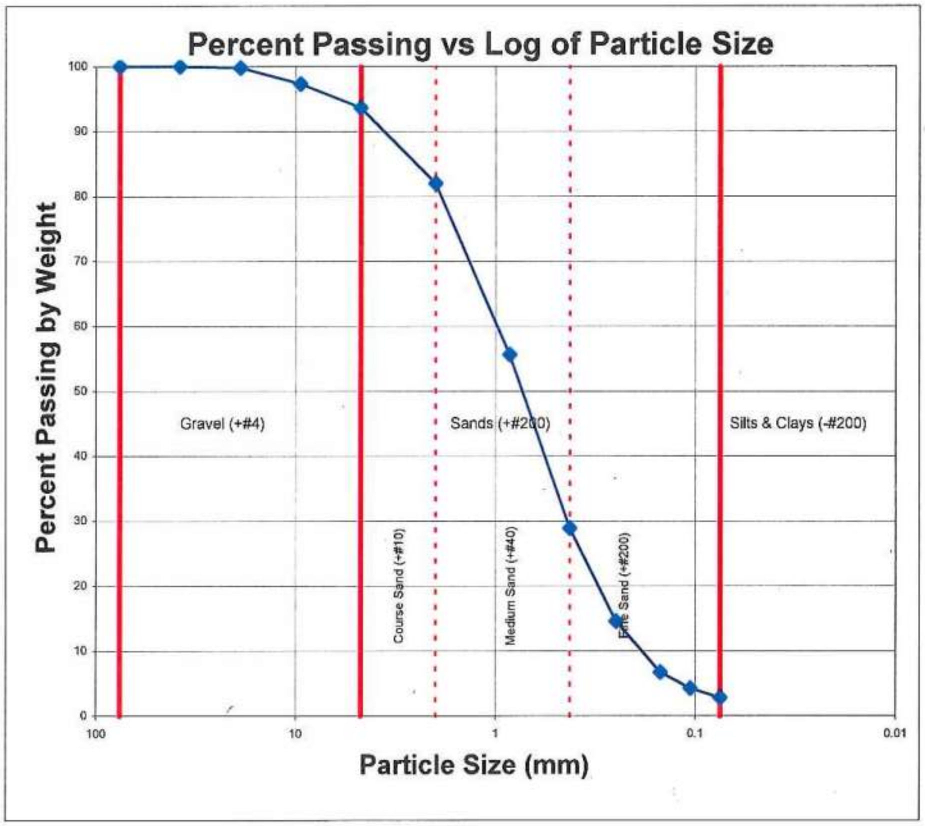
Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
3"	**76.2**	0.00	0.00	0.00	0.00	100.0
1.5"	**38.10**	0.00	0.00	0.00	0.00	100.0
3/4"	**19.05**	48.54	0.00	48.54	48.54	99.8
3/8"	**9.525**	631.34	0.00	631.34	631.34	97.3
#4	**4.750**	915.36	0.00	915.36	915.36	93.7
226.82g split out of -#4 material.						
#10	**2.000**	31.22	3.12	28.10	2933.33	82.0
#20	**0.850**	67.01	3.20	63.81	6660.30	55.6
#40	**0.425**	67.90	3.23	64.66	6749.96	28.9
#60	**0.250**	37.67	3.11	34.56	3607.13	14.6
#100	**0.150**	22.13	3.14	18.99	1981.86	6.7
#140	**0.106**	9.16	3.21	5.94	620.47	4.3
#200	**0.075**	6.70	3.21	3.49	363.99	2.8

Plus Split Data

Original Weight of +#4 (g): 1,621.54
Calculated Weight of +#4 (g): 1,595.24

Minus Split Data

Original Weight of -#4 (g): 23,650.35
Calculated Dry Weight of -#4 (g): 23,626.71



Data Entered By: NN
Date: 1/25/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_3.xls

Checked By: CAL
Date: 1-25-16

ADVANCED TERRA TESTING

Particle Size Distribution (Gradation) of Soil Using Sieve Analysis
ASTM D 6913

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: SS-102
Depth: 0-1'
Sample Number: Bu-1 (A+B)
Sampled Date: 12/17/15
(+) Wash Date: 1/19/16
(-) Wash Date: 1/20/16

Sampled By: --
Technician: BDF
Technician: NN

Grain Size Data

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 210.92
Weight of Dry Soil & Pan (g): 210.66
Weight of Water (g): 0.26
Weight of Pan (g): 7.02
Weight of Dry Soil (g): 203.64
Moisture (%): 0.1

Total Wet Weight of Sample (g): 34,539.00
Total Dry Weight of Sample (g): 34,507.40
Calculated Weight Plus #200 (g): 34,389.83
Moisture of Total Sample (%): 0.1
Percent Retained #200 Sieve (%): 99.7

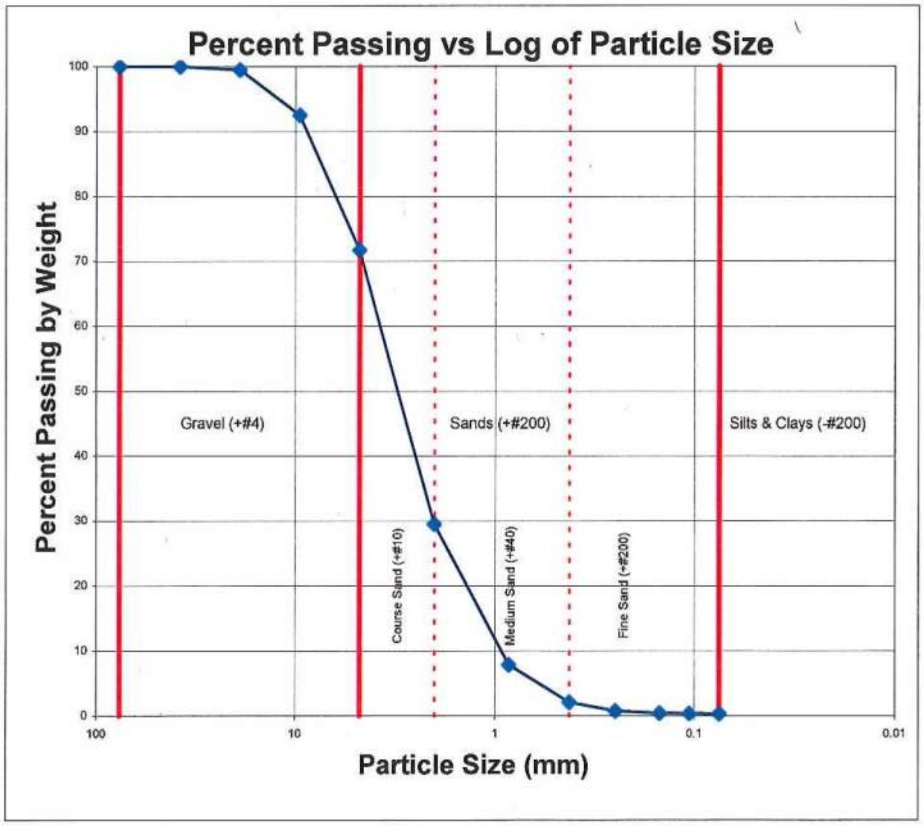
Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
3"	**76.2**	0.00	0.00	0.00	0.00	100.0
1.5"	**38.10**	0.00	0.00	0.00	0.00	100.0
3/4"	**19.05**	165.17	0.00	165.17	165.17	99.5
3/8"	**9.525**	2418.00	0.00	2418.00	2418.00	92.5
#4	**4.750**	7174.00	0.00	7174.00	7174.00	71.7
196.03g split out of -#4 material.						
#10	**2.000**	118.41	3.23	115.17	14560.13	29.5
#20	**0.850**	62.36	3.25	59.11	7472.73	7.9
#40	**0.425**	18.84	3.16	15.68	1982.75	2.1
#60	**0.250**	6.75	3.08	3.68	464.59	0.8
#100	**0.150**	3.94	3.08	0.85	107.96	0.5
#140	**0.106**	3.29	3.09	0.20	25.03	0.4
#200	**0.075**	3.25	3.10	0.15	19.47	0.3

Plus Split Data

Original Weight of +#4 (g): 9,948.00
Calculated Weight of +#4 (g): 9,757.17

Minus Split Data

Original Weight of -#4 (g): 24,591.00
Calculated Dry Weight of -#4 (g): 24,750.23



Data Entered By: NN
Date: 1/21/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_0.xls

Checked By: CM
Date: 1-21-16

ADVANCED TERRA TESTING

Particle Size Distribution (Gradation) of Soil Using Sieve Analysis
ASTM D 6913

Client: RJH Consultants
Job Number: 2679-91
Project: Upper Platte and Beaver Diversion
Location: --
Project Number: 15140

Boring Number: SS-103
Depth: 0-1'
Sample Number: Bu-1 (A + B)
Sampled Date: 12/21/15
(+) Wash Date: 1/19/16
(-) Wash Date: 1/20/16

Sampled By: --
Technician: CKP
Technician: NN

Grain Size Data

Hygroscopic Moisture of Fines

Weight of Wet Soil & Pan (g): 259.62
Weight of Dry Soil & Pan (g): 259.28
Weight of Water (g): 0.34
Weight of Pan (g): 7.03
Weight of Dry Soil (g): 252.25
Moisture (%): 0.1

Total Wet Weight of Sample (g): 32,027.40
Total Dry Weight of Sample (g): 31,986.20
Calculated Weight Plus #200 (g): 31,830.95
Moisture of Total Sample (%): 0.1
Percent Retained #200 Sieve (%): 99.5

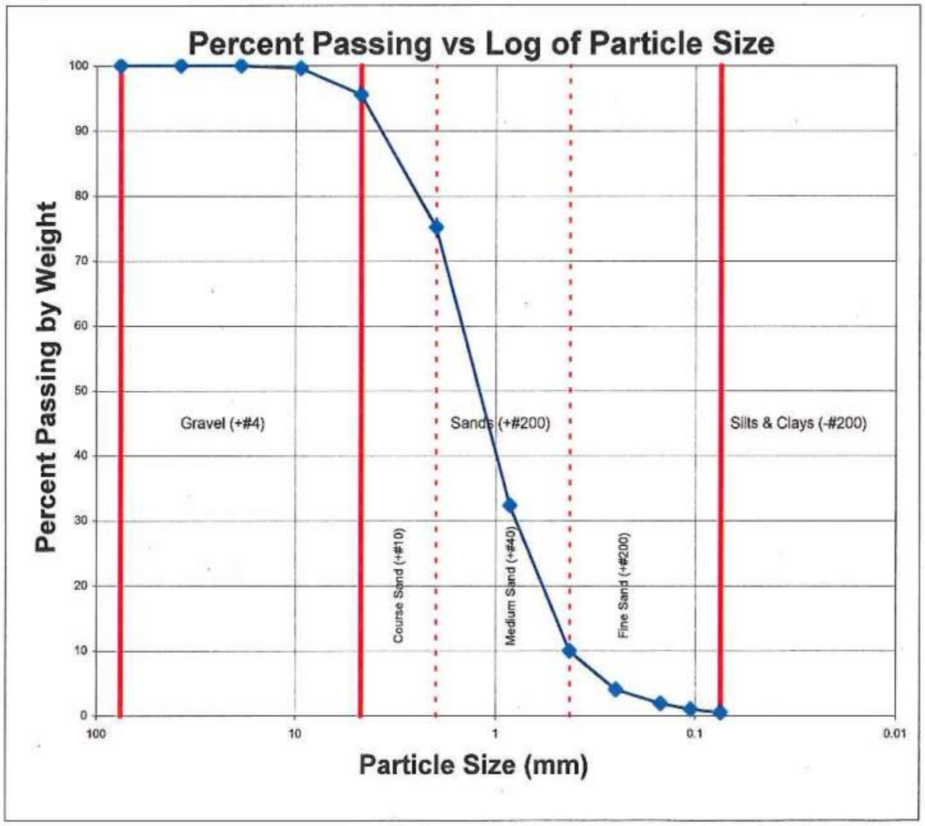
Plus Split Data

Original Weight of +#4 (g): 1,441.40
Calculated Weight of +#4 (g): 1,418.17

Minus Split Data

Original Weight of -#4 (g): 30,586.00
Calculated Dry Weight of -#4 (g): 30,568.03

Sieve Number	Sieve Size (mm)	Weight of Retained Soil & Pan (g)	Weight of Pan (g)	Weight of Retained Soil (g)	Calculated Weight of Retained Soil (g)	Percent Passing by Weight (%)
3"	**76.2**	0.00	0.00	0.00	0.00	100.0
1.5"	**38.10**	0.00	0.00	0.00	0.00	100.0
3/4"	**19.05**	0.00	0.00	0.00	0.00	100.0
3/8"	**9.525**	134.50	0.00	134.50	134.50	99.6
#4	**4.750**	1283.67	0.00	1283.67	1283.67	95.6
234.34g split out of -#4 material.						
#10	**2.000**	53.00	3.09	49.90	6518.40	75.2
#20	**0.850**	108.22	3.14	105.09	13726.48	32.3
#40	**0.425**	57.83	3.14	54.69	7143.55	9.9
#60	**0.250**	17.58	3.12	14.46	1888.75	4.0
#100	**0.150**	8.44	3.20	5.24	684.18	1.9
#140	**0.106**	5.53	3.25	2.28	297.68	1.0
#200	**0.075**	4.23	3.06	1.18	153.74	0.5



Data Entered By: NN
Date: 1/22/2016
File Name: 2679_91_grainSize-ASTM-C33-D1140-D6319-D2487-R6_2.xls

Checked By: CAL
Date: 1/25/16

ADVANCED TERRA TESTING

Consolidation/Swell Test

ASTM D 4546

CONSOLIDATION/SWELL TEST
ASTM D 4546 METHOD

CLIENT RJH Consultants

JOB NO. 2679-91

BORING NO.	B-102	SAMPLED	12/22/15
DEPTH	9.7-10.6'	TEST STARTED	01/21/16 DPM
SAMPLE NO.	HQ-3	TEST FINISHED	01/22/16 DPM
PROJ NO.	15140	SETUP NO.	ATT-15
LOCATION	Upper Platte and Beaver Diversion		

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil & Ring (s) (g)	201.2	202.4
Wt. Ring (s) (g)	42.4	42.4
Wt. Soil (g)	158.9	160.1
Wet Density PCF	133.5	135.5
Sample Diameter (in)	2.403	2.403
Sample Height (in)	1.000	0.993
Wt. Wet Soil & Pan (g)	162.0	163.2
Wt. Dry Soil & Pan (g)	139.8	139.8
Wt. Lost Moisture (g)	22.2	23.4
Wt. of Pan Only (g)	3.1	3.1
Wt. of Dry Soil (g)	136.7	136.7
Moisture Content %	16.2	17.1
Dry Density PCF	114.8	115.7
Max. Dry Density PCF		
Percent Compaction		

LOAD (PSF)	CONSOL. (IN.)
100	0.0000
5000	0.0075
5000	0.0075

	LOAD (PSF)	LOG LOAD	CONSOL. (IN.)	DEFL. (IN.)
	100	2.000	0.0000	0.0000
	5000	3.699	0.0075	-0.0075
Inundate	5000	3.699	0.0075	-0.0075

Data Entered By: NN Date: 01/26/2016
Data Checked By: DPM Date: 1/28/16
Filename: CNSWB102

ADVANCED TERRA TESTING, Inc.
ATT

CONSOLIDATION/SWELL TEST
ASTM D 4546 METHOD

CLIENT RJH Consultants

JOB NO. 2679-91

BORING NO. B-102
DEPTH 9.7-10.6'
SAMPLE NO. HQ-3
SOIL DESCR. --

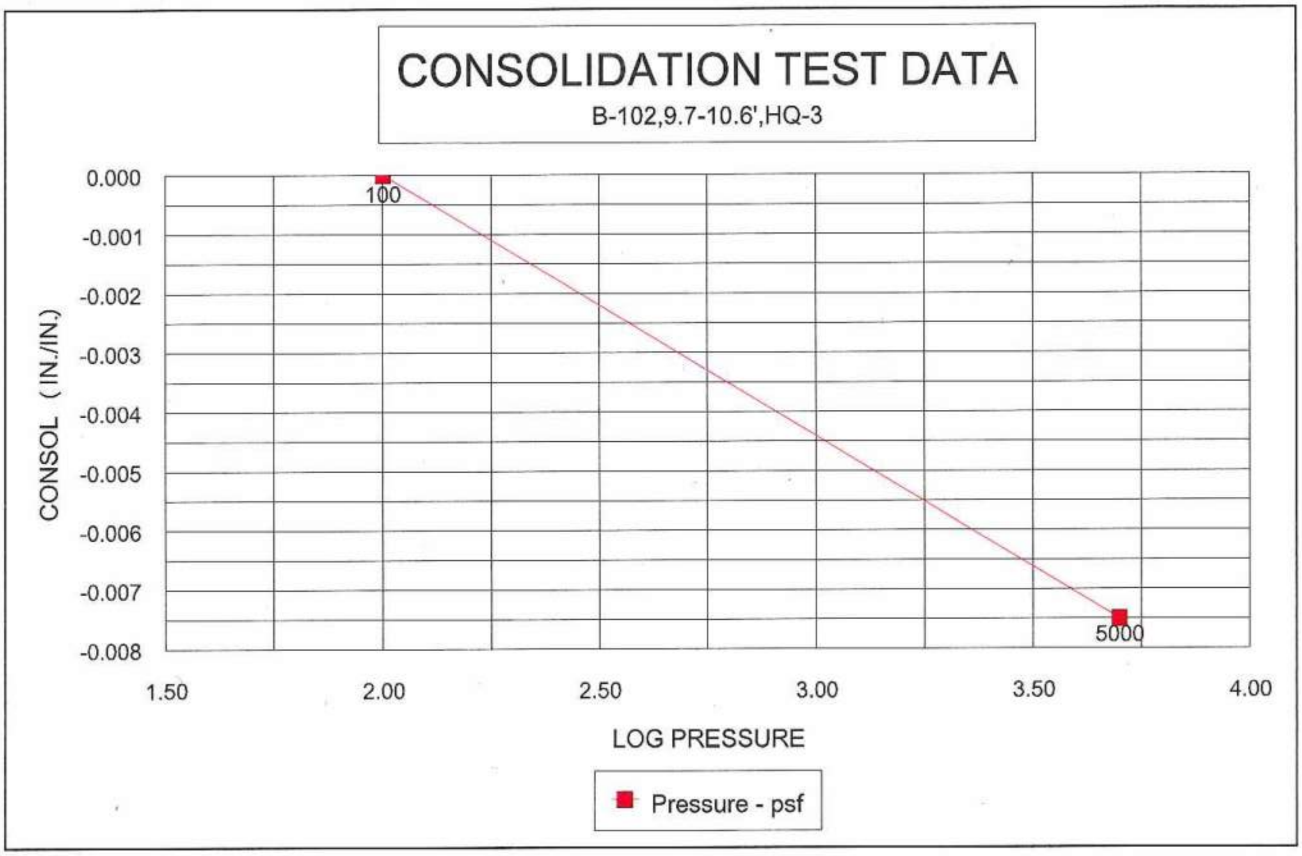
SAMPLED 12/22/15
TEST STARTED 01/21/16 DPM
TEST FINISHED 01/22/16 DPM
SETUP NO. ATT-15

TIME READING DATA

5000 wet psf load

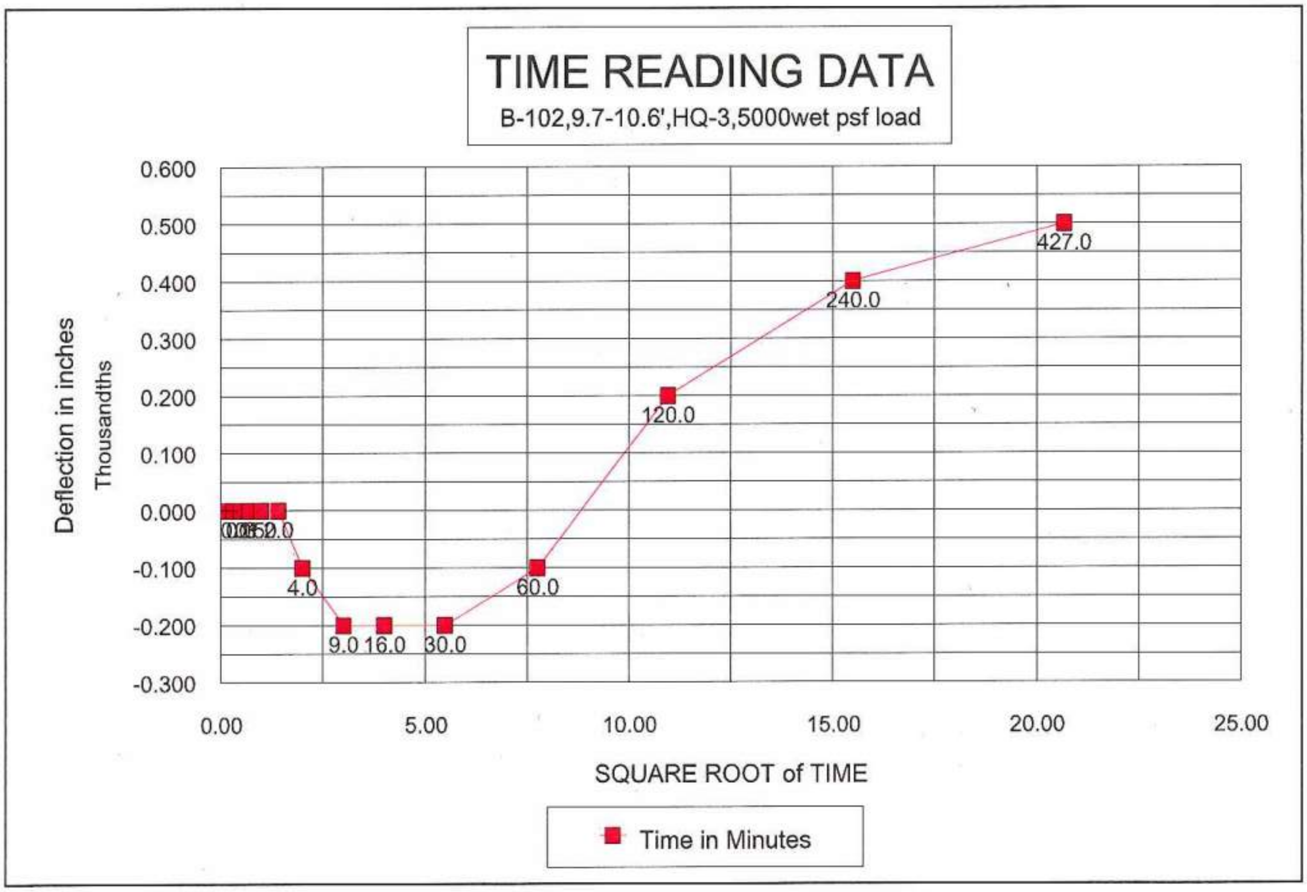
Elapsed Time (min)	SQRT Time (min)	Dial Reading (in)	Defl. (in)
0.0	0.00	0.0120	-0.0000
0.1	0.32	0.0120	-0.0000
0.3	0.50	0.0120	-0.0000
0.5	0.71	0.0120	-0.0000
1.0	1.00	0.0120	-0.0000
2.0	1.41	0.0120	-0.0000
4.0	2.00	0.0121	-0.0001
9.0	3.00	0.0122	-0.0002
16.0	4.00	0.0122	-0.0002
30.0	5.48	0.0122	-0.0002
60.0	7.75	0.0121	-0.0001
120.0	10.95	0.0118	0.0002
240.0	15.49	0.0116	0.0004
427.0	20.66	0.0115	0.0005

Data Entered By: NN Date: 01/26/2016
Data Checked By: DPM Date: 1/28/16
Filename: CNSWB102



CONSOLIDATION TEST DATA

B-102,9.7-10.6',HQ-3



TIME READING DATA

B-102,9.7-10.6',HQ-3,5000wet psf load

CONSOLIDATION/SWELL TEST
ASTM D 4546 METHOD

CLIENT RJH Consultants

JOB NO. 2679-91

BORING NO. B-104
DEPTH 21.4-22'
SAMPLE NO. HQ-5
PROJ NO. 15140
LOCATION Upper Platte and Beaver Diversion

SAMPLED 12/28/15
TEST STARTED 01/21/16 DPM
TEST FINISHED 01/22/16 DPM
SETUP NO. ATT-09

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil & Ring (s) (g)	201.6	202.2
Wt. Ring (s) (g)	41.3	41.3
Wt. Soil (g)	160.3	160.9
Wet Density PCF	133.9	135.1
Sample Diameter (in)	2.410	2.410
Sample Height (in)	1.000	0.995
Wt. Wet Soil & Pan (g)	163.5	164.0
Wt. Dry Soil & Pan (g)	140.7	140.7
Wt. Lost Moisture (g)	22.8	23.4
Wt. of Pan Only (g)	3.1	3.1
Wt. of Dry Soil (g)	137.5	137.5
Moisture Content %	16.6	17.0
Dry Density PCF	114.9	115.5
Max. Dry Density PCF		
Percent Compaction		

LOAD (PSF)	CONSOL. (IN.)
100	0.0000
5000	0.0052
5000	0.0054

	LOAD (PSF)	LOG LOAD	CONSOL. (IN.)	DEFL. (IN.)
	100	2.000	0.0000	0.0000
	5000	3.699	0.0052	-0.0052
Inundate	5000	3.699	0.0054	-0.0054

Data Entered By: NN Date: 01/26/2016
Data Checked By: DPM Date: 1/28/16
Filename: CNSWB104

CONSOLIDATION/SWELL TEST
ASTM D 4546 METHOD

CLIENT RJH Consultants

JOB NO. 2679-91

BORING NO. B-104
DEPTH 21.4-22'
SAMPLE NO. HQ-5
SOIL DESCR. --

SAMPLED 12/28/15
TEST STARTED 01/21/16 DPM
TEST FINISHED 01/22/16 DPM
SETUP NO. ATT-09

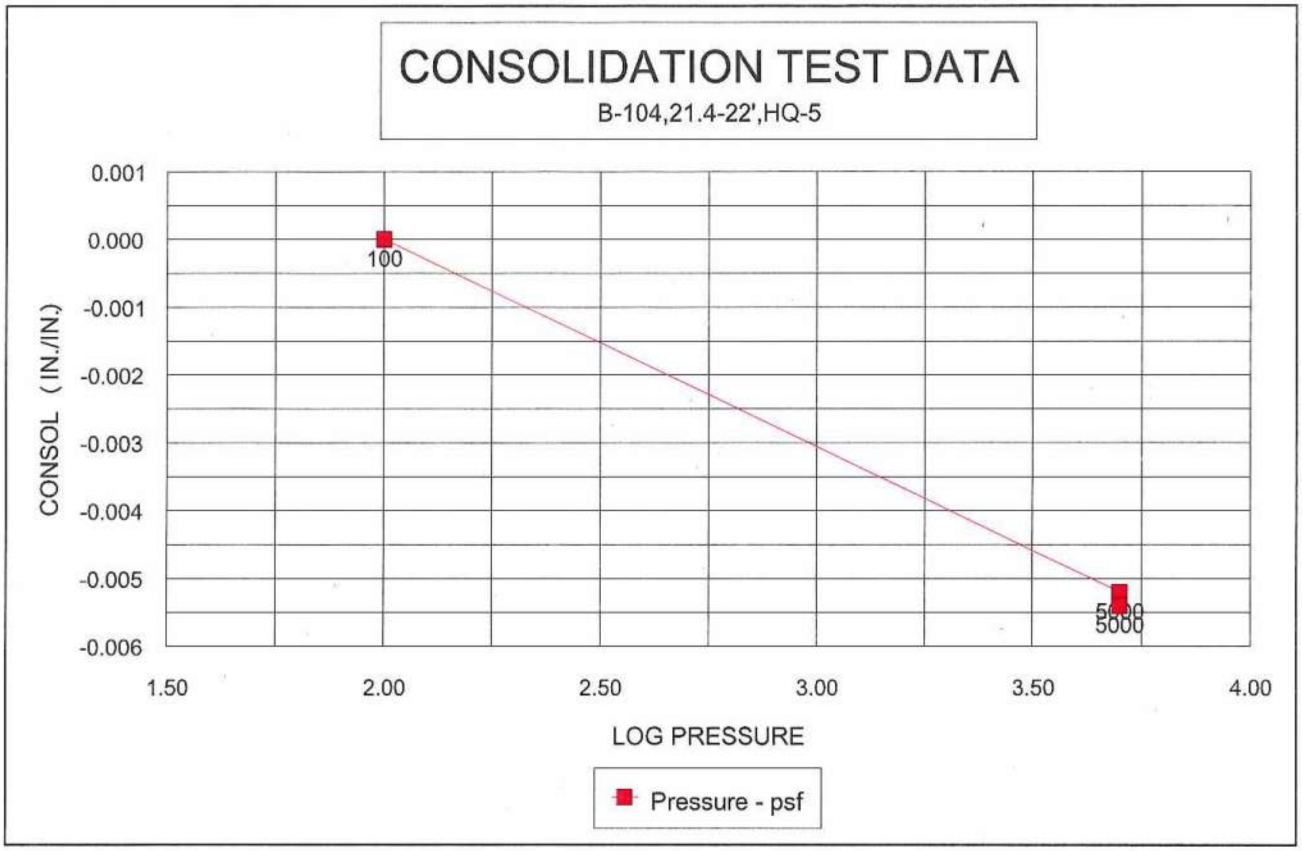
TIME READING DATA

5000 wet psf load

Elapsed Time (min)	SQRT Time (min)	Dial Reading (in)	Defl. (in)
0.0	0.00	0.0094	-0.0000
0.1	0.32	0.0095	-0.0001
0.3	0.50	0.0095	-0.0001
0.5	0.71	0.0095	-0.0001
1.0	1.00	0.0095	-0.0001
2.0	1.41	0.0095	-0.0001
4.0	2.00	0.0094	-0.0000
9.0	3.00	0.0094	-0.0000
16.0	4.00	0.0094	-0.0000
30.0	5.48	0.0094	-0.0000
60.0	7.75	0.0094	-0.0000
120.0	10.95	0.0095	-0.0001
240.0	15.49	0.0095	-0.0001
430.0	20.74	0.0095	-0.0001

Data Entered By: NN Date: 01/26/2016
Data Checked By: DPM Date: 1/28/16
Filename: CNSWB104

ADVANCED TERRA TESTING, INC.
ATT


CONSOLIDATION TEST DATA
B-104,21.4-22',HQ-5
0.001
0.000
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
CONSOL (IN./IN.)
100
5000
5000
1.50
2.00
2.50
3.00
3.50
4.00
LOG PRESSURE
Pressure - psf


TIME READING DATA
B-104,21.4-22',HQ-5,5000wet psf load
0.020
0.000
-0.020
-0.040
-0.060
-0.080
-0.100
Deflection in inches
Thousandths
0.0
4.0
9.0
16.0
30.0
60.0
2.0
120.0
240.0
430.0
0.00
5.00
10.00
15.00
20.00
25.00
SQUARE ROOT of TIME
Time in Minutes

Unconfined Compressive Strength

ASTM D 2166

ADVANCED TERRA TESTING

UNCONFINED COMPRESSIVE STRENGTH TEST DATA
ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	12/22/2015
PROJECT NO.	15140	SATURATED TEST	No
BORING NO.	B-102	AT FIELD MOIST.	Yes
DEPTH	2-2.9'		
SAMPLE NO.	HQ-1		
SOIL DESCR.	Silty Sandstone		
LOCATION	--		

MOISTURE/DENSITY DATA	BEFORE TEST
Wt. Soil + Moisture (g)	785.50
Wt. Wet Soil & Pan (g)	800.01
Wt. Dry Soil & Pan (g)	689.76
Wt. Lost Moisture (g)	110.25
Wt. of Pan Only (g)	14.51
Wt. of Dry Soil (g)	675.25
Moisture Content %	16.3
Wet Density PCF	134.3
Dry Density PCF	115.4
Init. Diameter (in)	2.383
Init. Area (sq in)	4.460
Init. Height (in)	4.997
Height to Diameter Ratio	2.097
Volume cu Ft.	0.01290

Notes & Comments:

Data entered by: NN Date: 01/25/2016

Data checked by: Date: 01/27/2016

UNCONFINED COMPRESSIVE STRENGTH TEST DATA

ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	12/22/2015
PROJECT NO.	15140	DATE TESTED	1/22/2016
BORING NO.	B-102	SATURATED TEST	No
DEPTH	2-2.9'	AT FIELD MOIST.	Yes
SAMPLE NO.	HQ-1		
SOIL DESCR.	Silty Sandstone	TEST TYPE	UCS
LOCATION	--		
Init. Ht. (in)	4.997	Init. Area (sq in)	4.460
		Strain Rate (in/min)	0.030

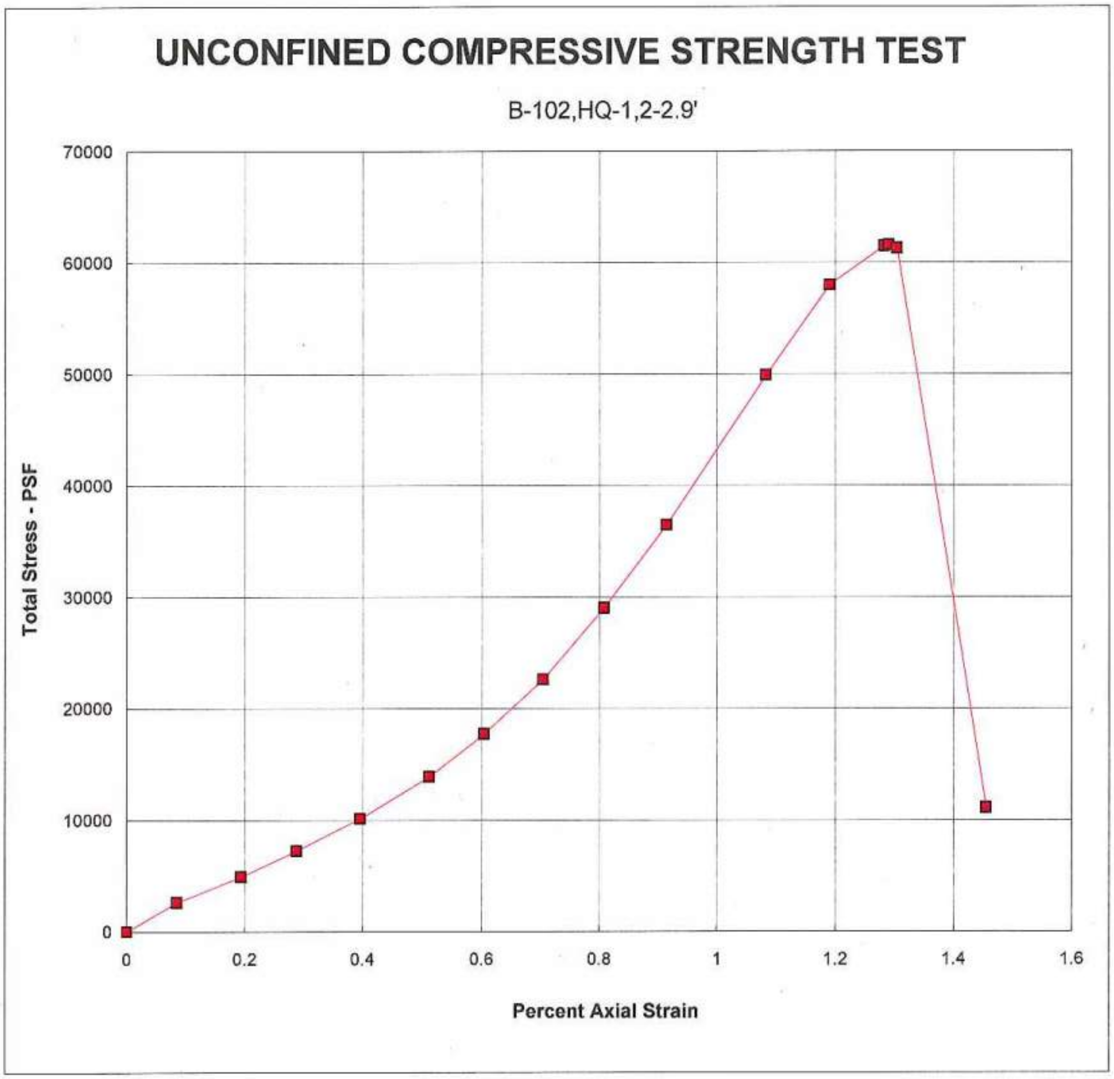
Axial Load Lbs.	Uncorrected Axial Stress PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Dev. Stress PSI
0.0	0	0.000	0.0000	4.460	0	0.0
81.0	2615	0.004	0.0861	4.464	2613	18.1
153.0	4940	0.010	0.1941	4.469	4930	34.2
225.0	7265	0.014	0.2882	4.473	7244	50.3
315.0	10170	0.020	0.3962	4.478	10130	70.3
432.0	13948	0.026	0.5123	4.483	13876	96.4
552.0	17822	0.030	0.6044	4.487	17715	123.0
705.0	22762	0.035	0.7044	4.492	22602	157.0
906.0	29252	0.040	0.8085	4.496	29015	201.5
1140.0	36807	0.046	0.9145	4.501	36470	253.3
1563.0	50464	0.054	1.0826	4.509	49918	346.7
1818.0	58697	0.060	1.1907	4.514	57998	402.8
1929.0	62281	0.064	1.2828	4.518	61482	427.0
1932.0	62378	0.065	1.2908	4.518	61573	427.6
1923.0	62087	0.065	1.3048	4.519	61277	425.5
348.0	11236	0.073	1.4549	4.526	11072	76.9

Peak Deviator Stress (psi) **427.6**

UNCONFINED COMPRESSIVE STRENGTH TEST DATA

ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	12/22/2015
PROJECT NO.	15140	SATURATED TEST	No
BORING NO.	B-102	AT FIELD MOIST.	Yes
DEPTH	2-2.9'		
SAMPLE NO.	HQ-1		
SOIL DESCR.	Silty Sandstone		
LOCATION	--		



Client RJH
Job No. 2679-91
BoringNo. B-102
Depth 2.0-2.9'
Sample No. HQ-1
Location —
Project Upper Platte & Beaver Diversion
Project No. 15140
Date Tested/By 1-22-16 JQ
Test Type UCS
Confining Stress 0

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ADVANCED TERRA TESTING

UNCONFINED COMPRESSIVE STRENGTH TEST DATA
ASTM D 2166

CLIENT RJH Consultants

JOB NO. 2679-91

PROJECT Upper Platte and Beaver Diversion
PROJECT NO. 15140
BORING NO. B-102
DEPTH 9.7-10.6'
SAMPLE NO. HQ-3
SOIL DESCR. Sandy Siltstone
LOCATION --

SAMPLED 12/22/2015
SATURATED TEST No
AT FIELD MOIST. Yes

MOISTURE/DENSITY DATA	BEFORE TEST
Wt. Soil + Moisture (g)	799.49
Wt. Wet Soil & Pan (g)	813.82
Wt. Dry Soil & Pan (g)	704.11
Wt. Lost Moisture (g)	109.71
Wt. of Pan Only (g)	14.33
Wt. of Dry Soil (g)	689.78
Moisture Content %	15.9
Wet Density PCF	135.3
Dry Density PCF	116.8

Init. Diameter (in)	2.395
Init. Area (sq in)	4.505
Init. Height (in)	4.996
Height to Diameter Ratio	2.086
Volume cu Ft.	0.01303

Notes & Comments:

Data entered by: NN Date: 01/25/2016
Data checked by:________ Date: 01/27/2016

UNCONFINED COMPRESSIVE STRENGTH TEST DATA
ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	12/22/2015
PROJECT NO.	15140	DATE TESTED	1/22/2016
BORING NO.	B-102	SATURATED TEST	No
DEPTH	9.7-10.6'	AT FIELD MOIST.	Yes
SAMPLE NO.	HQ-3		
SOIL DESCR.	Sandy Siltstone	TEST TYPE	UCS
LOCATION	--		
Init. Ht. (in)	4.996	Init. Area (sq in)	4.505
		Strain Rate (in/min)	0.030

Axial Load Lbs.	Uncorrected Axial Stress PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Dev. Stress PSI
0.0	0	0.000	0.0000	4.505	0	0.0
108.0	3452	0.006	0.1121	4.510	3448	23.9
189.0	6041	0.010	0.2002	4.514	6029	41.9
309.0	9877	0.016	0.3122	4.519	9846	68.4
405.0	12945	0.020	0.4003	4.523	12894	89.5
546.0	17452	0.025	0.5044	4.528	17364	120.6
675.0	21576	0.030	0.5925	4.532	21448	148.9
861.0	27521	0.035	0.7046	4.537	27327	189.8
1065.0	34042	0.041	0.8187	4.542	33763	234.5
1263.0	40371	0.045	0.9067	4.546	40005	277.8
1488.0	47562	0.050	0.9988	4.551	47087	327.0
1785.0	57056	0.055	1.1049	4.555	56425	391.8
2103.0	67220	0.060	1.2070	4.560	66409	461.2
2274.0	72686	0.064	1.2710	4.563	71762	498.3
2334.0	74604	0.067	1.3371	4.566	73607	511.2
2250.0	71919	0.069	1.3791	4.568	70927	492.6
522.0	16685	0.079	1.5793	4.577	16422	114.0

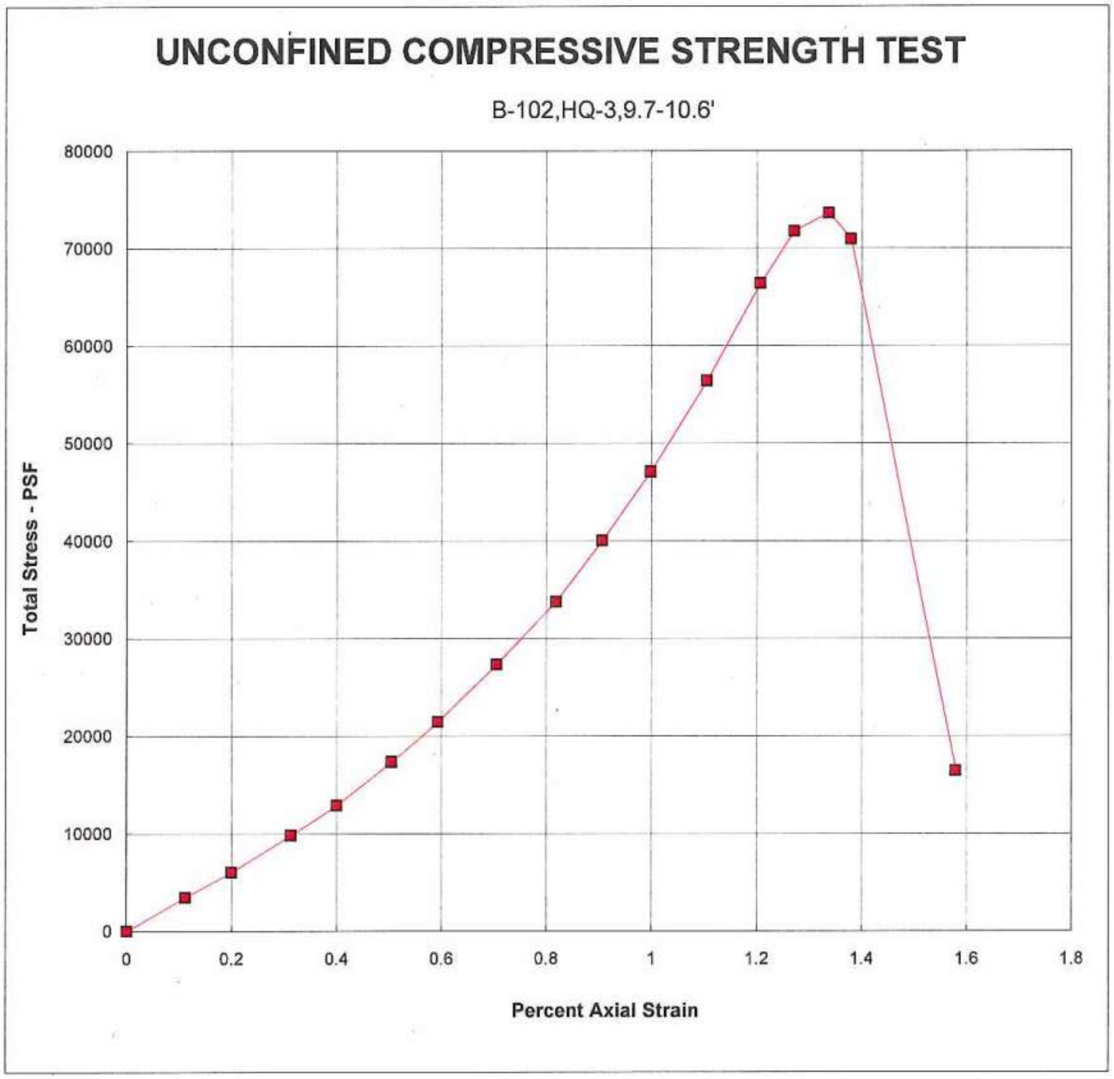
Peak Deviator Stress (psi) **511.2**

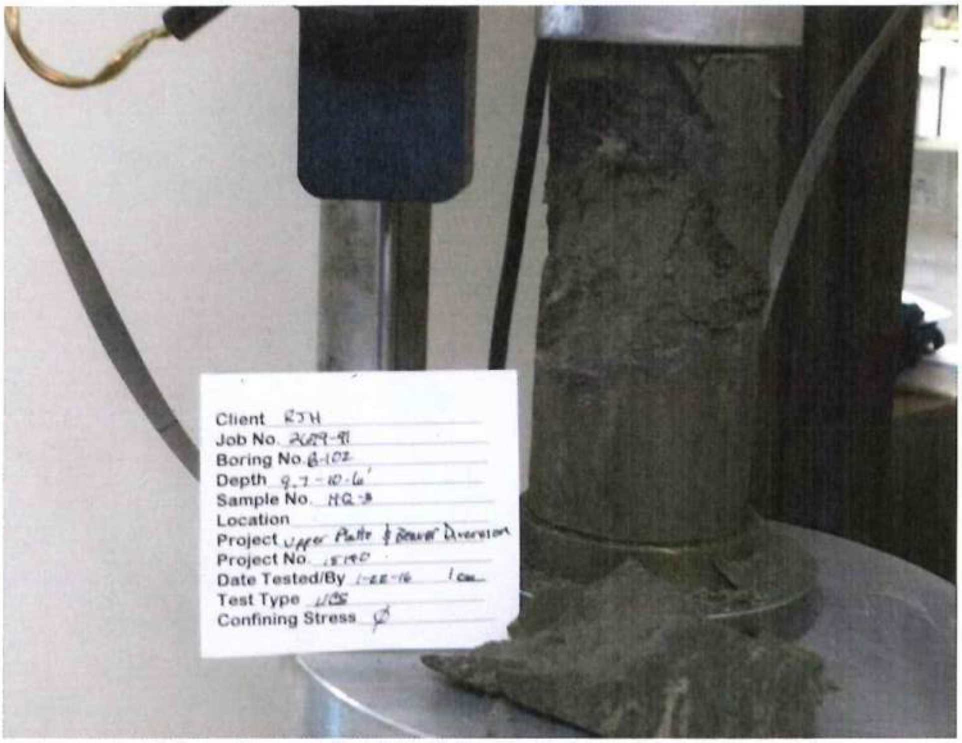
ADVANCED TERRA TESTING

UNCONFINED COMPRESSIVE STRENGTH TEST DATA

ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	12/22/2015
PROJECT NO.	15140	SATURATED TEST	No
BORING NO.	B-102	AT FIELD MOIST.	Yes
DEPTH	9.7-10.6'		
SAMPLE NO.	HQ-3		
SOIL DESCR.	Sandy Siltstone		
LOCATION	--		





Client RJH
Job No. 2679-91
Boring No. B-102
Depth 9.7-10.6'
Sample No. HQ-3
Location
Project Upper Platte & Beaver Diversion
Project No. 15140
Date Tested/By 1-22-16 / cm
Test Type UCS
Confining Stress 0

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ATT
ADVANCED TERRA TESTING

UNCONFINED COMPRESSIVE STRENGTH TEST DATA
ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	--
PROJECT NO.	15140	SATURATED TEST	No
BORING NO.	B-105	AT FIELD MOIST.	Yes
DEPTH	17.2-17.9'		
SAMPLE NO.	HQ-2		
SOIL DESCR.	Clayey Sandstone		
LOCATION	--		

MOISTURE/DENSITY DATA	BEFORE TEST
Wt. Soil + Moisture (g)	763.83
Wt. Wet Soil & Pan (g)	778.24
Wt. Dry Soil & Pan (g)	664.62
Wt. Lost Moisture (g)	113.62
Wt. of Pan Only (g)	14.41
Wt. of Dry Soil (g)	650.21
Moisture Content %	17.5
Wet Density PCF	132.6
Dry Density PCF	112.9
Init. Diameter (in)	2.389
Init. Area (sq in)	4.483
Init. Height (in)	4.896
Height to Diameter Ratio	2.049
Volume cu Ft.	0.01270

Notes & Comments:

Data entered by: NN Date: 01/25/2016

Data checked by: cl Date: 01/27/2016

UNCONFINED COMPRESSIVE STRENGTH TEST DATA
ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	--
PROJECT NO.	15140	DATE TESTED	1/22/2016
BORING NO.	B-105	SATURATED TEST	No
DEPTH	17.2-17.9'	AT FIELD MOIST.	Yes
SAMPLE NO.	HQ-2		
SOIL DESCR.	Clayey Sandstone	TEST TYPE	UCS
LOCATION	--		
Init. Ht. (in)	4.896	Init. Area (sq in)	4.483
		Strain Rate (in/min)	0.030

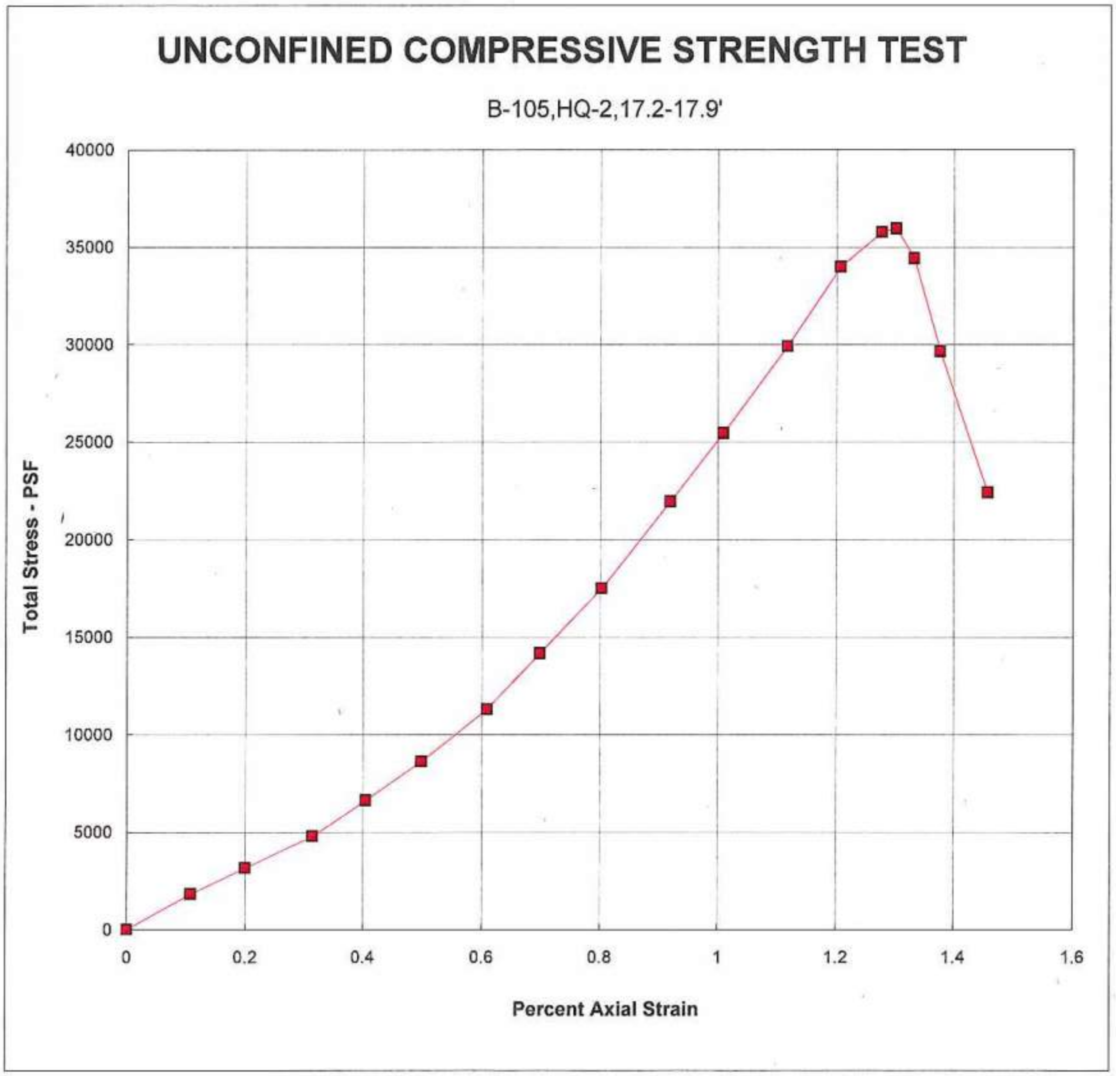
Axial Load Lbs.	Uncorrected Axial Stress PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Dev. Stress PSF	Dev. Stress PSI
0.0	0	0.000	0.0000	4.483	0	0.0
57.0	1831	0.005	0.1083	4.487	1829	12.7
99.0	3180	0.010	0.2002	4.492	3174	22.0
150.0	4819	0.015	0.3145	4.497	4804	33.4
207.0	6650	0.020	0.4044	4.501	6623	46.0
270.0	8674	0.024	0.4984	4.505	8630	59.9
354.0	11372	0.030	0.6087	4.510	11303	78.5
444.0	14263	0.034	0.6985	4.514	14164	98.4
549.0	17637	0.039	0.8027	4.519	17495	121.5
690.0	22166	0.045	0.9191	4.524	21962	152.5
801.0	25732	0.049	1.0090	4.528	25472	176.9
942.0	30262	0.055	1.1172	4.533	29923	207.8
1071.0	34406	0.059	1.2071	4.537	33990	236.0
1128.0	36237	0.063	1.2766	4.540	35774	248.4
1134.0	36430	0.064	1.3011	4.542	35956	249.7
1086.0	34888	0.065	1.3317	4.543	34423	239.0
936.0	30069	0.067	1.3766	4.545	29655	205.9
708.0	22744	0.071	1.4563	4.549	22413	155.6

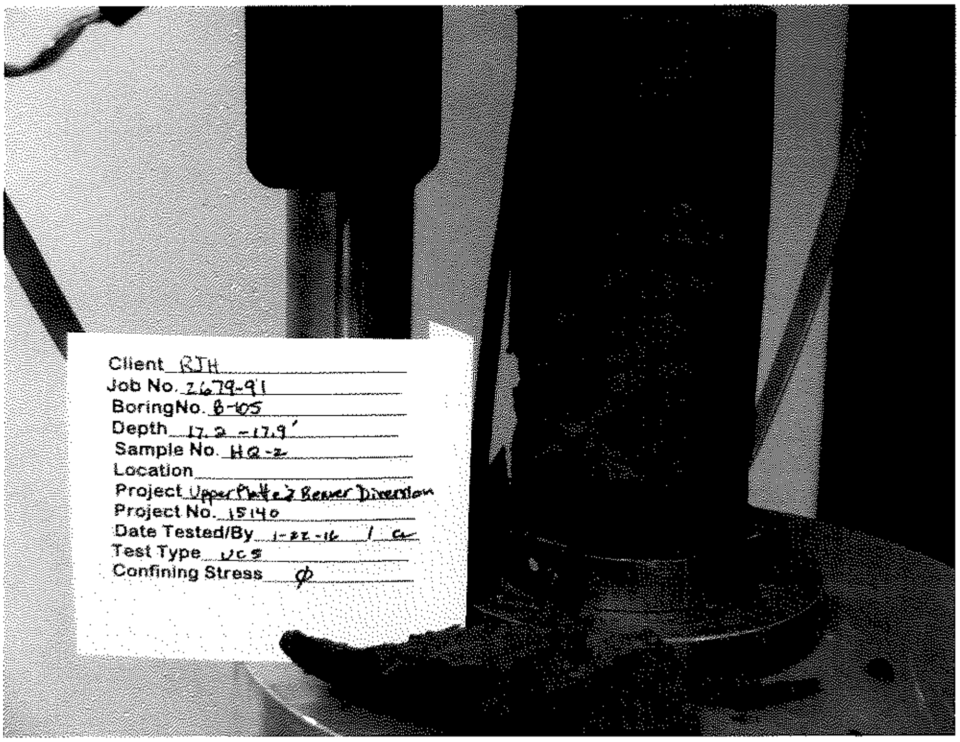
Peak Deviator Stress (psi) 249.7

UNCONFINED COMPRESSIVE STRENGTH TEST DATA

ASTM D 2166

CLIENT	RJH Consultants	JOB NO.	2679-91
PROJECT	Upper Platte and Beaver Diversion	SAMPLED	--
PROJECT NO.	15140	SATURATED TEST	No
BORING NO.	B-105	AT FIELD MOIST.	Yes
DEPTH	17.2-17.9'		
SAMPLE NO.	HQ-2		
SOIL DESCR.	Clayey Sandstone		
LOCATION	--		





Client RJH
Job No. 2679-91
BoringNo. B-105
Depth 17.2 - 17.9'
Sample No. HQ-2
Location
Project Upper Platte & Beaver Diversion
Project No. 15140
Date Tested/By 1-22-16 / ca
Test Type UCS
Confining Stress 0

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UNCONFINED COMPRESSIVE STRENGTH
ASTM D 7012; Method C (Previously ASTM D 2938)

CLIENT: RJH Consultants

JOB NO.: 2679-91

PROJECT: Upper Platte & Beaver Diversion

DATE TESTED: 1/22/16 BL

PROJECT NO.: 15140

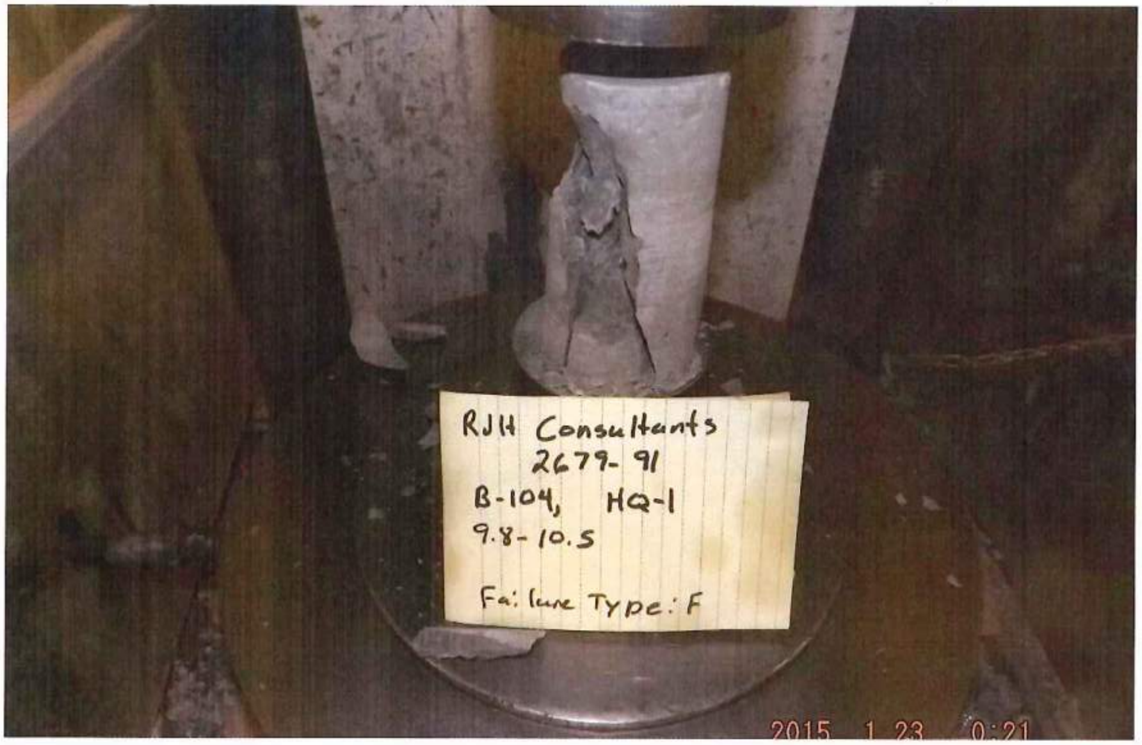
Specimen ID Boring, Depth(ft.), Rock type	Diameter (in.)	Length (in.)	Mass (gms)	Wet Density (pcf)	Failure Load (lb)	Failure Types **	Compressive Strength (psi)
B-104, HQ-1, 9.8-10.5	2.386	5.151	965.3	159.7	25,940	F	5,800

Notes and Comments:

* Indicates regardless of ASTM D 7012 method C, sample with L/D < 2.0.
was tested and correction factor for short sample was applied to the calculation.
C=Ca/[0.88+0.24b/h]
Ca = Failure Load / Surface Area
b = Sample Diameter
h = Sample Length

** Failure types S: Shear Failure, M: Matrix Failure, F: Failure due to Fracture/Bedding, V: Void Failure, C: Combination

Data Entered By: BKL Date: 01/22/2016
Data Checked By: HN Date: 1/22 2016
Filename: RJUC91AA



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Triaxial Shear Test
TX/CUPP
ASTM D 4647

Consolidated Undrained Triaxial Compression Test for Cohesive Soils
ASTM D 4767

Client	RJH Consultants	Boring Number:	B-104		
Job Number	2679-91	Depth:	18.5'-20.5		
Project	Upper Platte and Beaver Diversion	Sample Number:	HQ-4		
Location	--	Sampled Date:	12/28/15		
Project Number	15140	Sampled By:	--	Tested By:	CAL

TEST TYPE TX/CUPP

σ_3 Confining Stresses (psf)	
19.7-20.5'	3800
19.1-19.7'	1800
18.5-19.1'	800

Peak Points	p' (psf)	q (psf)
19.7-20.5'	34339	30395
19.1-19.7'	24860	22242
18.5-19.1'	20742	20792

Stress Condition at Maximum Deviator Stress (PSF)

	σ3	σ1	σ'3	σ'1
19.7-20.5'	3800	64589	3944	64733
19.1-19.7'	1800	46283	2618	47101
18.5-19.1'	800	42383	-50	41533

19.7-20.5' DATA

σ_3' (psf)	σ_1' (psf)	Deviator Stress $(\sigma_1-\sigma_3)$ (psf)	p' = $(\sigma_1'+\sigma_3')/2$ (psf)	q = $(\sigma_1-\sigma_3)/2$ (psf)
3800	3800	0	3800	0
3627	4207	580	3917	290
2965	5379	2414	4172	1207
1784	7475	5691	4630	2846
1035	9612	8577	5324	4289
574	12031	11457	6303	5729
301	14823	14522	7562	7261
157	17931	17774	9044	8887
56	21172	21116	10614	10558
13	24656	24643	12335	12322
-16	29009	29025	14497	14513
114	52345	52231	26230	26116
3944	64733	60789	34339	30395
7328	52147	44819	29738	22410
8120	53745	45625	30933	22813
9445	54839	45394	32142	22697
9992	51062	41070	30527	20535
10352	50446	40094	30399	20047
10654	50145	39491	30400	19746
10885	49420	38535	30153	19268
11058	49089	38031	30074	19016
11202	48731	37529	29967	18765
11259	47687	36428	29473	18214
11346	47710	36364	29528	18182
11432	47470	36038	29451	18019
11504	47134	35630	29319	17815
11547	45657	34110	28802	17055

19.1-19.7' DATA

σ_3' (psf)	σ_1' (psf)	Deviator Stress $(\sigma_1-\sigma_3)$ (psf)	p' = $(\sigma_1'+\sigma_3')/2$ (psf)	q = $(\sigma_1-\sigma_3)/2$ (psf)
1800	1800	0	1800	0
1202	3364	2162	2283	1081
716	5056	4340	2886	2170
405	6815	6410	3610	3205
229	8886	8457	4458	4229
138	10739	10601	5439	5301
101	13047	12946	6574	8473
73	15380	15307	7727	7654
9	18182	18173	9096	9087
27	21184	21157	10606	10579
19	24295	24276	12157	12138
248	40350	40102	20299	20051
2618	47101	44483	24860	22242
5262	28221	22959	16742	11480
5822	29001	23179	17412	11590
6695	30599	23904	18647	11952
7145	31440	24295	19293	12148
7540	32774	25234	20157	12617
7741	33131	25390	20436	12695
7991	33651	25860	20821	12830
8109	33577	25468	20843	12734
8173	33745	25572	20959	12786
8220	33529	25309	20875	12655
8330	33657	25327	20994	12664
8366	32879	24513	20823	12257
8421	32698	24277	20560	12139
5905	17821	11916	11863	5958

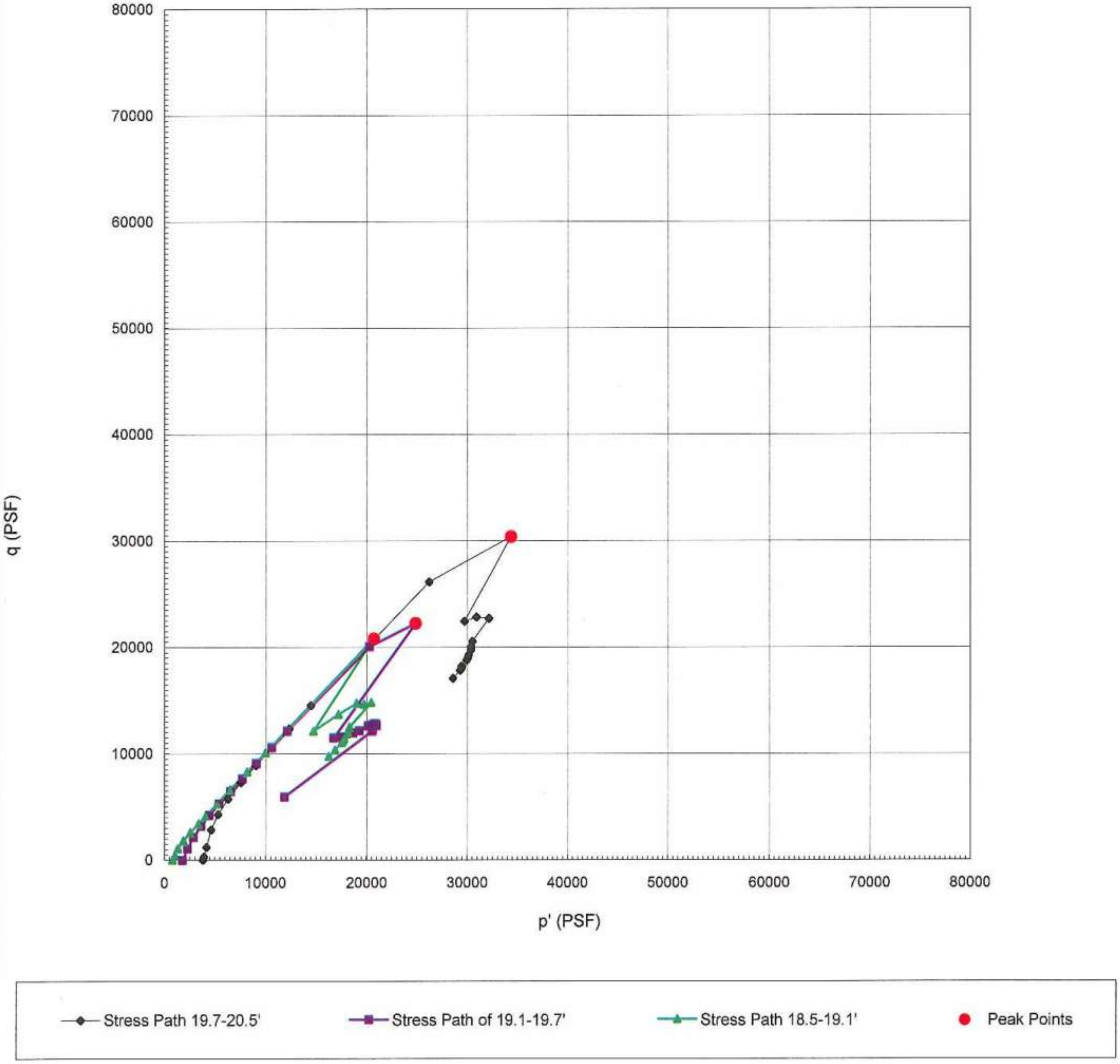
18.5-19.1' DATA

σ_3' (psf)	σ_1' (psf)	Deviator Stress $(\sigma_1-\sigma_3)$ (psf)	p' = $(\sigma_1'+\sigma_3')/2$ (psf)	q = $(\sigma_1-\sigma_3)/2$ (psf)
800	800	0	800	0
613	1475	862	1044	431
224	2426	2202	1325	1101
51	3686	3635	1869	1818
-6	5154	5160	2574	2580
-35	6838	6873	3402	3437
-35	8262	8297	4114	4149
-50	10526	10576	5238	5288
-78	13151	13229	6537	6615
-64	16480	16544	8208	8272
-64	20073	20137	10005	10069
-50	41533	41583	20742	20792
2672	26836	24164	14754	12082
3550	30864	27314	17207	13657
4299	33707	29408	19003	14704
5192	34387	29195	19790	14598
5710	35237	29527	20474	14764
5840	30817	24977	18329	12489
6099	30274	24175	18187	12088
6229	29877	23648	18053	11824
6344	29210	22866	17777	11433
6402	28928	22526	17665	11263
6459	28907	22448	17683	11224
8474	28669	22195	17572	11098
6517	28542	22025	17530	11013
6546	27186	20640	16866	10320
6560	25980	19420	16270	9710

Data entry by:	CAL		
Date:	1/29/16	Data checked by:	DAM
FileName:	2679_91_PQPlots-ASTM-D4767-withmetric-R2_1.xls	Date:	1/29/16

Effective Stress Path Analysis - p' q Plots

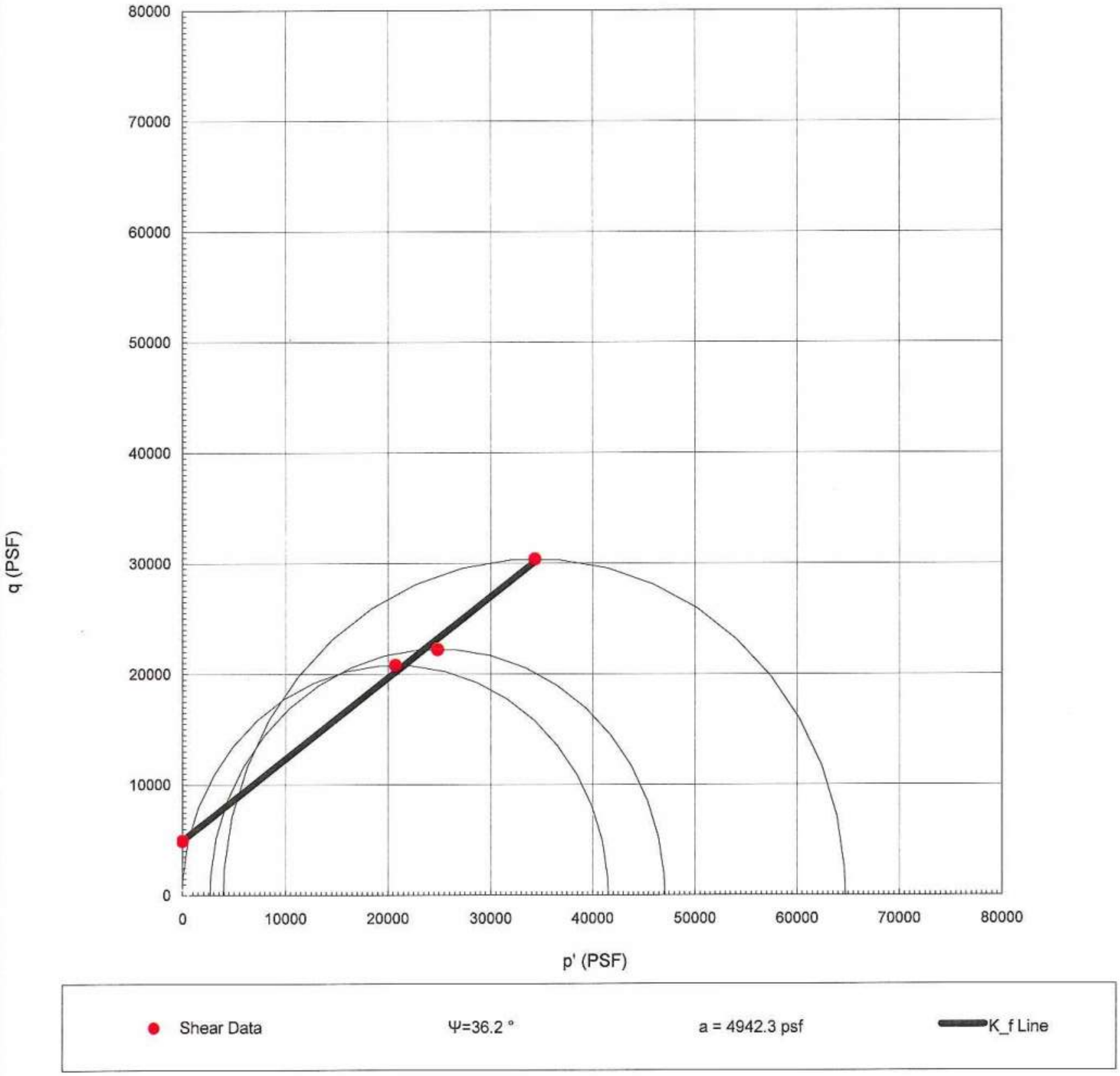
--,B-104,HQ-4,18.5'-20.5



NOTE 1: The peak points shown in the plot represent maximum values of q [(σ1-σ3)/2].

Effective Stress Path Analysis - p'-q Regression Plot at Maximum q

--,B-104,HQ-4,18.5'-20.5



NOTE 2: The line presented in the graph is the K_f line taken at Peak q values defined by the equation $q=a+p' \tan(\Psi)$ where a = the intercept on the q-axis in stress units and Ψ = the angle of the K_f line with respect to the horizontal in degrees.

NOTE 3: The K_f is NOT the Mohr-Coulomb failure envelope defined by the equation $\tau=c+\sigma \tan(\Phi)$. The equations $\sin(\Phi)=\tan(\Psi)$ and $c=a/\cos(\Phi)$ may be used to approximate values for Φ and c at the effective stress condition described in NOTE 1.

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client:	RJH Consultants	Job number:	2679 - 91
Location	Upper Platte and Beaver Diversion		
Project Number:	15140	Sampled:	12/28/15
Boring:	B-104	Test started:	01/19/16
Depth:	19.7-20.5'	Test ended:	01/27/16
Sample Number:	HQ-4	Cell number:	19S
Soil Desc:	Sandy Claystone	Conf. Press(psf):	3800
Test type:	Tx/Cupp		
Saturated test:	Yes		

Moisture density data	Before test	After test
Weight Soil & Moisture (g)	798.04	805.86
Weight Wet Soil & Pan (g)	812.34	820.16
Weight Dry Soil & Pan (g)	696.69	696.69
Weight lost moisture	115.65	123.47
Weight of Pan Only (g)	14.30	14.30
Weight of dry soil	682.39	682.39
Moisture content (%)	16.95	18.09
Wet density (PCF)	134.71	138.11
Dry density (PCF)	115.19	116.95
Initial Diameter (in.)	2.397	
Initial Area (sq in)	4.513	
Initial Height (in.)	5.001	
Volume before consol. (cu ft)	0.0131	
Volume after consol. (cu ft)	0.0129	

ATT
ADVANCED TERRA TESTING

Data entry by:	NN	Date:	01/28/16
Data checked by:	CH		01/28/16
Filename	2679_91_TX_CU_All_ASTMD-4767-R2_2.xls		

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client:	RJH Consultants
Location	Upper Platte and Beaver Diversion
Project Number:	15140
Boring:	B-104
Depth:	19.7-20.5'
Sample Number:	HQ-4
Soil Desc:	Sandy Claystone
Test type:	Tx/Cupp
Saturated test:	Yes

Job number:	2679 - 91
Sampled:	12/28/15
Test started:	01/19/16
Test ended:	01/27/16
Cell number:	19S
Conf. Press(psf):	3800

SATURATION DATA

Cell press. (psi)	Back press. (psi)	Burette rdg. (cc) Close	Open	Pore press. (psi) Close	Open	Change	B
40.0	38.0	2.7	11.6				
50.0	48.0	13.0	14.2	37.9	46.8	8.9	0.89
60.0	58.0	14.5	15.3	47.8	57.1	9.3	0.93
70.0		15.5	15.7	57.6	67.2	9.6	0.96

CONSOLIDATION DATA

Elapsed time (min)	SQRT time	Burette rdg. (cc)	Vol defl. (cc)
0.00	0.000	0.30	0.00
0.25	0.500	4.10	-3.80
0.5	0.707	4.30	-4.00
1	1.000	4.50	-4.20
2	1.414	4.80	-4.50
4	2.000	5.00	-4.70
9	3.000	5.20	-4.90
16	4.000	5.30	-5.00
30	5.477	5.40	-5.10
60	7.746	5.45	-5.15
120	10.954	5.45	-5.15
240	15.492	5.50	-5.20
360	18.974	5.55	-5.25
1440	37.947	5.75	-5.45

Init ht (in):	5.001
Height change(in):	0.023
Ht. after consol(in):	4.978
Initial area (sq in):	4.513
Area after cons (sq in)	4.465

Init vol (cc):	369.881
Vol change(cc):	18.500
Cell exp. (cc):	12.935
Net change (cc):	5.565
Cons vol (cc):	364.316

Data entry by: NN
Data checked by: cn
Filename 2679_91_TX_CU_All_ASTMD-4767-R2_2.xls

ATT
ADVANCED TERRA TESTING

Date: 01/28/16
01/28/16

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client: RJH Consultants
Location Upper Platte and Beaver Diversion
Project Number: 15140
Boring: B-104
Depth: 19.7-20.5'
Sample Number: HQ-4
Soil Desc: Sandy Claystone
Test type: Tx/Cupp
Saturated test: Yes

Job number: 2679 - 91

Sampled: 12/28/15
Test started: 01/19/16
Test ended: 01/27/16
Cell number: 19S
Conf. Press(psf): 3800

Init ht (in): 5.001
Consol ht (in): 4.978
Back press (psi): 58.1

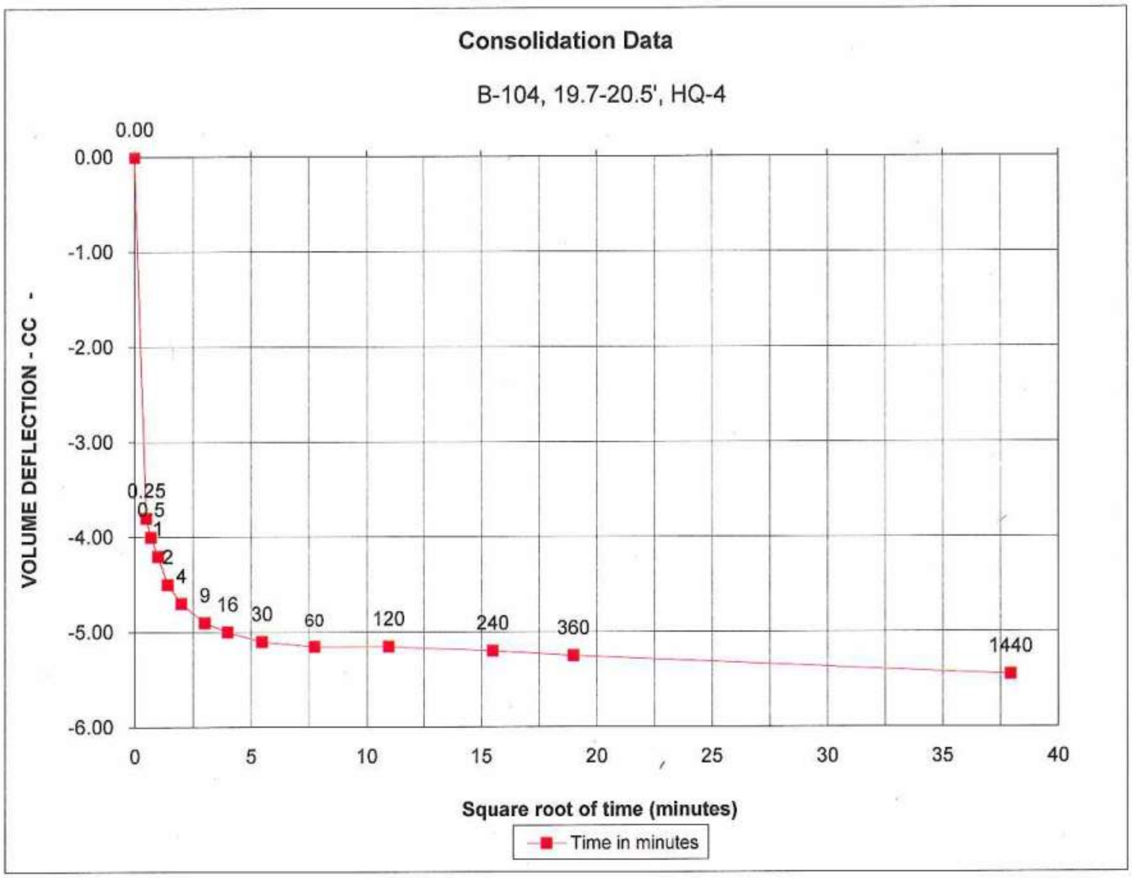
Init area (sq in): 4.513
Cons area (sq in): 4.465
Strain rate (in/min): 0.0053

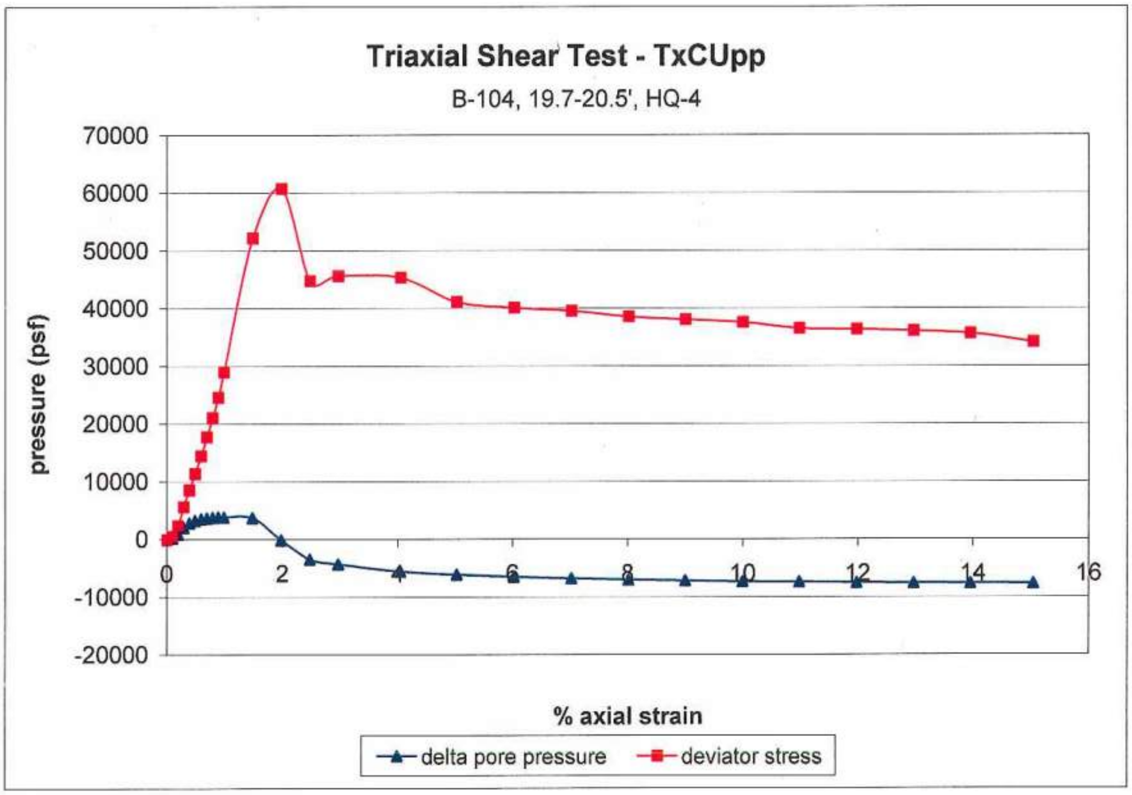
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Deviator Stress PSF	Pore Press PSI	Delta Press PSF	Sigma 3' PSF	Sigma 1' PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	4.465	0	58.1	0	3800	3800	1.00
18.0	580	0.005	0.10	4.470	580	59.3	173	3627	4207	1.16
75.0	2419	0.010	0.20	4.474	2414	63.9	835	2965	5379	1.81
177.0	5708	0.015	0.30	4.478	5691	72.1	2016	1784	7475	4.19
267.0	8611	0.020	0.39	4.483	8577	77.3	2765	1035	9612	9.28
357.0	11513	0.025	0.49	4.487	11456	80.5	3226	574	12031	20.94
453.0	14609	0.030	0.59	4.492	14522	82.4	3499	301	14823	49.28
555.0	17898	0.034	0.69	4.496	17775	83.4	3643	157	17931	114.36
660.0	21284	0.039	0.79	4.501	21116	84.1	3744	56	21172	378.08
771.0	24864	0.044	0.89	4.505	24643	84.4	3787	13	24656	1926.26
909.0	29314	0.049	0.99	4.510	29025	84.6	3816	-16	29009	-1813.04
1644.0	53018	0.074	1.48	4.532	52232	83.7	3686	114	52345	460.78
1923.0	62015	0.098	1.98	4.555	60789	57.1	-144	3944	64733	16.41
1425.0	45955	0.123	2.47	4.578	44819	33.6	-3528	7328	52147	7.12
1458.0	47019	0.148	2.97	4.602	45625	28.1	-4320	8120	53745	6.62
1467.0	47309	0.202	4.05	4.654	45394	18.9	-5645	9445	54839	5.81
1341.0	43246	0.251	5.03	4.702	41070	15.1	-6192	9992	51062	5.11
1323.0	42666	0.300	6.03	4.752	40094	12.6	-6552	10352	50446	4.87
1317.0	42472	0.349	7.02	4.802	39491	10.5	-6854	10654	50145	4.71
1299.0	41892	0.399	8.01	4.854	38536	8.9	-7085	10885	49420	4.54
1296.0	41795	0.448	9.01	4.907	38031	7.7	-7258	11058	49089	4.44
1293.0	41698	0.498	10.00	4.961	37529	6.7	-7402	11202	48731	4.35
1269.0	40924	0.547	10.99	5.016	36428	6.3	-7459	11259	47687	4.24
1281.0	41311	0.596	11.97	5.073	36364	5.7	-7546	11346	47710	4.21
1284.0	41408	0.646	12.97	5.131	36038	5.1	-7632	11432	47470	4.15
1284.0	41408	0.695	13.95	5.189	35630	4.6	-7704	11504	47134	4.10
1245.0	40150	0.749	15.04	5.256	34110	4.3	-7747	11547	45657	3.95

Data entry by: NN
Data checked by: en
Filename 2679_91_TX_CU_All_ASTMD-4767-R2_2.xls

ATT
ADVANCED TERRA TESTING

Date: 01/28/16
01/28/16


Consolidation Data
B-104, 19.7-20.5', HQ-4
VOLUME DEFLECTION - CC -
0.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
0.25
0.5
1
2
4
9
16
30
60
120
240
360
1440
0
5
10
15
20
25
30
35
40
Square root of time (minutes)
Time in minutes


Triaxial Shear Test - TxCUpp
B-104, 19.7-20.5', HQ-4
pressure (psf)
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20000
0
2
4
6
8
10
12
14
16
% axial strain
delta pore pressure
deviator stress

Client RJH Consultants
Job No. 2679-91
Boring No. B-104
Depth 19.7-20.5'
Sample No. HQ-4
Location
Project Upper Platte & Beaver Diversion
Project No. 15140
Date Tested/By 1-27-16 | [illegible]
Test Type Tx/cupp ASTM D4767
Confining Stress 3800 psf

Q:\Client Data File\2679\91\PICTURE\DSCF6118

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client:	RJH Consultants	Job number:	2679 - 91
Location	Upper Platte & Beaver Diversion		
Project Number:	15140	Sampled:	12/28/15
Boring:	B-104	Test started:	01/19/16
Depth:	19.1-19.7'	Test ended:	01/26/16
Sample Number:	HQ-4	Cell number:	21S
Soil Desc:	Clayey Sandstone	Conf. Press(psf):	1800
Test type:	Tx/Cupp		
Saturated test:	Yes		

Moisture density data	Before test	After test
Weight Soil & Moisture (g)	795.70	817.26
Weight Wet Soil & Pan (g)	809.91	831.47
Weight Dry Soil & Pan (g)	698.92	698.92
Weight lost moisture	110.99	132.55
Weight of Pan Only (g)	14.21	14.21
Weight of dry soil	684.71	684.71
Moisture content (%)	16.21	19.36
Wet density (PCF)	134.80	140.11
Dry density (PCF)	116.00	117.38
Initial Diameter (in.)	2.392	
Initial Area (sq in)	4.494	
Initial Height (in.)	5.004	
Volume before consol. (cu ft)	0.0130	
Volume after consol. (cu ft)	0.0129	

NOTE: The membrane ruptured at 14% strain.

Data entry by:	NN	Date:	01/28/16
Data checked by:	Cm		1/28/16
Filename	2679_91_TX_CU_All_ASTMD-4767-R2_1.xls		

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client: RJH Consultants
Location Upper Platte & Beaver Diversion
Project Number: 15140
Boring: B-104
Depth: 19.1-19.7'
Sample Number: HQ-4
Soil Desc: Clayey Sandstone
Test type: Tx/Cupp
Saturated test: Yes

Job number: 2679 - 91

Sampled: 12/28/15
Test started: 01/19/16
Test ended: 01/26/16
Cell number: 21S
Conf. Press(psf): 1800

SATURATION DATA

Cell press. (psi)	Back press. (psi)	Burette rdg. (cc) Close	Open	Pore press. (psi) Close	Open	Change	B
40.0	38.0	2.4	11.2				
50.0	48.0	12.5	13.3	37.8	47.2	9.4	0.94
60.0		13.8	13.9	48.0	57.5	9.5	0.95

CONSOLIDATION DATA

Elapsed time (min)	SQRT time	Burette rdg. (cc)	Vol defl. (cc)
0.00	0.000	13.90	0.00
0.25	0.500	15.60	-1.70
0.5	0.707	15.70	-1.80
1	1.000	15.80	-1.90
2	1.414	15.90	-2.00
4	2.000	16.00	-2.10
9	3.000	16.05	-2.15
16	4.000	16.10	-2.20
30	5.477	16.10	-2.20
60	7.746	16.20	-2.30
177	13.304	16.25	-2.35
240	15.492	16.25	-2.35
360	18.974	16.30	-2.40
4244	65.146	17.30	-3.40

Init ht (in): 5.004
Height change(in): 0.017
Ht. after consol(in): 4.987
Initial area (sq in): 4.494
Area after cons (sq in) 4.456

Init vol (cc): 368.560
Vol change(cc): 14.900
Cell exp. (cc): 10.545
Net change (cc): 4.355
Cons vol (cc): 364.205

Data entry by: NN
Data checked by: am
Filename 2679_91_TX_CU_All_ASTMD-4767-R2_1.xls

ADVANCED TERRA TESTING

Date: 01/27/16
01/28/16

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client: RJH Consultants
Location Upper Platte & Beaver Diversion
Project Number: 15140
Boring: B-104
Depth: 19.1-19.7'
Sample Number: HQ-4
Soil Desc: Clayey Sandstone
Test type: Tx/Cupp
Saturated test: Yes

Job number: 2679 - 91

Sampled: 12/28/15
Test started: 01/19/16
Test ended: 01/26/16
Cell number: 21S
Conf. Press(psf): 1800

Init ht (in): 5.004
Consol ht (in): 4.987
Back press (psi): 47.6

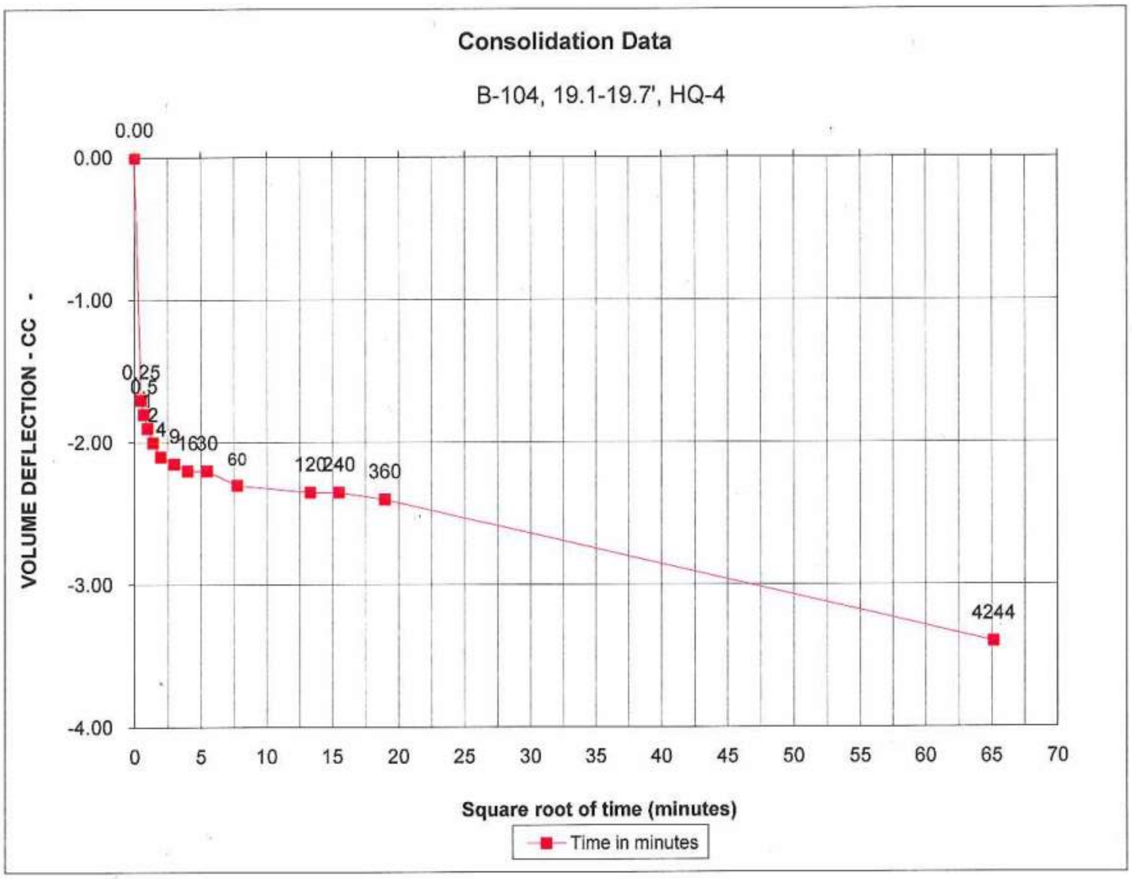
Init area (sq in): 4.494
Cons area (sq in): 4.456
Strain rate (in/min): 0.0033

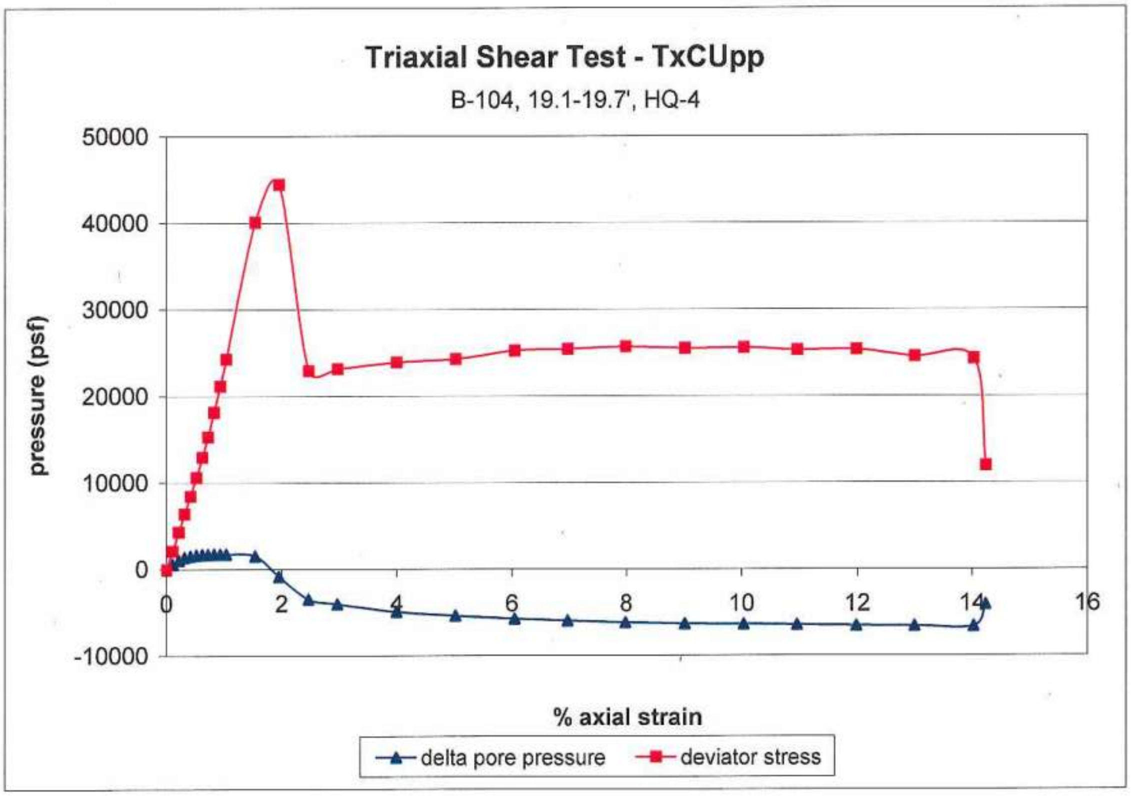
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Deviator Stress PSF	Pore Press PSI	Delta Press PSF	Sigma 3' PSF	Sigma 1' PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	4.456	0	47.6	0	1800	1800	1.00
67.0	2164	0.005	0.11	4.461	2162	51.8	598	1202	3364	2.80
134.6	4349	0.011	0.21	4.465	4340	55.2	1084	716	5056	7.06
199.0	6431	0.016	0.31	4.470	6411	57.3	1395	405	6815	16.84
262.8	8492	0.021	0.42	4.474	8457	58.5	1571	229	8686	37.94
329.7	10656	0.026	0.52	4.479	10601	59.2	1662	138	10739	77.69
403.1	13027	0.031	0.62	4.484	12946	59.4	1699	101	13047	129.43
477.1	15418	0.036	0.72	4.488	15307	59.6	1727	73	15380	209.42
567.0	18324	0.041	0.82	4.493	18173	60.1	1791	9	18182	2104.38
660.8	21354	0.046	0.93	4.497	21156	59.9	1773	27	21184	774.25
759.0	24528	0.051	1.03	4.502	24276	60.0	1781	19	24295	1297.79
1260.3	40730	0.077	1.54	4.526	40102	58.4	1552	248	40350	162.91
1403.8	45367	0.097	1.95	4.544	44483	41.9	-818	2618	47101	17.99
728.4	23539	0.123	2.46	4.568	22959	23.6	-3462	5262	28221	5.36
739.2	23889	0.148	2.97	4.592	23179	19.7	-4022	5822	29001	4.98
770.5	24899	0.199	4.00	4.641	23904	13.6	-4895	6695	30599	4.57
791.5	25579	0.250	5.02	4.691	24295	10.5	-5345	7145	31440	4.40
831.1	26858	0.301	6.04	4.742	25234	7.8	-5740	7540	32774	4.35
844.5	27290	0.347	6.97	4.789	25389	6.4	-5941	7741	33131	4.28
863.0	27888	0.398	7.99	4.843	25660	4.6	-6191	7991	33651	4.21
866.1	27991	0.450	9.01	4.897	25468	3.8	-6309	8109	33577	4.14
879.5	28424	0.501	10.04	4.953	25571	3.4	-6373	8173	33745	4.13
879.5	28424	0.546	10.96	5.004	25310	3.0	-6420	8220	33529	4.08
890.4	28774	0.598	11.98	5.062	25327	2.3	-6530	8330	33657	4.04
871.9	28176	0.649	13.00	5.122	24512	2.0	-6566	8366	32879	3.93
873.8	28239	0.700	14.03	5.183	24277	1.6	-6621	8421	32698	3.88
429.9	13893	0.710	14.23	5.195	11915	19.1	-4105	5905	17821	3.02

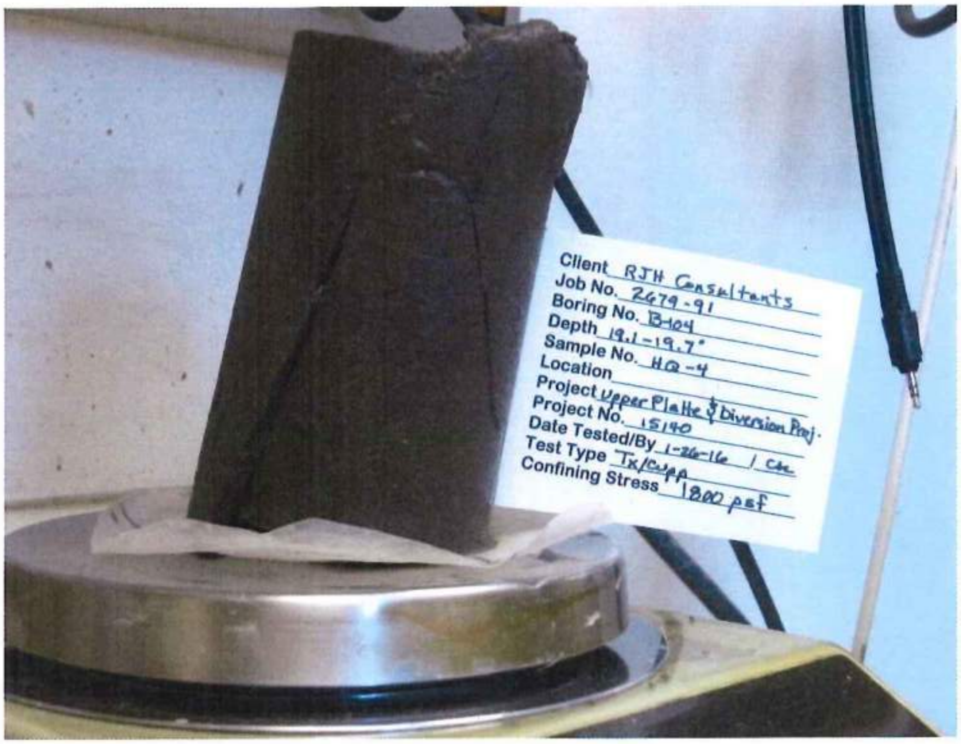
Data entry by: NN
Data checked by: cm
Filename 2679_91_TX_CU_All_ASTMD-4767-R2_1.xls

ATT
ADVANCED TERRA TESTING

Date: 01/27/16
01/28/16


Consolidation Data
B-104, 19.1-19.7', HQ-4
VOLUME DEFLECTION - CC -
0.00
0.00
-1.00
-2.00
-3.00
-4.00
0.25
0.5
2
4
9
16
30
60
120
240
360
4244
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Square root of time (minutes)
Time in minutes


Triaxial Shear Test - TxCUpp
B-104, 19.1-19.7', HQ-4
pressure (psf)
50000
40000
30000
20000
10000
0
-10000
0
2
4
6
8
10
12
14
16
% axial strain
delta pore pressure
deviator stress



Client RJH Consultants
Job No. 2679-91
Boring No. B-104
Depth 19.1-19.7'
Sample No. HQ-4
Location
Project Upper Platte & Diversion Proj.
Project No. 15140
Date Tested/By 1-26-16 / CH
Test Type Tx/CUpp
Confining Stress 1800 psf

Q:\Client Data File\2679\90\PICTURE\DSCF6116

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client:	RJH Consultants	Job number:	2679 - 91
Location	Upper Platte & Beaver Diversion		
Project Number:	15140	Sampled:	12/28/15
Boring:	B-104	Test started:	01/19/16
Depth:	18.5-19.1'	Test ended:	01/26/16
Sample Number:	HQ-4	Cell number:	27S
Soil Desc:	Clayey Sandstone	Conf. Press(psf):	800
Test type:	Tx/Cupp		
Saturated test:	Yes		

Moisture density data	Before test	After test
Weight Soil & Moisture (g)	791.86	804.34
Weight Wet Soil & Pan (g)	806.19	818.67
Weight Dry Soil & Pan (g)	693.34	693.34
Weight lost moisture	112.85	125.33
Weight of Pan Only (g)	14.33	14.33
Weight of dry soil	679.01	679.01
Moisture content (%)	16.62	18.46
Wet density (PCF)	133.89	135.81
Dry density (PCF)	114.81	114.65
Initial Diameter (in.)	2.391	
Initial Area (sq in)	4.490	
Initial Height (in.)	5.018	
Volume before consol. (cu ft)	0.0130	
Volume after consol. (cu ft)	0.0131	

NOTE: Gradually increased shear rate to .0032 in./min. after failure.

ATT
ADVANCED TERRA TESTING

Data entry by:	NN	Date:	01/28/16
Data checked by:	an		01/28/16
Filename	2679_91_TX_CU_All_ASTMD-4767-R2_3.xls		

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client:	RJH Consultants
Location	Upper Platte & Beaver Diversion
Project Number:	15140
Boring:	B-104
Depth:	18.5-19.1'
Sample Number:	HQ-4
Soil Desc:	Clayey Sandstone
Test type:	Tx/Cupp
Saturated test:	Yes

Job number:	2679 - 91
Sampled:	12/28/15
Test started:	01/19/16
Test ended:	01/26/16
Cell number:	27S
Conf. Press(psf):	800

SATURATION DATA

Cell press. (psi)	Back press. (psi)	Burette rdg. (cc) Close	Open	Pore press. (psi) Close	Open	Change	B
40.0	38.0	2.5	13.1				
50.0		14.2	14.9	38.2	47.9	9.7	0.97

CONSOLIDATION DATA

Elapsed time (min)	SQRT time	Burette rdg. (cc)	Vol defl. (cc)
0.00	0.000	0.70	0.00
0.25	0.500	1.75	-1.05
0.5	0.707	1.80	-1.10
1	1.000	1.85	-1.15
2	1.414	1.90	-1.20
4	2.000	2.00	-1.30
9	3.000	2.10	-1.40
16	4.000	2.15	-1.45
30	5.477	2.20	-1.50
60	7.746	2.30	-1.60
120	10.954	2.30	-1.60
240	15.492	2.40	-1.70
380	19.494	2.40	-1.70
1454	38.131	2.60	-1.90

Init ht (in):	5.018
Height change(in):	0.007
Ht. after consol(in):	5.011
Initial area (sq in):	4.490
Area after cons (sq in)	4.503

Init vol (cc):	369.282
Vol change(cc):	15.000
Cell exp. (cc):	15.511
Net change (cc):	-0.511
Cons vol (cc):	369.794

Data entry by: NN

Data checked by: CM

Filename 2679_91_TX_CU_All_ASTMD-4767-R2_3.xls

ATT ADVANCED TERRA TESTING

Date: 01/28/16

01/28/16

TRIAXIAL COMPRESSION TEST
ASTM D 4767

Client: RJH Consultants
Location Upper Platte & Beaver Diversion
Project Number: 15140
Boring: B-104
Depth: 18.5-19.1'
Sample Number: HQ-4
Soil Desc: Clayey Sandstone
Test type: Tx/Cupp
Saturated test: Yes

Job number: 2679 - 91

Sampled: 12/28/15
Test started: 01/19/16
Test ended: 01/26/16
Cell number: 27S
Conf. Press(psf): 800

Init ht (in): 5.018
Consol ht (in): 5.011
Back press (psi): 38.4

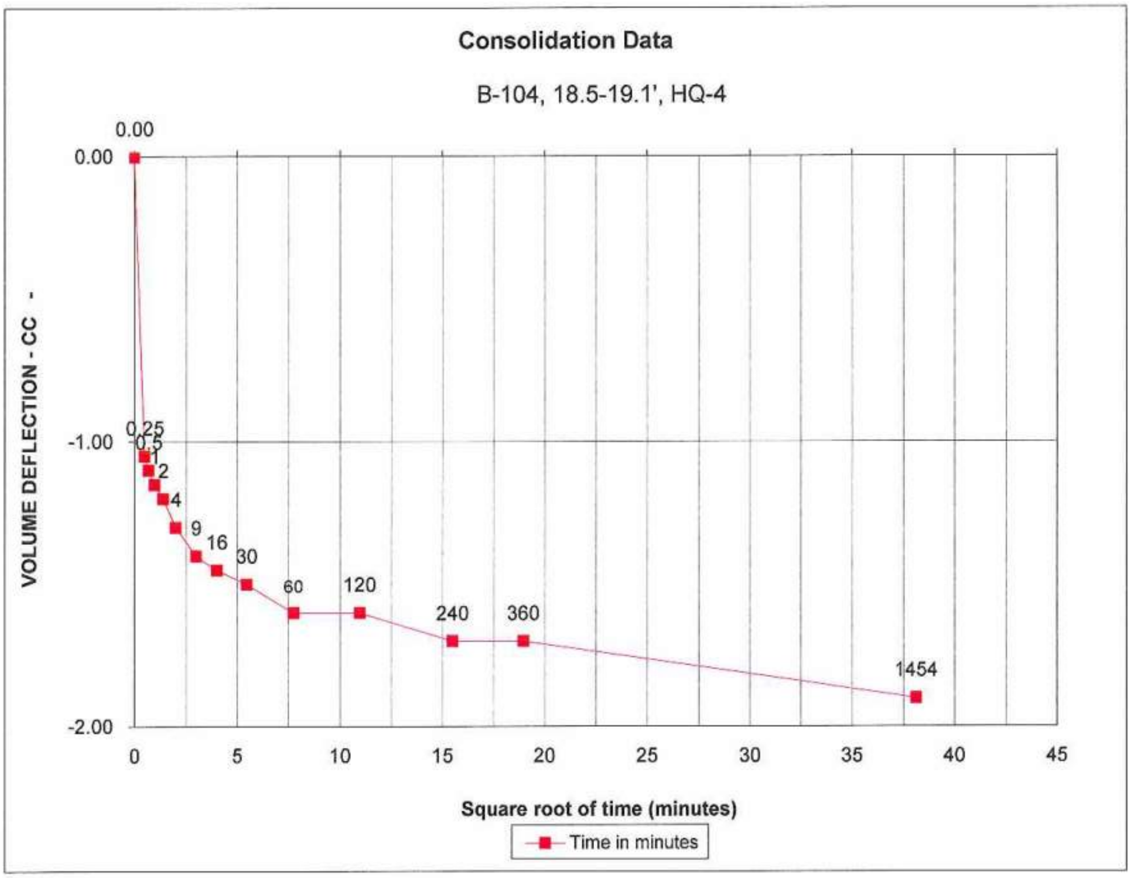
Init area (sq in): 4.490
Cons area (sq in): 4.503
Strain rate (in/min): 0.0016

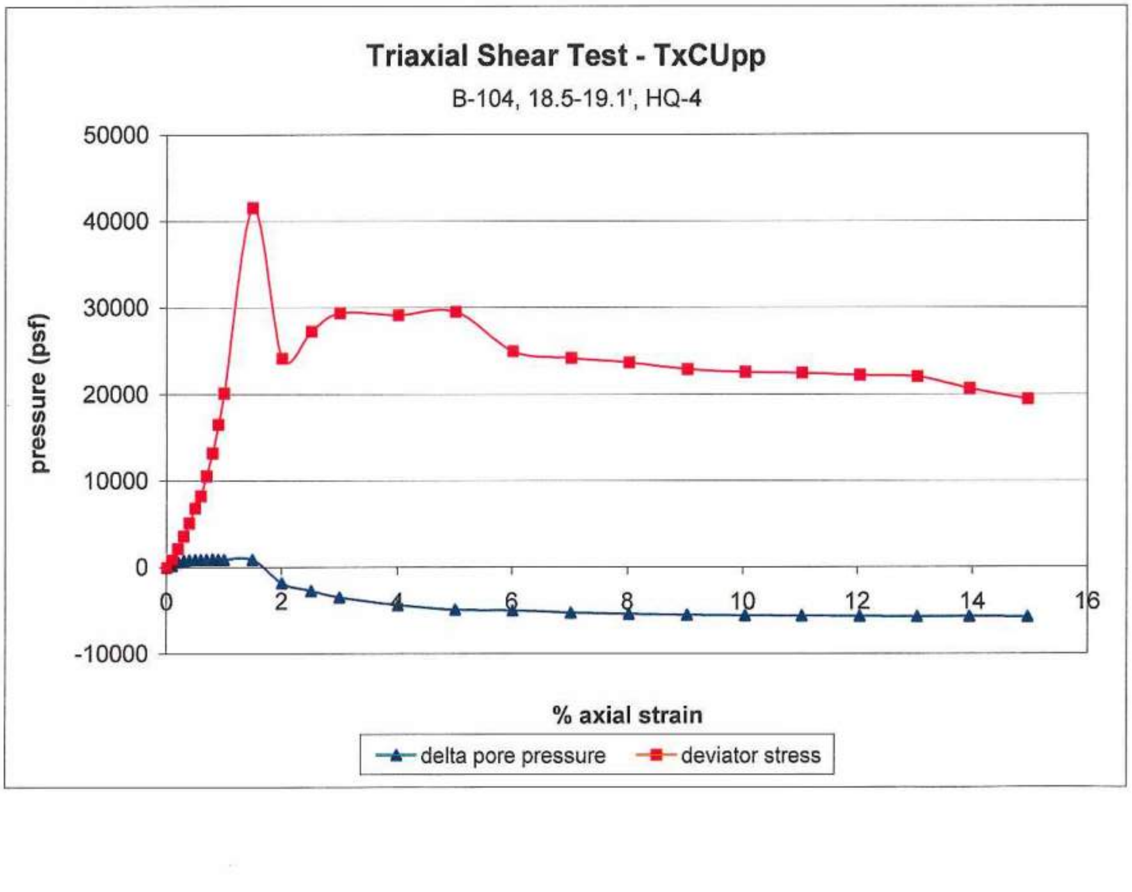
Axial Load Lbs.	Axial Load PSF	Delta Ht. In.	Axial % Strain	Area Final Sq In.	Deviator Stress PSF	Pore Press PSI	Delta Press PSF	Sigma 3' PSF	Sigma 1' PSF	Prin. Stress Ratio
0.0	0	0.000	0.00	4.503	0	38.4	0	800	800	1.00
27.0	864	0.005	0.10	4.507	863	39.7	187	613	1475	2.41
69.0	2207	0.010	0.20	4.512	2202	42.4	576	224	2426	10.83
114.0	3646	0.015	0.30	4.516	3635	43.6	749	51	3686	72.00
162.0	5181	0.020	0.40	4.521	5160	44.0	806	-6	5154	-805.31
216.0	6908	0.025	0.50	4.525	6874	44.2	835	-35	6838	-194.27
261.0	8347	0.030	0.60	4.530	8297	44.2	835	-35	8262	-234.72
333.0	10650	0.035	0.70	4.534	10575	44.3	850	-50	10526	-212.21
417.0	13337	0.040	0.80	4.539	13230	44.5	878	-78	13151	-167.75
522.0	16695	0.045	0.90	4.543	16544	44.4	864	-64	16480	-257.51
636.0	20341	0.050	1.00	4.548	20137	44.4	864	-64	20073	-313.64
1320.0	42216	0.075	1.50	4.571	41583	44.3	850	-50	41533	-837.36
771.0	24658	0.100	2.00	4.595	24164	25.4	-1872	2672	26836	10.04
876.0	28016	0.126	2.51	4.618	27314	19.3	-2750	3550	30864	8.69
948.0	30319	0.151	3.01	4.642	29408	14.1	-3499	4299	33707	7.84
951.0	30415	0.201	4.01	4.691	29195	7.9	-4392	5192	34387	6.62
972.0	31087	0.251	5.02	4.740	29527	4.3	-4910	5710	35237	6.17
831.0	26577	0.302	6.02	4.791	24977	3.4	-5040	5840	30817	5.28
813.0	26001	0.352	7.03	4.843	24174	1.6	-5299	6099	30274	4.96
804.0	25714	0.403	8.03	4.896	23648	0.7	-5429	6229	29877	4.80
786.0	25138	0.453	9.04	4.950	22866	-0.1	-5544	6344	29210	4.60
783.0	25042	0.503	10.04	5.005	22527	-0.5	-5602	6402	28928	4.52
789.0	25234	0.553	11.04	5.061	22448	-0.9	-5659	6459	28907	4.48
789.0	25234	0.603	12.04	5.119	22195	-1.0	-5674	6474	28669	4.43
792.0	25330	0.654	13.05	5.178	22025	-1.3	-5717	6517	28542	4.38
750.0	23987	0.699	13.95	5.233	20640	-1.5	-5746	6546	27186	4.15
714.0	22835	0.750	14.96	5.294	19420	-1.6	-5760	6560	25980	3.96

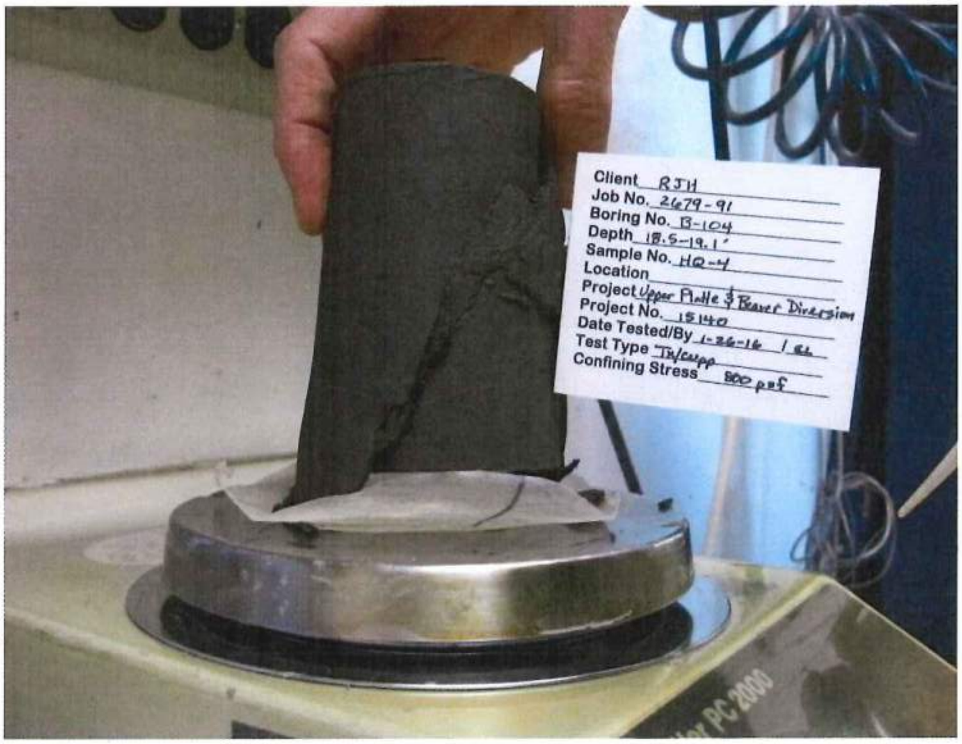
Data entry by: NN
Data checked by: cn
Filename 2679_91_TX_CU_All_ASTMD-4767-R2_3.xls

ATT
ADVANCED TERRA TESTING

Date: 01/28/16
01/28/16


Consolidation Data
B-104, 18.5-19.1', HQ-4
VOLUME DEFLECTION - CC -
0.00
-1.00
-2.00
0.00
0.25
0.5
1
2
4
9
16
30
60
120
240
360
1454
0
5
10
15
20
25
30
35
40
45
Square root of time (minutes)
Time in minutes


Triaxial Shear Test - TxCUpp
B-104, 18.5-19.1', HQ-4
pressure (psf)
50000
40000
30000
20000
10000
0
-10000
0
2
4
6
8
10
12
14
16
% axial strain
delta pore pressure
deviator stress



Client RJH
Job No. 2679-91
Boring No. B-104
Depth 18.5-19.1'
Sample No. HQ-4
Location
Project Upper Platte $ Beaver Diversion
Project No. 15140
Date Tested/By 1-26-16 / EL
Test Type TX/CUPP
Confining Stress 800 psf

Q:\Client Data File\2679\90\PICTURE\DSCF6117

Corrosion Analysis

Colorado Analytical
LABORATORIES, INC.

Analytical Results

TASK NO: 160201033

Report To: Kerry Repola
Company: Advanced Terra Testing
833 Parfet Street
Unit A
Lakewood CO 80215

Bill To: Kerry Repola
Company: Advanced Terra Testing
833 Parfet Street
Unit A
Lakewood CO 80215

Task No.: 160201033
Client PO: 2679-91
Client Project: RJH-Upper Platte and Beaver Diversion

Date Received: 2/1/16
Date Reported: 2/8/16
Matrix: Soil - Geotech

Customer Sample ID B-102 @ 5.6-6.5ft HQ-3
Lab Number: 160201033-01

Test	Result	Method
Chloride - Water Soluble	**0.0010 %**	AASHTO T291-91/ ASTM D4327
Electrical Conductivity	**1.2 mmhos/cm**	ASA2 10-3.3
pH	**7.6 units**	AASHTO T289-91
Resistivity	**812 ohm.cm**	AASHTO T288-91
Sulfate - Water Soluble	**0.054 %**	AASHTO T290-91/ ASTM D4327
Sulfide	**Positive**	AWWA C105

Abbreviations/ References:

AASHTO - American Association of State Highway and Transportation Officials.
ASTM - American Society for Testing and Materials.
ASA - American Society of Agronomy.
DIPRA - Ductile Iron Pipe Research Association Handbook of Ductile Iron Pipe.

DATA APPROVED FOR RELEASE BY

Appendix E Cost Estimate

UP&B Alternative 1 - Rehabilitate Existing Dam Cost Estimate						Comment
Item Number	Description	Quantity	Unit	Unit Price ($)	Total ($)	
	Earthwork					
1	Clear & Grub (Access)	2	AC	$1,000.00	$2,000.00	
2	Temporary Access Road	1200	LF	$40.00	$48,000.00	12' width Incl. grading and river rock surfacing at channels
3	Saw Cut Existing Slab	2400	LF	$6.00	$14,400.00	
4	Demolish Existing Slab	410	CY	$40.00	$16,400.00	Dispose on site as riprap
5	Unclassified Excavation	450	CY	$10.00	$4,500.00	Alluvial sand & gravel
6	Rock Excavation by machine	1800	CY	$10.00	$18,000.00	Clayey sandstone to 20' depth for cut-off walls
7	Embankment	600	CY	$25.00	$15,000.00	From Borrow onsite
8	Riprap	1400	CY	$150.00	$210,000.00	CDOT Type L
9	Dispose of waste material onsite	2400	CY	$25.00	$60,000.00	Waste from rock excavation in stockpile, incl grading and seeding
10	Diversion and Dewatering	1	LS	$225,000.00	$225,000.00	
	Concrete					
11	Structural Concrete (CIP)	1800	CY	$600.00	$1,080,000.00	Slabs
12	Concrete Backfill	700	CY	$300.00	$210,000.00	
13	Concrete Scour Pad	2200	CY	$400.00	$880,000.00	
14	Pressure grouting under slab	3000	CF	$75.00	$225,000.00	
15	Concrete Repair	700	SY	$150.00	$105,000.00	Incl surface preparation
16	Concrete Cut-Off Wall	1900	CY	$500.00	$950,000.00	Trench walls used as form
	Subtotal				**$4,064,000.00**	
	Construction contingency@30%				$1,220,000.00	
	Engineering				$344,000.00	
	Construction Services				$291,000.00	
	Total				**$5,919,000.00**	

Notes:

Items not accounted for in this cost estimate:

- Owner's legal costs
- Owner's administrative costs

UP&B Alternative 2 - New diversion Dam Cost Estimate						Comment
Item Number	Description	Quantity	Unit	Unit Price ($)	Total ($)	
	Earthwork					
1	Clear & Grub	3	AC	$1,000.00	$3,000.00	
2	Stripping	2400	CY	$5.00	$12,000.00	Incl. topsoil stockpile
3	Demolish Existing Dam Structure	600	CY	$40.00	$24,000.00	Crest wall and buttress, dispose on site, leave slab in place
4	Demolish Existing Slab	20	CY	$40.00	$800.00	North Dam downstream slab incl. sawcut, dispose on site
5	Rock Excavation by machine	1500	CY	$10.00	$15,000.00	Clayey sandstone to 20' depth
6	Unclassified Excavation	12600	CY	$10.00	$126,000.00	Canal and structure exc., waste excess onsite
7	Embankment - Zone 1 (CIP)	4700	CY	$25.00	$117,500.00	Select Material CL, SC compacted in 6 inch lifts
8	Embankment - Zone 2 (CIP)	8600	CY	$10.00	$86,000.00	Random fill from excavation compacted in 12 inch lifts
9	Riprap & Filter	4500	CY	$150.00	$675,000.00	CDOT Type L Riprap
10	Topsoil, Seed & Mulch	15000	SY	$2.00	$30,000.00	
11	Diversion and Dewatering	1	LS	$225,000.00	$225,000.00	
	Concrete					
12	Structural Concrete (CIP)	2500	CY	$600.00	$1,500,000.00	Ogee dam, slabs and walls for bladder dam, headgates, fish passage and sluice gates.
13	Concrete Backfill	30	CY	$300.00	$9,000.00	
14	Concrete Scour Pad	1200	CY	$400.00	$480,000.00	
15	Concrete Cut-Off Wall	1000	CY	$500.00	$500,000.00	
	Miscellaneous					
16	Gravel Surfacing	200	CY	$40.00	$8,000.00	Access road
17	Bladder Dam 7' height	200	LF	$4,000.00	$800,000.00	
18	Bladder Headgate - 15' x 5'	2	LS	$132,000.00	$264,000.00	
19	Radial Gate 10'	4	LS	$72,000.00	$288,000.00	
20	Handrail	500	LF	$30.00	$15,000.00	
20	Gate Building	1	LS	$25,000.00	$25,000.00	
21	Power Service	1	LS	$40,000.00	$40,000.00	
22	Access Road Bridges	900	SF	$300.00	$270,000.00	2 Bridges, Prefabricated 16' width
	Subtotal				**$5,514,000.00**	
	Construction contingency@20%				$1,103,000.00	
	Engineering				$431,000.00	
	Construction Services				$364,000.00	
	Total				**$7,412,000.00**	

Notes:

Items not accounted for in this cost estimate:

- Owner's legal costs
- Owner's administrative costs

Appendix F Hydraulic Model and River Mechanics

```
1
   Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.002.000
   Version 7.1          Annual peak flow frequency analysis     Run Date / Time
   3/14/2014                                                    01/04/2016 16:21

                            --- PROCESSING OPTIONS ---

                        Plot option          = None
                        Basin char output    = None
                        Print option         = Yes
                        Debug print          = No
                        Input peaks listing  = Long
                        Input peaks format   = WATSTORE peak file

                        Input files used:
                           peaks (ascii)  - F:\AA-office 7-2-15\Colorado\PeakFQ\PLATTE
AT FT MORGAN.TXT
                           specifications - F:\AA-office
7-2-15\Colorado\PeakFQ\PKFQWPSF.TMP
                        Output file(s):
                           main - F:\AA-office 7-2-15\Colorado\PeakFQ\PLATTE AT FT
MORGAN.PRT

1


   Program PeakFq          U. S. GEOLOGICAL SURVEY              Seq.001.001
   Version 7.1          Annual peak flow frequency analysis     Run Date / Time
   3/14/2014                                                    01/04/2016 16:21

          Station - 06759500  SOUTH PLATTE RIVER AT FORT MORGAN, CO


                     I N P U T   D A T A   S U M M A R Y

                Number of peaks in record            =       29
                Peaks not used in analysis           =        0
                Systematic peaks in analysis         =       29
                Historic peaks in analysis           =        0
                Beginning Year                       =     1935
                Ending Year                          =     2014
                Historical Period Length             =        0
                Generalized skew                     =   -0.046
                     Standard error                  =    0.550
                     Mean Square error               =    0.303
                Skew option                          =   WEIGHTED
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =    --
                User supplied PILF (LO) criterion    =    --
                Plotting position parameter          =     0.00
                Type of analysis                          BULL.17B
                PILF (LO) Test Method                       GBT
                Perception Thresholds            =   Not Applicable
                Interval Data                    =   Not Applicable


  *********  NOTICE  --  Preliminary machine computations.       *********
  *********  User responsible for assessment and interpretation.  *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.   108283.3
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           244.1
```

```
                                     Kendall's Tau Parameters

                                                          MEDIAN    No. of
                                     TAU      P-VALUE     SLOPE     PEAKS
                                  -------------------------------------------
          SYSTEMATIC RECORD       -0.005       0.985      -4.038      29

1

    Program PeakFq           U. S. GEOLOGICAL SURVEY               Seq.001.002
    Version 7.1           Annual peak flow frequency analysis      Run Date / Time
    3/14/2014                                                      01/04/2016 16:21

             Station - 06759500  SOUTH PLATTE RIVER AT FORT MORGAN, CO

             ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                           FLOOD BASE                 LOGARITHMIC
                      ----------------------  -------------------------------
                                 EXCEEDANCE              STANDARD
                      DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                      -------------------------------------------------------
   SYSTEMATIC RECORD        0.0     1.0000     3.7110     0.5192      0.703
   BULL.17B ESTIMATE        0.0     1.0000     3.7110     0.5192      0.373

   BULL.17B ESTIMATE OF MSE OF AT-SITE SKEW     0.2377


      ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

     ANNUAL                              <-- FOR BULLETIN 17B ESTIMATES -->
  EXCEEDANCE   BULL.17B  SYSTEMATIC      VARIANCE  95% CONFIDENCE INTERVALS
  PROBABILITY  ESTIMATE    RECORD         OF EST.       LOWER        UPPER

     0.9950      359.2      515.8          ----          152.8        644.5
     0.9900      443.6      594.8          ----          198.7        772.1
     0.9500      823.2      938.6          ----          426.3       1320.0
     0.9000     1174.      1250.           ----          656.6       1808.0
     0.8000     1851.      1845.           ----         1129.0       2735.0
     0.6667     2901.      2777.           ----         1895.0       4192.0
     0.5000     4773.      4474.           ----         3269.0       6918.0
     0.4292     5914.      5534.           ----         4090.0       8673.0
     0.2000    13680.     13220.           ----         9282.0      22260.0
     0.1000    24760.     25310.           ----        15920.0      45180.0
     0.0400    48210.     54020.           ----        28530.0     102300.0
     0.0200    75550.     91500.           ----        41940.0     178800.0
     0.0100   114600.    150700.           ----        59750.0     301300.0
     0.0050   169600.    243100.           ----        83160.0     493300.0
     0.0020   276500.    446100.           ----       125300.0     914400.0
1

    Program PeakFq           U. S. GEOLOGICAL SURVEY               Seq.001.003
    Version 7.1           Annual peak flow frequency analysis      Run Date / Time
    3/14/2014                                                      01/04/2016 16:21

             Station - 06759500  SOUTH PLATTE RIVER AT FORT MORGAN, CO
```

```
                    I N P U T   D A T A   L I S T I N G

       WATER        PEAK     PEAKFQ
        YEAR       VALUE      CODES   REMARKS
        1935     84300.0
        1944      2920.0
        1945     10400.0
        1946      2710.0
        1947     16200.0
        1948      2740.0
        1949     18100.0
        1950      1020.0
        1951     33800.0
        1952      4080.0
        1953      1460.0
        1954      1000.0
        1955      1660.0
        1956      5600.0
        1957     20900.0
        1958      9850.0
        2002      1680.0
        2003      2520.0
        2004      2210.0
        2005      4940.0
        2006      1890.0
        2007      3260.0
        2008      2960.0
        2009      3730.0
        2010     10500.0
        2011      8450.0
        2012      1160.0
        2013     60000.0
        2014      9810.0


          Explanation of peak discharge qualification codes

         PeakFQ    NWIS
          CODE     CODE    DEFINITION

           D         3     Dam failure, non-recurrent flow anomaly
           G         8     Discharge greater than stated value
           X        3+8    Both of the above
           L         4     Discharge less than stated value
           K       6 OR C  Known effect of regulation or urbanization
           H         7     Historic peak

           -   Minus-flagged discharge -- Not used in computation
                  -8888.0 -- No discharge value given
           -   Minus-flagged water year -- Historic peak used in computation


1
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  EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

  WATER      RANKED    SYSTEMATIC      B17B
   YEAR    DISCHARGE     RECORD      ESTIMATE
   1935     84300.0      0.0333       0.0333
   2013     60000.0      0.0667       0.0667
   1951     33800.0      0.1000       0.1000
   1957     20900.0      0.1333       0.1333
   1949     18100.0      0.1667       0.1667
   1947     16200.0      0.2000       0.2000
   2010     10500.0      0.2333       0.2333
   1945     10400.0      0.2667       0.2667
   1958      9850.0      0.3000       0.3000
   2014      9810.0      0.3333       0.3333
   2011      8450.0      0.3667       0.3667
   1956      5600.0      0.4000       0.4000
   2005      4940.0      0.4333       0.4333
   1952      4080.0      0.4667       0.4667
   2009      3730.0      0.5000       0.5000
   2007      3260.0      0.5333       0.5333
   2008      2960.0      0.5667       0.5667
   1944      2920.0      0.6000       0.6000
   1948      2740.0      0.6333       0.6333
   1946      2710.0      0.6667       0.6667
   2003      2520.0      0.7000       0.7000
   2004      2210.0      0.7333       0.7333
   2006      1890.0      0.7667       0.7667
   2002      1680.0      0.8000       0.8000
   1955      1660.0      0.8333       0.8333
   1953      1460.0      0.8667       0.8667
   2012      1160.0      0.9000       0.9000
   1950      1020.0      0.9333       0.9333
   1954      1000.0      0.9667       0.9667
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      29

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  06759500      USGS SOUTH PLATTE RIVER AT FORT MO


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
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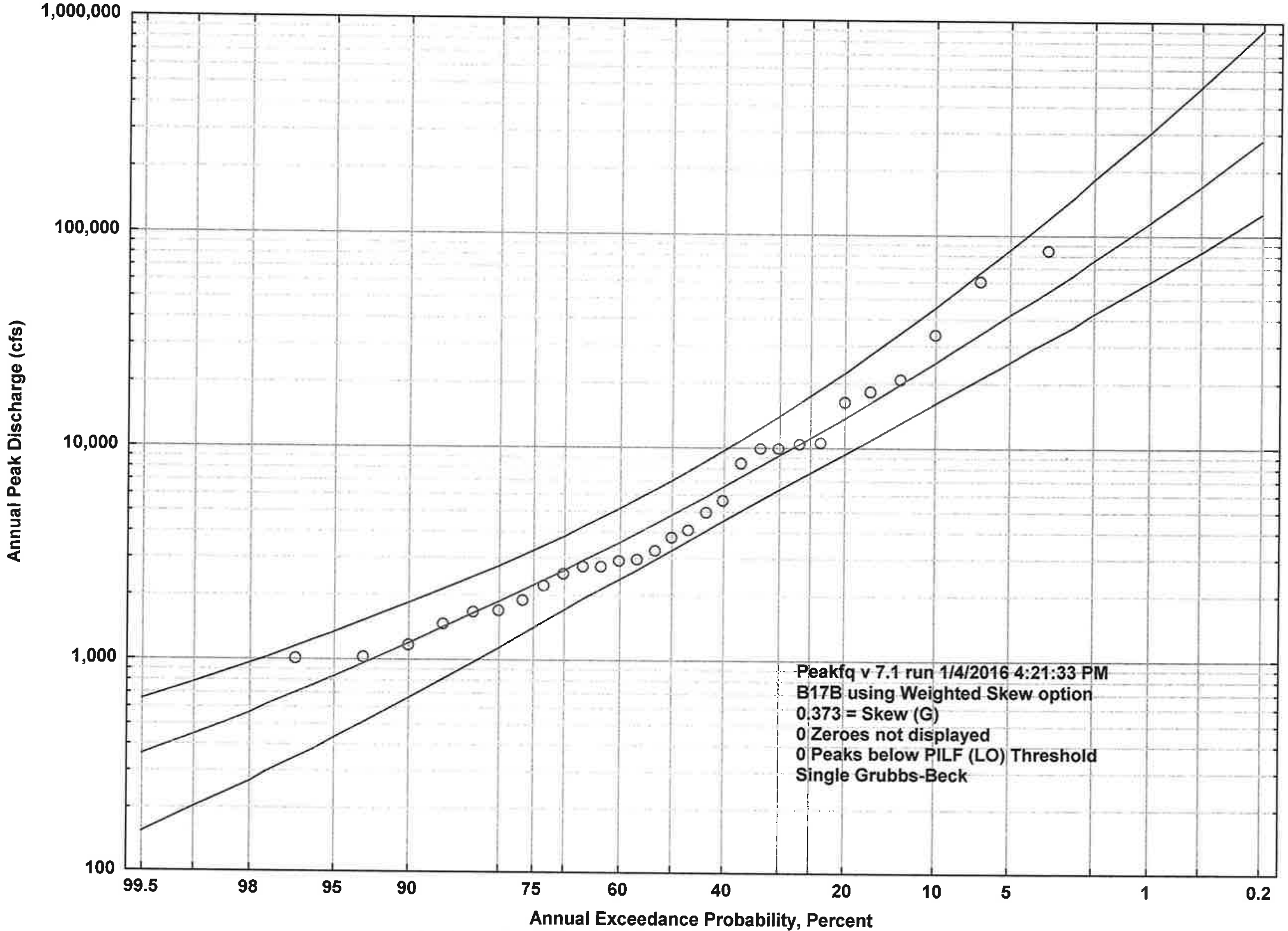


Station - 06759500 SOUTH PLATTE RIVER AT FORT MORGAN, CO

StreamStats Data-Collection Station Report

USGS Station Number	**06758500**
Station Name	**SOUTH PLATTE RIVER NEAR WELDONA, CO.**

Click here to link to available data on NWIS-Web for this site.

Descriptive Information

Station Type	Streamgage, continuous record
Location	
Gage	
Regulation and Diversions	
Regulated?	Unknown
Period of Record	
Remarks	
Latitude (degrees NAD83)	40.32193
Longitude (degrees NAD83)	-103.9219
Hydrologic unit code	10190003
County	-
HCDN2009	No

Physical Characteristics

Characteristic Name	Value	Units	Citation Number
Descriptive Information			
Datum_of_Latitude_Longitude	NAD83	dimensionless	30
District_Code	08	dimensionless	30
Begin_date_of_record	10/1/1952	days	41
End_date_of_record	9/30/2003	days	41
Number_of_days_of_record	18627	days	41
Number_of_days_GT_0	18627	days	41
Basin Dimensional Characteristics			
Drainage_Area	13190	square miles	30

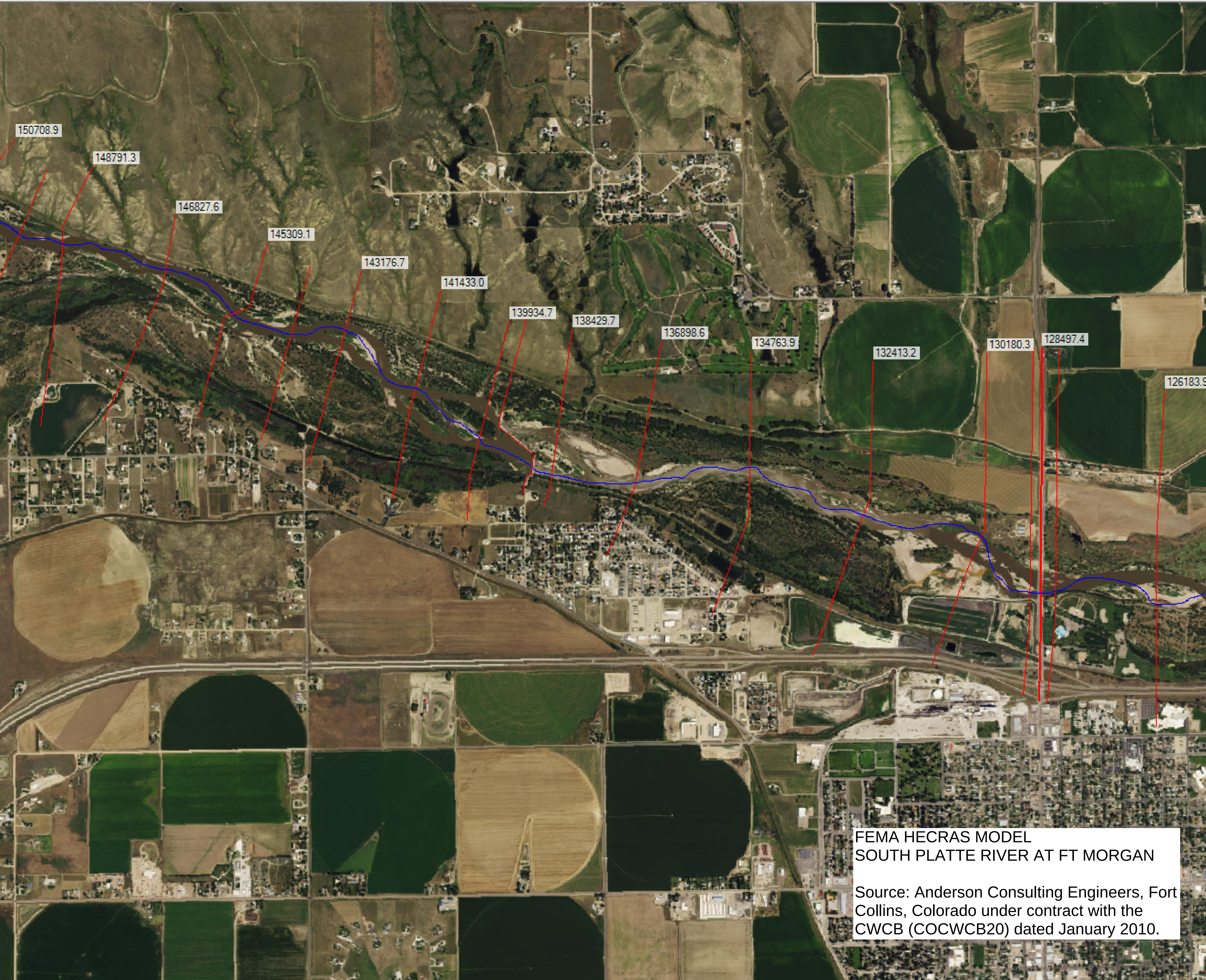
Streamflow Statistics

Statistic Name	Value	Units	Citation Number	Preferred?	Years of Record	Standard Error, percent	Variance log-10	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Start Date	End Date	Remarks
Flow-Duration Statistics												
1_Percent_Duration	7992.3	cubic feet per second	41	Y	52							
5_Percent_Duration	2240	cubic feet per second	41	Y	52							
10_Percent_Duration	1300	cubic feet per second	41	Y	52							
20_Percent_Duration	860	cubic feet per second	41	Y	52							
25_Percent_Duration	740	cubic feet per second	41	Y	52							
30_Percent_Duration	634		41	Y	52							

		cubic feet per second			
40_Percent_Duration	472	cubic feet per second	41	Y	52
50_Percent_Duration	361	cubic feet per second	41	Y	52
60_Percent_Duration	282	cubic feet per second	41	Y	52
70_Percent_Duration	219	cubic feet per second	41	Y	52
75_Percent_Duration	191	cubic feet per second	41	Y	52
80_Percent_Duration	167	cubic feet per second	41	Y	52
90_Percent_Duration	124	cubic feet per second	41	Y	52
95_Percent_Duration	99	cubic feet per second	41	Y	52
99_Percent_Duration	64	cubic feet per second	41	Y	52
General Flow Statistics					
Minimum_daily_flow	28	cubic feet per second	41	Y	52
Maximum_daily_flow	20800	cubic feet per second	41	Y	52
Std_Dev_of_daily_flows	1338.942	cubic feet per second	41	Y	52
Average_daily_streamflow	727.94	cubic feet per second	41	Y	52
Base Flow Statistics					
Number_of_years_to_compute_BFI	51	years	42	Y	52
Average_BFI_value	0.599	dimensionless	42	Y	52
Std_dev_of_annual_BFI_values	0.129	dimensionless	42	Y	52

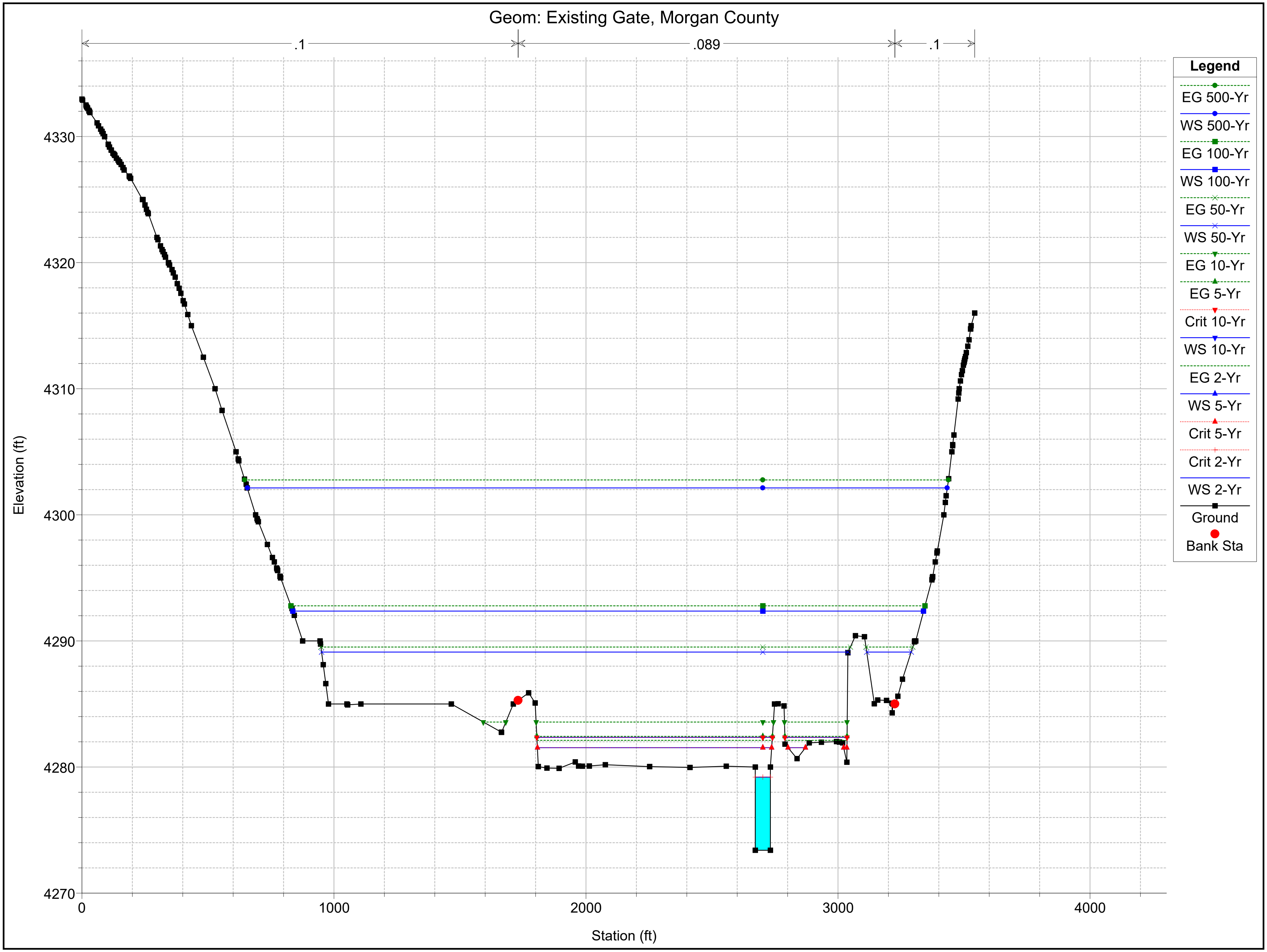
Citations

Citation Number	*Citation Name and URL*
30	Imported from NWIS file
41	Wolock, D.M., 2003, Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States: U.S. Geological Survey Open-File Report 03-146, digital data set
42	Wolock, D.M., 2003, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03-263, digital data set



FEMA HECRAS MODEL
SOUTH PLATTE RIVER AT FT MORGAN

Source: Anderson Consulting Engineers, Fort Collins, Colorado under contract with the CWCB (COCWCB20) dated January 2010.



1 in Horiz. = 500 ft   1 in Vert. = 10 ft

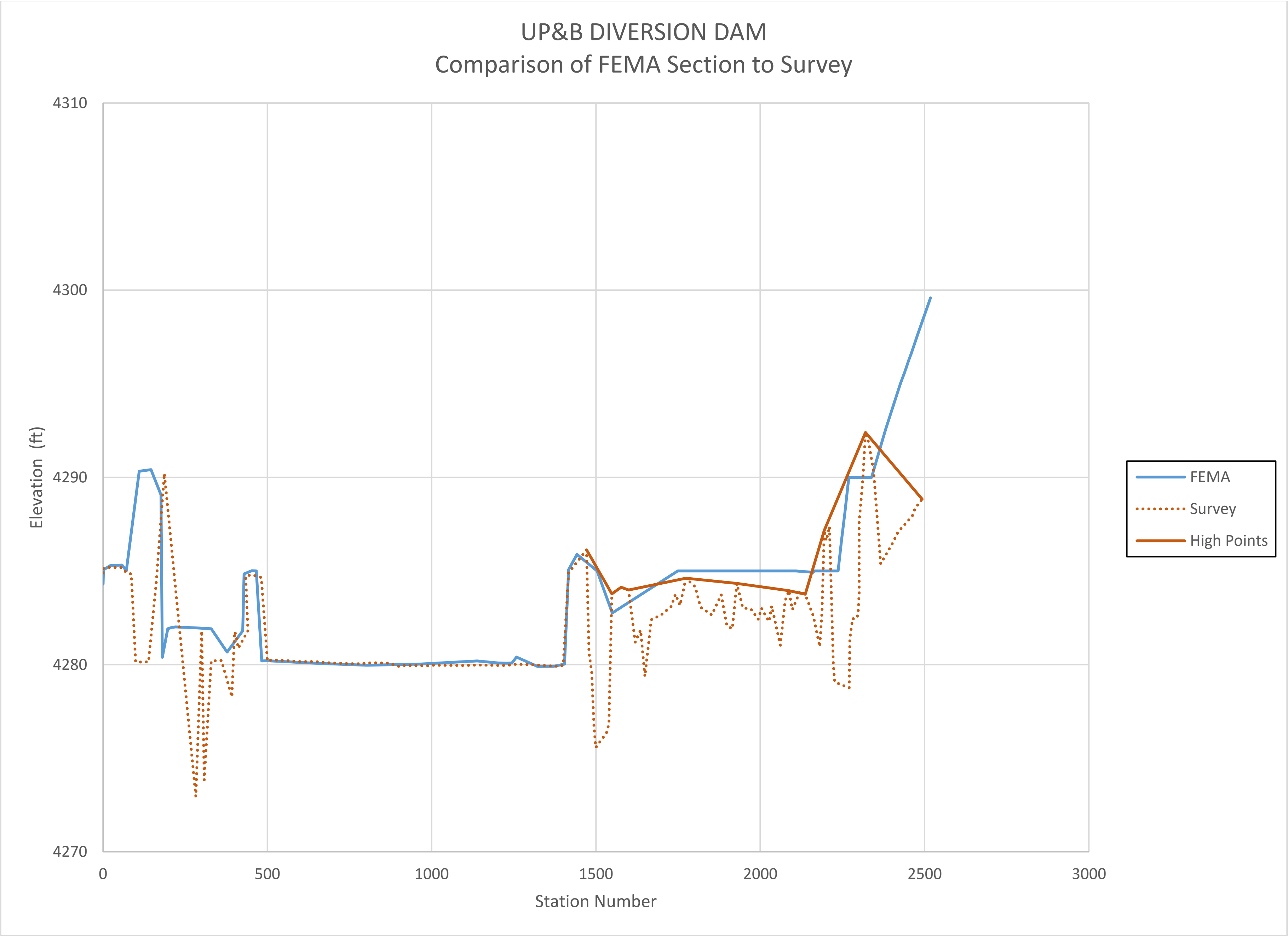
Profile Output Table - Standard Table 1
HEC-RAS Plan: Plan 03   River: South Platte   Reach: Morgan County Re
Existing Conditions
Rivers   = 1
Hydraulic Reaches = 1
River Stations   = 166
Plans   = 1
Profiles   = 6

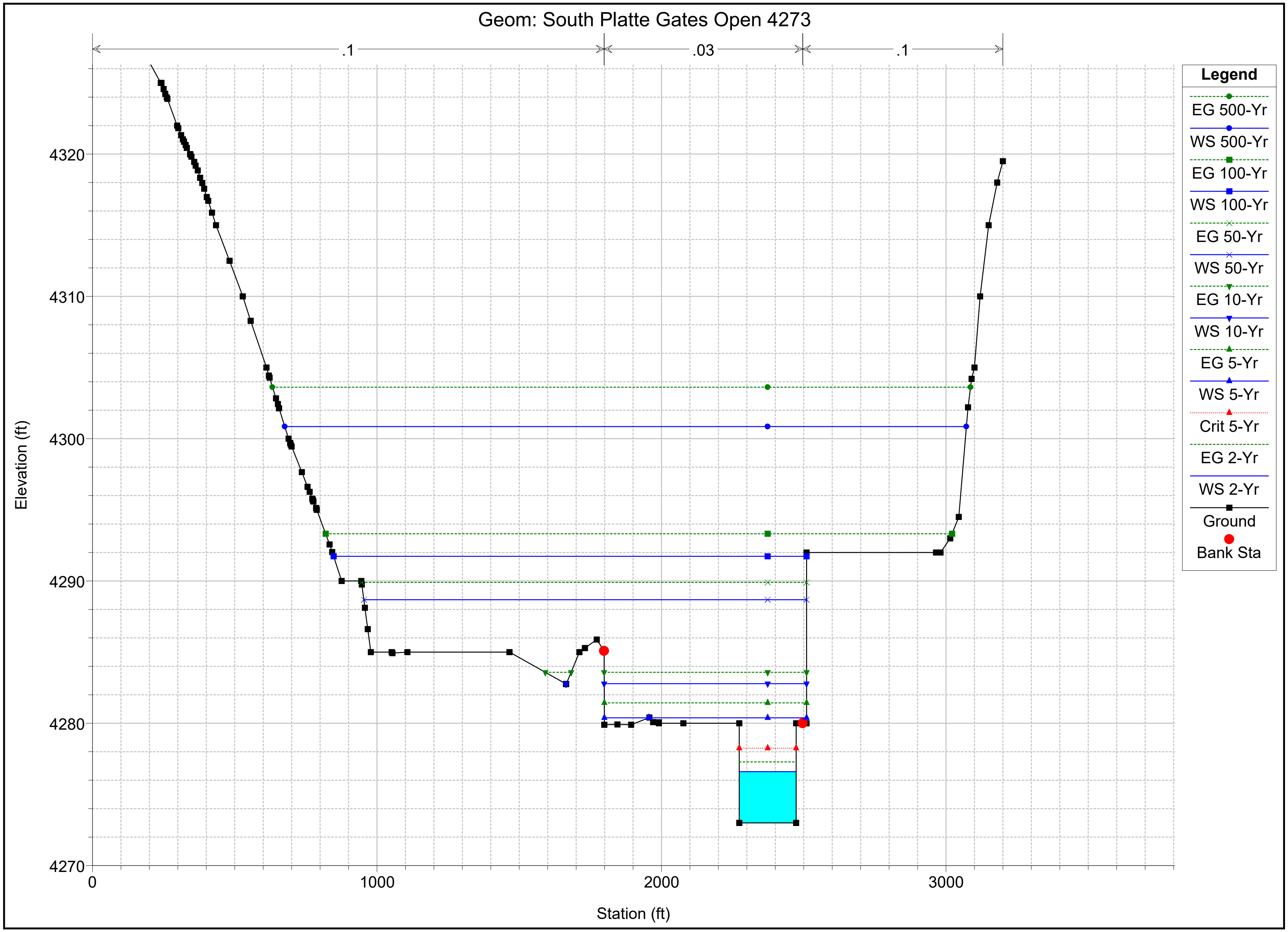
Table truncated to River Stations 150708.9 to 126183.9

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
150709	2-Yr	4773	4290	4298.02		4298.05	0.00037	1.56	3943.21	1057.7	0.11
150709	5-Yr	13700	4290	4301.2		4301.28	0.000566	2.51	8104.31	1475.11	0.14
150709	10-Yr	13500	4290	4302.71		4302.76	0.000291	1.98	10407.17	1572.52	0.1
150709	50-Yr	30500	4290	4308.47		4308.52	0.000242	2.38	19789.46	1668.81	0.1
150709	100-Yr	42500	4290	4311.54		4311.63	0.000315	3.04	26843.34	3521.09	0.12
150709	500-Yr	82500	4290	4321.47		4321.52	0.000124	2.5	63643.12	3827.79	0.08
149608	2-Yr	4773	4290	4297.73		4297.75	0.000207	1.31	4801.57	1097.5	0.08
149608	5-Yr	13700	4290	4300.63		4300.7	0.000456	2.4	9040.24	2113.83	0.13
149608	10-Yr	13500	4290	4302.45		4302.48	0.000198	1.75	13051	2310.64	0.09
149608	50-Yr	30500	4290	4308.25		4308.28	0.00016	2.04	29880.35	3703.4	0.08
149608	100-Yr	42500	4290	4311.35		4311.38	0.000132	2.05	42465.07	4217.64	0.08
149608	500-Yr	82500	4290	4321.38		4321.4	0.000063	1.83	85872.58	4419.84	0.06
148791	2-Yr	4773	4290	4297.33		4297.41	0.001044	2.39	2625.81	992.28	0.18
148791	5-Yr	13700	4290	4299.83		4300	0.001591	3.76	6060.63	1633.97	0.23
148791	10-Yr	24000	4290	4301.69		4301.89	0.001732	4.5	9356.17	1848.85	0.25
148791	50-Yr	73000	4290	4307.22		4307.57	0.002041	6.54	21718.5	2762.97	0.29
148791	100-Yr	114000	4290	4310.31		4310.69	0.001927	7.17	30481.95	2922.01	0.29
148791	500-Yr	300000	4290	4320.33		4320.83	0.001672	8.89	64940.18	3764.2	0.29
146828	2-Yr	4773	4290.01	4292.34		4292.56	0.012001	3.75	1288.28	734.75	0.49
146828	5-Yr	13700	4290.01	4295.2		4295.46	0.003987	4.09	3502.18	935.29	0.33
146828	10-Yr	24000	4290.01	4297.44		4297.74	0.002974	4.58	6263.8	1533.53	0.31
146828	50-Yr	73000	4290.01	4303.22		4303.67	0.002331	6.09	16572.33	1910.31	0.3
146828	100-Yr	114000	4290.01	4306.46		4307.02	0.002261	6.98	22853.9	1974.47	0.31
146828	500-Yr	300000	4290.01	4316.52		4317.48	0.002268	9.7	50026.98	3194.67	0.34
145309	2-Yr	4773	4285	4290.3		4290.33	0.000518	1.44	3848.56	1042.66	0.12
145309	5-Yr	13700	4285	4293.3		4293.37	0.000656	2.28	7304.05	1208.77	0.15
145309	10-Yr	24000	4285	4295.45		4295.57	0.000796	2.97	10809.79	2150.04	0.17
145309	50-Yr	73000	4285	4301.08		4301.32	0.001051	4.63	23660.21	2461.59	0.21
145309	100-Yr	114000	4285	4304.26		4304.57	0.001144	5.48	31563.53	2513.44	0.23
145309	500-Yr	300000	4285	4314.13		4314.74	0.001383	8.02	57247.84	2715.68	0.27
144186	2-Yr	4773	4285	4289.48		4289.53	0.000986	1.98	2753.98	743.81	0.17
144186	5-Yr	13700	4285	4292.23		4292.35	0.001261	3.08	6053.81	1602.18	0.2
144186	10-Yr	24000	4285	4294.2		4294.37	0.001398	3.81	9283.7	1970.72	0.22
144186	50-Yr	73000	4285	4299.47		4299.78	0.001681	5.65	21001	2608.09	0.26
144186	100-Yr	114000	4285	4302.54		4302.93	0.001734	6.53	28277.47	2717.29	0.27
144186	500-Yr	300000	4285	4312.09		4312.82	0.00192	9.18	51771.25	2967.2	0.31
143177	2-Yr	4773	4285	4288.35		4288.4	0.001314	1.86	2694.25	885.01	0.18
143177	5-Yr	13700	4285	4290.78		4290.91	0.00165	3.01	5120.64	1299.3	0.22
143177	10-Yr	24000	4285	4292.62		4292.81	0.001759	3.75	8121.76	1966.12	0.24
143177	50-Yr	73000	4285	4297.81		4298.12	0.001697	5.22	20453.97	2469.89	0.26
143177	100-Yr	114000	4285	4300.88		4301.27	0.001655	5.95	28123.96	2519.63	0.26
143177	500-Yr	300000	4285	4310.3		4311.02	0.001772	8.41	52780.18	2741.63	0.3
141433	2-Yr	4773	4282.55	4286.69		4286.72	0.000757	1.44	4530.08	1958.84	0.14
141433	5-Yr	13700	4282.55	4288.86		4288.91	0.00086	2.13	9032.12	2154.66	0.16

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
141433	10-Yr	24000	4282.55	4290.6		4290.67	0.000927	2.66	12886.01	2281.32	0.17
141433	50-Yr	73000	4282.55	4295.46		4295.65	0.001256	4.35	24469.14	2517.64	0.22
141433	100-Yr	114000	4282.55	4298.48		4298.74	0.001345	5.22	32363.87	2702.15	0.24
141433	500-Yr	300000	4282.55	4307.63		4308.18	0.001579	7.74	58823.83	3059.34	0.28
139935	2-Yr	4773	4280	4285.48		4285.5	0.000955	1.15	4729.07	1865.16	0.11
139935	5-Yr	13700	4280	4287.25		4287.3	0.00155	1.95	8120.87	1972.32	0.15
139935	10-Yr	24000	4280	4288.83		4288.91	0.001718	2.46	11326.88	2069.09	0.17
139935	50-Yr	73000	4280	4292.92		4293.14	0.002677	4.21	20401.86	2373.55	0.23
139935	100-Yr	114000	4280	4295.75		4296.04	0.002897	5.12	27585.14	2645.61	0.24
139935	500-Yr	300000	4280	4304.74		4305.29	0.002785	7.04	52852.31	2991.05	0.26
138808	2-Yr	4773	4273.4	4279.21	4279.21	4282.13	0.081566	13.7	348.36	60.07	1
138808	5-Yr	13700	4273.4	4281.53	4281.53	4282.43	0.096677	7.57	1808.85	1012.1	1
138808	10-Yr	24000	4273.4	4282.35	4282.35	4283.57	0.095209	8.87	2704.42	1180.84	1.03
138808	50-Yr	73000	4273.4	4289.12		4289.52	0.006342	5.33	15159.93	2265.69	0.33
138808	100-Yr	114000	4273.4	4292.37		4292.79	0.004564	5.51	23017.04	2502.83	0.29
138808	500-Yr	300000	4273.4	4302.13		4302.77	0.003067	6.91	48863.94	2777.32	0.27
138430	2-Yr	4773	4265.99	4276.03		4276.05	0.000511	1.15	4316.02	989.43	0.09
138430	5-Yr	13700	4265.99	4279.31		4279.36	0.000761	1.9	7777.29	1113.3	0.12
138430	10-Yr	24000	4265.99	4281.9		4281.98	0.000877	2.44	11188.91	1404.37	0.13
138430	50-Yr	73000	4265.99	4287.94		4288.17	0.001472	4.22	20728.38	1749.03	0.18
138430	100-Yr	114000	4265.99	4291		4291.36	0.001865	5.31	26413.86	1938.94	0.21
138430	500-Yr	300000	4265.99	4300.38		4301.17	0.002643	8.16	46404.48	2316.6	0.26
136899	2-Yr	4773	4269.32	4274.61		4274.68	0.001885	2.36	2408.19	937.25	0.2
136899	5-Yr	13700	4269.32	4277.67		4277.77	0.001427	2.91	5739.39	1185.59	0.19
136899	10-Yr	24000	4269.32	4280.18		4280.31	0.00132	3.39	9022.03	1519.91	0.19
136899	50-Yr	73000	4269.32	4285.38		4285.66	0.001707	5.09	17890.56	1892.1	0.23
136899	100-Yr	114000	4269.32	4287.85		4288.27	0.002028	6.13	22702.56	1995.34	0.26
136899	500-Yr	300000	4269.32	4296.28		4297.13	0.002418	8.68	41205.91	2413.64	0.3
134764	2-Yr	4773	4265	4270.24		4270.36	0.002238	2.78	1800.27	450.77	0.22
134764	5-Yr	13700	4265	4274.06		4274.26	0.002014	3.85	4218.94	832.83	0.23
134764	10-Yr	24000	4265	4276.47		4276.76	0.002321	4.85	7106.16	1844.93	0.26
134764	50-Yr	73000	4265	4280.97		4281.36	0.002647	6.48	16961.41	2682.23	0.29
134764	100-Yr	114000	4265	4283.45		4283.87	0.002311	6.68	23660.3	2756.36	0.28
134764	500-Yr	300000	4265	4293.23		4293.74	0.001165	6.32	54081.05	3339.74	0.21
132413	2-Yr	4773	4260	4268.06		4268.09	0.00053	1.59	3145.89	650.62	0.11
132413	5-Yr	13700	4260	4270.85		4270.96	0.001054	2.86	5732.51	1343.38	0.17
132413	10-Yr	24000	4260	4272.73		4272.89	0.001259	3.53	8990.92	2112.4	0.19
132413	50-Yr	73000	4260	4277.82		4277.99	0.000966	3.98	23402.95	3086.41	0.17
132413	100-Yr	114000	4260	4280.76		4280.97	0.000838	4.15	32618.26	3169.43	0.17
132413	500-Yr	300000	4260	4291.67		4292.01	0.000571	4.63	69420.06	3747.83	0.15
130180	2-Yr	4773	4260	4266.07		4266.15	0.001716	2.34	2148.73	1030.34	0.19
130180	5-Yr	13700	4260	4268.95		4269.08	0.000715	2.08	5742.68	1454.81	0.13
130180	10-Yr	24000	4260	4270.37		4270.61	0.000877	2.58	8400.3	2323.42	0.15
130180	50-Yr	73000	4260	4276.11		4276.42	0.000562	2.86	22892.52	2809.07	0.13
130180	100-Yr	114000	4260	4279.15		4279.52	0.00055	3.2	31530.67	2871.9	0.13
130180	500-Yr	300000	4260	4290.64		4291.02	0.00038	3.71	73618.14	4626.02	0.12
128680	2-Yr	4773	4252.56	4264.15	4258.73	4264.19	0.001024	1.69	2847.36	734.89	0.14
128680	5-Yr	13700	4252.56	4267.8	4261.08	4267.88	0.000915	2.28	6147.27	968.85	0.15
128680	10-Yr	20000	4252.56	4269.03	4262.34	4269.15	0.001107	2.78	7358.11	988.37	0.17
128680	50-Yr	62000	4252.56	4275.04	4266.49	4275.32	0.001324	4.3	16554.11	2438.19	0.2
128680	100-Yr	93000	4252.56	4278.21	4268.16	4278.49	0.001204	4.68	24287.17	2784.68	0.2
128680	500-Yr	240000	4252.56	4290.08	4275.3	4290.38	0.000678	4.95	60012.34	4468.54	0.16
128515		Bridge									

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
128497	2-Yr	4773	4254.16	4263.12	4258.18	4263.17	0.001567	1.81	2630.93	687	0.16
128497	5-Yr	13700	4254.16	4266.79	4260.58	4266.88	0.001275	2.48	5607.86	949.54	0.16
128497	10-Yr	20000	4254.16	4268.11	4261.73	4268.25	0.001407	2.92	6878.12	971.27	0.18
128497	50-Yr	62000	4254.16	4273.51	4266.05	4273.69	0.001097	3.58	18679.1	2974.71	0.17
128497	100-Yr	93000	4254.16	4277.48	4267.68	4277.62	0.000504	2.87	31520.41	3429.59	0.12
128497	500-Yr	240000	4254.16	4289.75	4273.37	4289.9	0.000195	2.53	79086.32	4399.22	0.08
128491	2-Yr	4773	4255	4263.11		4263.16	0.001579	1.8	2656.76	711.75	0.16
128491	5-Yr	13700	4255	4266.78		4266.87	0.001193	2.43	5713.56	952.77	0.16
128491	10-Yr	20000	4255	4268.11		4268.23	0.001329	2.87	7008.22	1029.23	0.17
128491	50-Yr	62000	4255	4273.22		4273.61	0.001912	4.7	12543.51	2939.94	0.22
128491	100-Yr	93000	4255	4276.97		4277.5	0.001618	5.08	16661.76	3357.39	0.21
128491	500-Yr	240000	4255	4288.29		4289.56	0.001575	7	29093.73	4264.06	0.23
128482	2-Yr	4773	4253.53	4263.1	4257.67	4263.15	0.001301	1.7	2814.49	707.52	0.15
128482	5-Yr	13700	4253.53	4266.78	4260.13	4266.86	0.00127	2.22	6178.06	1044.99	0.16
128482	10-Yr	20000	4253.53	4268.11	4261.33	4268.21	0.001381	2.64	7570.84	1061.41	0.17
128482	50-Yr	62000	4253.53	4273.22	4265.65	4273.58	0.00217	4.7	13067.53	2917.29	0.23
128482	100-Yr	93000	4253.53	4276.98	4267.19	4277.46	0.001965	5.33	17132.86	3393.78	0.23
128482	500-Yr	240000	4253.53	4288.35	4272.66	4289.46	0.00212	7.89	29422.78	4276.91	0.26
128432		Bridge									
128228	2-Yr	4773	4253.2	4262.57		4262.62	0.00108	1.78	2675.73	539.29	0.14
128228	5-Yr	13700	4253.2	4266.08		4266.19	0.001629	2.61	5346.88	1822.15	0.18
128228	10-Yr	20000	4253.2	4267.38		4267.52	0.001739	3.02	6725.9	2501	0.19
128228	50-Yr	62000	4253.2	4271.66		4272.08	0.002745	5.08	11918.15	3126.2	0.26
128228	100-Yr	93000	4253.2	4273.47		4274.16	0.003375	6.2	14224.37	3154.38	0.3
128228	500-Yr	240000	4253.2	4279.14		4281.32	0.005437	9.91	21441.95	3416.43	0.4
126184	2-Yr	4773	4255	4260.75		4260.78	0.000754	1.49	3263.56	852.69	0.12
126184	5-Yr	13700	4255	4263.29		4263.38	0.001176	2.46	5919.38	1466.78	0.16
126184	10-Yr	20000	4255	4264.08		4264.21	0.001523	2.99	7237.13	1862.96	0.18
126184	50-Yr	62000	4255	4267.2		4267.45	0.00189	4.13	15531.8	2880.33	0.22
126184	100-Yr	93000	4255	4268.78		4269.11	0.001815	4.41	20115.31	2915.72	0.22
126184	500-Yr	240000	4255	4273.89		4274.58	0.001888	5.62	36491.87	3402.43	0.23


UP&B DIVERSION DAM
Comparison of FEMA Section to Survey
4310
4300
4290
4280
4270
Elevation (ft)
0
500
1000
1500
2000
2500
3000
Station Number
FEMA
Survey
High Points



1 in Horiz. = 500 ft 1 in Vert. = 10 ft

Profile Output Table - Standard Table 1
HEC-RAS Plan: Plan 06 River: South Platte Reach: Morgan County Re
New Dam, Gates Open
Rivers = 1
Hydraulic Reaches = 1
River Stations = 166
Plans = 1
Profiles = 6

Table truncated to River Stations 150708.9 to 126183.9

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
150709	2-Yr	4773	4290	4298.02		4298.05	0.00037	1.56	3943.73	1057.79	0.11
150709	5-Yr	13700	4290	4301.2		4301.28	0.000566	2.51	8104.31	1475.11	0.14
150709	10-Yr	13500	4290	4302.71		4302.76	0.000291	1.98	10407.17	1572.52	0.1
150709	50-Yr	30500	4290	4308.46		4308.52	0.000242	2.38	19785.39	1668.77	0.1
150709	100-Yr	42500	4290	4311.54		4311.63	0.000316	3.04	26819.27	3520.78	0.12
150709	500-Yr	82500	4290	4321.49		4321.54	0.000124	2.5	63706.66	3828.04	0.08
149608	2-Yr	4773	4290	4297.73		4297.75	0.000207	1.31	4802.1	1097.58	0.08
149608	5-Yr	13700	4290	4300.63		4300.7	0.000456	2.4	9040.24	2113.83	0.13
149608	10-Yr	13500	4290	4302.45		4302.48	0.000198	1.75	13051	2310.64	0.09
149608	50-Yr	30500	4290	4308.24		4308.28	0.00016	2.04	29871.31	3702.73	0.08
149608	100-Yr	42500	4290	4311.34		4311.37	0.000132	2.05	42436.25	4217.47	0.08
149608	500-Yr	82500	4290	4321.4		4321.42	0.000063	1.83	85948.11	4420.14	0.06
148791	2-Yr	4773	4290	4297.33		4297.41	0.001043	2.39	2626.78	992.54	0.18
148791	5-Yr	13700	4290	4299.83		4300	0.001591	3.76	6060.63	1633.97	0.23
148791	10-Yr	24000	4290	4301.69		4301.89	0.001732	4.5	9356.17	1848.85	0.25
148791	50-Yr	73000	4290	4307.22		4307.56	0.002044	6.54	21709.04	2762.85	0.29
148791	100-Yr	114000	4290	4310.3		4310.68	0.001932	7.17	30456.28	2921.56	0.29
148791	500-Yr	300000	4290	4320.35		4320.85	0.001666	8.88	65013.74	3764.47	0.29
146828	2-Yr	4773	4290.01	4292.34		4292.55	0.012023	3.76	1287.56	734.73	0.49
146828	5-Yr	13700	4290.01	4295.2		4295.45	0.003989	4.09	3501.72	935.16	0.33
146828	10-Yr	24000	4290.01	4297.43		4297.73	0.002981	4.59	6257.06	1532.37	0.31
146828	50-Yr	73000	4290.01	4303.2		4303.65	0.002348	6.11	16530.36	1909.87	0.3
146828	100-Yr	114000	4290.01	4306.43		4306.99	0.002277	7	22797.99	1973.92	0.31
146828	500-Yr	300000	4290.01	4316.57		4317.52	0.002251	9.67	50164.25	3194.81	0.33
145309	2-Yr	4773	4285	4290.3		4290.33	0.000518	1.44	3850.09	1042.84	0.12
145309	5-Yr	13700	4285	4293.3		4293.36	0.000657	2.28	7300.51	1208.68	0.15
145309	10-Yr	24000	4285	4295.44		4295.55	0.000801	2.97	10778.3	2149.44	0.17
145309	50-Yr	73000	4285	4301.04		4301.28	0.001066	4.65	23544.85	2460.68	0.21
145309	100-Yr	114000	4285	4304.21		4304.52	0.001158	5.5	31433.46	2512.66	0.23
145309	500-Yr	300000	4285	4314.19		4314.8	0.00137	8	57421.59	2717.32	0.26
144186	2-Yr	4773	4285	4289.48		4289.54	0.000985	1.98	2755.44	743.92	0.16
144186	5-Yr	13700	4285	4292.22		4292.34	0.001265	3.09	6045.14	1601.09	0.2
144186	10-Yr	24000	4285	4294.17		4294.35	0.001416	3.83	9234.72	1965.61	0.22
144186	50-Yr	73000	4285	4299.39		4299.71	0.001724	5.7	20815.65	2605.57	0.27
144186	100-Yr	114000	4285	4302.46		4302.86	0.00177	6.57	28084.34	2715.18	0.28
144186	500-Yr	300000	4285	4312.18		4312.9	0.001895	9.14	51990.29	2969.47	0.31
143177	2-Yr	4773	4285	4288.35		4288.4	0.001306	1.85	2699	885.22	0.18
143177	5-Yr	13700	4285	4290.76		4290.9	0.001667	3.02	5100.38	1293.75	0.22
143177	10-Yr	24000	4285	4292.55		4292.75	0.001825	3.79	7986.32	1940.79	0.24
143177	50-Yr	73000	4285	4297.66		4297.98	0.001788	5.31	20079.08	2467.62	0.26
143177	100-Yr	114000	4285	4300.75		4301.15	0.001713	6.02	27794.4	2517.2	0.27
143177	500-Yr	300000	4285	4310.42		4311.13	0.001741	8.36	53101.62	2744.34	0.29
141433	2-Yr	4773	4282.55	4286.63		4286.66	0.000814	1.47	4411.05	1941.51	0.14
141433	5-Yr	13700	4282.55	4288.7		4288.76	0.000966	2.22	8684.87	2142.34	0.17
141433	10-Yr	24000	4282.55	4290.22		4290.31	0.001137	2.84	12040.4	2270.09	0.19
141433	50-Yr	73000	4282.55	4295.09		4295.29	0.001408	4.51	23537.02	2492.82	0.23
141433	100-Yr	114000	4282.55	4298.21		4298.49	0.001437	5.33	31653.18	2688.52	0.24
141433	500-Yr	300000	4282.55	4307.81		4308.35	0.001536	7.68	59378.66	3066.13	0.27
139935	2-Yr	4773	4280	4283.45		4283.56	0.014154	2.96	1773.71	1090.43	0.39
139935	5-Yr	13700	4280	4286.37		4286.45	0.003186	2.46	6407.35	1918.26	0.21
139935	10-Yr	24000	4280	4287.09		4287.25	0.005345	3.54	7816.32	1962.82	0.28
139935	50-Yr	73000	4280	4291.88		4292.16	0.003905	4.76	17977.55	2295.27	0.27
139935	100-Yr	114000	4280	4295.13		4295.47	0.003486	5.44	25959.9	2620.33	0.27
139935	500-Yr	300000	4280	4305.03		4305.56	0.002652	6.93	53727.55	3003.44	0.26
138808	2-Yr	4773	4273	4276.6		4277.28	0.003414	6.64	719.16	200	0.62
138808	5-Yr	13700	4273	4280.38	4278.26	4281.44	0.008965	8.27	1661.97	706.99	0.94
138808	10-Yr	24000	4273	4282.78		4283.58	0.002694	7.18	3372.22	713.93	0.58

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
138808	50-Yr	73000	4273	4288.69		4289.9	0.001492	9.12	10888.07	1556.17	0.49
138808	100-Yr	114000	4273	4291.74		4293.32	0.00145	10.63	15795.63	1662.88	0.51
138808	500-Yr	300000	4273	4300.85		4303.62	0.001445	14.9	36482.36	2395.76	0.55
138430	2-Yr	4773	4265.99	4276.03		4276.05	0.000511	1.15	4316.02	989.43	0.09
138430	5-Yr	13700	4265.99	4279.31		4279.36	0.000761	1.9	7777.29	1113.3	0.12
138430	10-Yr	24000	4265.99	4281.9		4281.98	0.000877	2.44	11188.91	1404.37	0.13
138430	50-Yr	73000	4265.99	4287.94		4288.17	0.001472	4.22	20728.38	1749.03	0.18
138430	100-Yr	114000	4265.99	4291		4291.36	0.001865	5.31	26413.86	1938.94	0.21
138430	500-Yr	300000	4265.99	4300.38		4301.17	0.002643	8.16	46404.48	2316.6	0.26
136899	2-Yr	4773	4269.32	4274.61		4274.68	0.001885	2.36	2408.19	937.25	0.2
136899	5-Yr	13700	4269.32	4277.67		4277.77	0.001427	2.91	5739.39	1185.59	0.19
136899	10-Yr	24000	4269.32	4280.18		4280.31	0.00132	3.39	9022.03	1519.91	0.19
136899	50-Yr	73000	4269.32	4285.38		4285.66	0.001707	5.09	17890.56	1892.1	0.23
136899	100-Yr	114000	4269.32	4287.85		4288.27	0.002028	6.13	22702.56	1995.34	0.26
136899	500-Yr	300000	4269.32	4296.28		4297.13	0.002418	8.68	41205.91	2413.64	0.3
134764	2-Yr	4773	4265	4270.24		4270.36	0.002238	2.78	1800.27	450.77	0.22
134764	5-Yr	13700	4265	4274.06		4274.26	0.002014	3.85	4218.94	832.83	0.23
134764	10-Yr	24000	4265	4276.47		4276.76	0.002321	4.85	7106.16	1844.93	0.26
134764	50-Yr	73000	4265	4280.97		4281.36	0.002647	6.48	16961.41	2682.23	0.29
134764	100-Yr	114000	4265	4283.45		4283.87	0.002311	6.68	23660.3	2756.36	0.28
134764	500-Yr	300000	4265	4293.23		4293.74	0.001165	6.32	54081.05	3339.74	0.21
132413	2-Yr	4773	4260	4268.06		4268.09	0.00053	1.59	3145.89	650.62	0.11
132413	5-Yr	13700	4260	4270.85		4270.96	0.001054	2.86	5732.51	1343.38	0.17
132413	10-Yr	24000	4260	4272.73		4272.89	0.001259	3.53	8990.92	2112.4	0.19
132413	50-Yr	73000	4260	4277.82		4277.99	0.000966	3.98	23402.95	3086.41	0.17
132413	100-Yr	114000	4260	4280.76		4280.97	0.000838	4.15	32618.26	3169.43	0.17
132413	500-Yr	300000	4260	4291.67		4292.01	0.000571	4.63	69420.06	3747.83	0.15
130180	2-Yr	4773	4260	4266.07		4266.15	0.001716	2.34	2148.73	1030.34	0.19
130180	5-Yr	13700	4260	4268.95		4269.08	0.000715	2.08	5742.68	1454.81	0.13
130180	10-Yr	24000	4260	4270.37		4270.61	0.000877	2.58	8400.3	2323.42	0.15
130180	50-Yr	73000	4260	4276.11		4276.42	0.000562	2.86	22892.52	2809.07	0.13
130180	100-Yr	114000	4260	4279.15		4279.52	0.00055	3.2	31530.67	2871.9	0.13
130180	500-Yr	300000	4260	4290.64		4291.02	0.00038	3.71	73618.14	4626.02	0.12
128680	2-Yr	4773	4252.56	4264.15	4258.73	4264.19	0.001024	1.69	2847.36	734.89	0.14
128680	5-Yr	13700	4252.56	4267.8	4261.08	4267.88	0.000915	2.28	6147.27	968.85	0.15
128680	10-Yr	20000	4252.56	4269.03	4262.34	4269.15	0.001107	2.78	7358.11	988.37	0.17
128680	50-Yr	62000	4252.56	4275.04	4266.49	4275.32	0.001324	4.3	16554.11	2438.19	0.2
128680	100-Yr	93000	4252.56	4278.21	4268.16	4278.49	0.001204	4.68	24287.17	2784.68	0.2
128680	500-Yr	240000	4252.56	4290.08	4275.3	4290.38	0.000678	4.95	60012.34	4468.54	0.16
128515		Bridge									
128497	2-Yr	4773	4254.16	4263.12	4258.18	4263.17	0.001567	1.81	2630.93	687	0.16
128497	5-Yr	13700	4254.16	4266.79	4260.58	4266.88	0.001275	2.48	5607.86	949.54	0.16
128497	10-Yr	20000	4254.16	4268.11	4261.73	4268.25	0.001407	2.92	6878.12	971.27	0.18
128497	50-Yr	62000	4254.16	4273.51	4266.05	4273.69	0.001097	3.58	18679.1	2974.71	0.17
128497	100-Yr	93000	4254.16	4277.48	4267.68	4277.62	0.000504	2.87	31520.41	3429.59	0.12
128497	500-Yr	240000	4254.16	4289.75	4273.37	4289.9	0.000195	2.53	79086.32	4399.22	0.08
128491	2-Yr	4773	4255	4263.11		4263.16	0.001579	1.8	2656.76	711.75	0.16
128491	5-Yr	13700	4255	4266.78		4266.87	0.001193	2.43	5713.56	952.77	0.16
128491	10-Yr	20000	4255	4268.11		4268.23	0.001329	2.87	7008.22	1029.23	0.17
128491	50-Yr	62000	4255	4273.22		4273.61	0.001912	4.7	12543.51	2939.94	0.22
128491	100-Yr	93000	4255	4276.97		4277.5	0.001618	5.08	16661.76	3357.39	0.21
128491	500-Yr	240000	4255	4288.29		4289.56	0.001575	7	29093.73	4264.06	0.23
128482	2-Yr	4773	4253.53	4263.1	4257.67	4263.15	0.001301	1.7	2814.49	707.52	0.15
128482	5-Yr	13700	4253.53	4266.78	4260.13	4266.86	0.00127	2.22	6178.06	1044.99	0.16
128482	10-Yr	20000	4253.53	4268.11	4261.33	4268.21	0.001381	2.64	7570.84	1061.41	0.17
128482	50-Yr	62000	4253.53	4273.22	4265.65	4273.58	0.00217	4.7	13067.53	2917.29	0.23
128482	100-Yr	93000	4253.53	4276.98	4267.19	4277.46	0.001965	5.33	17132.86	3393.78	0.23
128482	500-Yr	240000	4253.53	4288.35	4272.66	4289.46	0.00212	7.89	29422.78	4276.91	0.26
128432		Bridge									
128228	2-Yr	4773	4253.2	4262.57		4262.62	0.00108	1.78	2675.73	539.29	0.14
128228	5-Yr	13700	4253.2	4266.08		4266.19	0.001629	2.61	5346.88	1822.15	0.18
128228	10-Yr	20000	4253.2	4267.38		4267.52	0.001739	3.02	6725.9	2501	0.19
128228	50-Yr	62000	4253.2	4271.66		4272.08	0.002745	5.08	11918.15	3126.2	0.26
128228	100-Yr	93000	4253.2	4273.47		4274.16	0.003375	6.2	14224.37	3154.38	0.3
128228	500-Yr	240000	4253.2	4279.14		4281.32	0.005437	9.91	21441.95	3416.43	0.4

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
126184	2-Yr	4773	4255	4260.75		4260.78	0.000754	1.49	3263.56	852.69	0.12
126184	5-Yr	13700	4255	4263.29		4263.38	0.001176	2.46	5919.38	1466.78	0.16
126184	10-Yr	20000	4255	4264.08		4264.21	0.001523	2.99	7237.13	1862.96	0.18
126184	50-Yr	62000	4255	4267.2		4267.45	0.00189	4.13	15531.8	2880.33	0.22
126184	100-Yr	93000	4255	4268.78		4269.11	0.001815	4.41	20115.31	2915.72	0.22
126184	500-Yr	240000	4255	4273.89		4274.58	0.001888	5.62	36491.87	3402.43	0.23

Profile Output Table - Standard Table 1
HEC-RAS Plan: Plan 04   River: South Platte   Reach: Morgan County Re
Diversion Simulation, Gates Closed
Rivers = 1
Hydraulic Reaches = 1
River Stations = 166
Plans = 1
Profiles = 6

Table truncated to River Stations 150708.9 to 126183.9

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Q Left (cfs)	Q Right (cfs)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
150709	2-Yr	4773	4290	4298.02	437.44	211.86	0.00037	1.56	3943.73	1057.79	0.11
150709	10-Yr	24000	4290	4303.4	2997.77	5468.18	0.000706	3.22	11501.64	1603.05	0.16
150709	5-Yr	13700	4290	4301.2	1641.02	2165.45	0.000566	2.51	8104.31	1475.11	0.14
150709	High Flow	2100	4290	4296.2	104.37	10.25	0.000255	1.04	2300.55	752.96	0.08
150709	Average	577	4290	4294	0.63		0.000145	0.55	1053.25	393.88	0.06
150709	Low	167	4290	4292.72			0.000089	0.29	567.17	364.97	0.04
149608	2-Yr	4773	4290	4297.73	587.13	255.36	0.000207	1.31	4802.1	1097.58	0.08
149608	10-Yr	24000	4290	4302.68	2983.17	6158.9	0.000569	3.01	13592.11	2335.92	0.15
149608	5-Yr	13700	4290	4300.63	1827.69	1943.69	0.000456	2.4	9040.24	2113.83	0.13
149608	High Flow	2100	4290	4296.03	218.71	27.36	0.000105	0.79	3179.96	818.31	0.06
149608	Average	577	4290	4293.93	38.57	2.86	0.000037	0.35	1825.36	539.14	0.03
149608	Low	167	4290	4292.69	7.82	0.58	0.000011	0.15	1186.49	491.92	0.02
148791	2-Yr	4773	4290	4297.33	21.52	425.2	0.001043	2.39	2626.78	992.54	0.18
148791	10-Yr	24000	4290	4301.69	160.01	9464.79	0.001732	4.5	9355.26	1848.84	0.25
148791	5-Yr	13700	4290	4299.83	85.9	3806.91	0.001591	3.76	6060.63	1633.97	0.23
148791	High Flow	2100	4290	4295.83	5.7	25.64	0.000662	1.55	1455.16	564.49	0.13
148791	Average	577	4290	4293.85	0.2	0.3	0.00043	0.82	707.87	324.68	0.1
148791	Low	167	4290	4292.66			0.000297	0.48	345.21	259.22	0.07
146828	2-Yr	4773	4290.01	4292.34	36.17	20.05	0.012023	3.76	1287.56	734.73	0.49
146828	10-Yr	24000	4290.01	4297.43	152.02	1721.77	0.002976	4.59	6261.55	1533.14	0.31
146828	5-Yr	13700	4290.01	4295.2	88.44	279.78	0.003987	4.09	3502.18	935.29	0.33
146828	High Flow	2100	4290.01	4291.19	27.43	0.07	0.070683	4.6	457.64	709.28	1.01
146828	Average	577	4290.01	4290.72	12.98		0.086753	3.43	168.52	469.48	1.01
146828	Low	167	4290.01	4290.44	6.11		0.100309	2.65	63.18	287.47	1
145309	2-Yr	4773	4285	4290.3	605.11	7.84	0.000518	1.44	3850.09	1042.84	0.12
145309	10-Yr	24000	4285	4295.45	4494.22	1038.16	0.000798	2.97	10801.39	2149.88	0.17
145309	5-Yr	13700	4285	4293.3	2383.58	320.36	0.000657	2.28	7302.87	1208.74	0.15
145309	High Flow	2100	4285	4288.72	201.09	1.08	0.000458	1.01	2320.51	906.2	0.1
145309	Average	577	4285	4287.19	40.51	0	0.000447	0.61	1019.95	788.7	0.09
145309	Low	167	4285	4286.35	9.12		0.000525	0.43	411.93	596.23	0.09
144186	2-Yr	4773	4285	4289.48	226.48	233.91	0.000985	1.98	2755.44	743.92	0.16
144186	10-Yr	24000	4285	4294.19	1845.02	5091.48	0.001403	3.82	9269.69	1969.26	0.22
144186	5-Yr	13700	4285	4292.23	979.52	1887.46	0.001262	3.08	6050.92	1601.82	0.2
144186	High Flow	2100	4285	4288.07	70.4	72.72	0.000715	1.31	1763.25	662.8	0.13
144186	Average	577	4285	4286.7	11.07	11.43	0.00041	0.67	911.1	584.21	0.09
144186	Low	167	4285	4285.97	1.86	1.92	0.000231	0.35	499.17	542.15	0.06
143177	2-Yr	4773	4285	4288.35	88.65	67.48	0.001308	1.86	2697.7	885.16	0.18
143177	10-Yr	24000	4285	4292.6	1135.72	1410.3	0.001778	3.76	8083.43	1958.98	0.24
143177	5-Yr	13700	4285	4290.77	422.69	242.71	0.001657	3.02	5112.4	1297.05	0.22
143177	High Flow	2100	4285	4287.18	26.18	18.74	0.001131	1.29	1686.05	839.24	0.16
143177	Average	577	4285	4286.13	3.95	2.4	0.000864	0.71	825.84	798.79	0.12
143177	Low	167	4285	4285.58	0.66	0.28	0.000796	0.42	398.22	777.74	0.1
141433	2-Yr	4773	4282.55	4286.65	1159.4	187.03	0.000799	1.46	4440.47	1945.81	0.14
141433	10-Yr	24000	4282.55	4290.51	6903.87	3479.82	0.000971	2.7	12691.18	2278.74	0.18
141433	5-Yr	13700	4282.55	4288.81	3828.54	1532.17	0.000896	2.16	8907.05	2150.24	0.16
141433	High Flow	2100	4282.55	4285.47	343.02	17.97	0.000879	1.15	2347.32	1611.68	0.14
141433	Average	577	4282.55	4284.29	10.87	0.33	0.00131	0.83	743.93	988.04	0.15
141433	Low	167	4282.55	4283.72			0.001517	0.57	294.8	594.55	0.14
139935	2-Yr	4773	4280	4285.09	1508.54	10.73	0.001527	1.34	4013.93	1842.71	0.14
139935	10-Yr	24000	4280	4288.59	8292.5	2097.94	0.001979	2.57	10816.51	2054.11	0.18
139935	5-Yr	13700	4280	4287.02	4689.47	753.37	0.001847	2.06	7667.95	1958.18	0.16
139935	High Flow	2100	4280	4283.96	597.25	0.21	0.001249	0.98	2375.57	1263.09	0.12
139935	Average	577	4280	4282.58	120.45		0.001032	0.66	957.05	796.22	0.1
139935	Low	167	4280	4281.57	15.71		0.001386	0.56	324.1	451.4	0.11
138808	2-Yr	4773	4279.9	4280.99	205.77	343.68	0.016644	6.29	807.39	713.25	1.12
138808	10-Yr	24000	4279.9	4283.25	267.91	435.38	0.009296	10.46	2435.28	767.67	1.02
138808	5-Yr	13700	4279.9	4282.18	227.67	380.87	0.011142	8.77	1659.67	713.38	1.05

River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Q Left (cfs)	Q Right (cfs)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
138808	High Flow	2100	4279.9	4280.51	203.13	338.8	0.021524	4.56	465.41	713.19	1.14
138808	Average	577	4279.9	4278.17	220.57	356.43	0.161738		64.47	25.19	0
138808	Low	167	4279.9	4276.72	65.23	101.77	0.172835		27.98	25.08	0
138430	2-Yr	4773	4265.99	4276.03	73.58	3.27	0.000511	1.15	4316.02	989.43	0.09
138430	10-Yr	24000	4265.99	4281.9	2640.04	85.3	0.000877	2.44	11188.91	1404.37	0.13
138430	5-Yr	13700	4265.99	4279.31	987.47	30.99	0.000761	1.9	7777.29	1113.3	0.12
138430	High Flow	2100	4265.99	4274.03		0.09	0.000275	0.76	2760.53	601.6	0.06
138430	Average	577	4265.99	4272.13			0.000083	0.34	1712.17	514.03	0.03
138430	Low	167	4265.99	4270.95			0.00002	0.14	1159.33	431.56	0.02
136899	2-Yr	4773	4269.32	4274.61	999.66	0.83	0.001885	2.36	2408.19	937.25	0.2
136899	10-Yr	24000	4269.32	4280.18	11578.02	249.32	0.00132	3.39	9022.03	1519.91	0.19
136899	5-Yr	13700	4269.32	4277.67	5813.62	56.34	0.001427	2.91	5739.39	1185.59	0.19
136899	High Flow	2100	4269.32	4273.11	201.9		0.001861	1.79	1257.21	595.87	0.18
136899	Average	577	4269.32	4271.82	30.72		0.000936	0.9	657.23	394.92	0.12
136899	Low	167	4269.32	4270.86	3.6		0.000734	0.55	306.42	313.48	0.1
134764	2-Yr	4773	4265	4270.24	14.51	125.51	0.002238	2.78	1800.27	450.77	0.22
134764	10-Yr	24000	4265	4276.47	3192.37	2677.14	0.002321	4.85	7106.16	1844.93	0.26
134764	5-Yr	13700	4265	4274.06	645.36	1758.32	0.002014	3.85	4218.94	832.83	0.23
134764	High Flow	2100	4265	4268.03		16.51	0.003138	2.24	949.14	356	0.24
134764	Average	577	4265	4265.73			0.038338	2.96	195.14	299.12	0.65
134764	Low	167	4265	4265.27			0.146087	2.73	61.18	288.38	1.04
132413	2-Yr	4773	4260	4268.06	86.29	156.19	0.00053	1.59	3145.89	650.62	0.11
132413	10-Yr	24000	4260	4272.73	3843.09	2715.72	0.001259	3.53	8990.92	2112.4	0.19
132413	5-Yr	13700	4260	4270.85	1117.07	891.94	0.001054	2.86	5732.51	1343.38	0.17
132413	High Flow	2100	4260	4266.07	2.63	8.11	0.000391	1.06	1992.43	509.99	0.09
132413	Average	577	4260	4263.56			0.000284	0.63	915.22	359.2	0.07
132413	Low	167	4260	4262.16			0.000166	0.36	465.27	284.31	0.05
130180	2-Yr	4773	4260	4266.07	46.23	1328.63	0.001716	2.34	2148.73	1030.34	0.19
130180	10-Yr	24000	4260	4270.37	2239.23	14647.1	0.000877	2.58	8400.3	2323.42	0.15
130180	5-Yr	13700	4260	4268.95	988.25	7882.45	0.000715	2.08	5742.68	1454.81	0.13
130180	High Flow	2100	4260	4264			0.003686	2.53	831.55	277.8	0.26
130180	Average	577	4260	4261.52			0.014013	2.53	228.49	208.26	0.43
130180	Low	167	4260	4260.63			0.112171	3.1	53.87	171.99	0.98
128680	2-Yr	4773	4252.56	4264.15		9.53	0.001024	1.69	2847.36	734.89	0.14
128680	10-Yr	20000	4252.56	4269.03	659.35	1445.45	0.001107	2.78	7358.11	988.37	0.17
128680	5-Yr	13700	4252.56	4267.8	308.23	804.68	0.000915	2.28	6147.27	968.85	0.15
128680	High Flow	2100	4252.56	4261.69			0.000863	1.4	1501.32	404.52	0.13
128680	Average	577	4252.56	4259.06			0.000616	0.89	646.95	266.81	0.1
128680	Low	167	4252.56	4257.19			0.00015	0.51	327.06	107.56	0.05
128515		Bridge									
128497	2-Yr	4773	4254.16	4263.12			0.001567	1.81	2630.93	687	0.16
128497	10-Yr	20000	4254.16	4268.11	1748.88	5.74	0.001407	2.92	6878.12	971.27	0.18
128497	5-Yr	13700	4254.16	4266.79	608.63	0	0.001275	2.48	5607.86	949.54	0.16
128497	High Flow	2100	4254.16	4260.92			0.001124	1.45	1445.09	409.48	0.14
128497	Average	577	4254.16	4258.67			0.000577	0.83	695.21	277.6	0.09
128497	Low	167	4254.16	4257.12			0.000249	0.47	353.26	175.28	0.06
128491	2-Yr	4773	4255	4263.11			0.001579	1.8	2656.76	711.75	0.16
128491	10-Yr	20000	4255	4268.11	1858.42	67.19	0.001329	2.87	7008.22	1029.23	0.17
128491	5-Yr	13700	4255	4266.78	738.59	10.3	0.001193	2.43	5713.56	952.77	0.16
128491	High Flow	2100	4255	4260.87			0.005875	1.94	1083	693.79	0.27
128491	Average	577	4255	4258.56			0.007934	2.43	237.93	136.43	0.32
128491	Low	167	4255	4257.02			0.013357	2.19	76.38	75.61	0.38
128482	2-Yr	4773	4253.53	4263.1			0.001301	1.7	2814.49	707.52	0.15
128482	10-Yr	20000	4253.53	4268.11	82.64	179.64	0.001381	2.64	7570.84	1061.41	0.17
128482	5-Yr	13700	4253.53	4266.78	27.05	60.89	0.00127	2.22	6178.06	1044.99	0.16
128482	High Flow	2100	4253.53	4260.87			0.000798	1.33	1579.87	396.34	0.12
128482	Average	577	4253.53	4258.59			0.000475	0.75	773.22	313.34	0.08
128482	Low	167	4253.53	4257.05			0.000166	0.41	407.48	184.33	0.05
128432		Bridge									
128228	2-Yr	4773	4253.2	4262.57			0.00108	1.78	2675.73	539.29	0.14
128228	10-Yr	20000	4253.2	4267.38	230.42	1151.53	0.001739	3.02	6725.9	2501	0.19
128228	5-Yr	13700	4253.2	4266.08	37.63	290.9	0.001629	2.61	5346.88	1822.15	0.18
128228	High Flow	2100	4253.2	4260.56			0.000829	1.28	1643.18	447.62	0.12
128228	Average	577	4253.2	4258.4			0.000473	0.74	778.25	314.71	0.08
128228	Low	167	4253.2	4257			0.000117	0.37	452.08	181.42	0.04

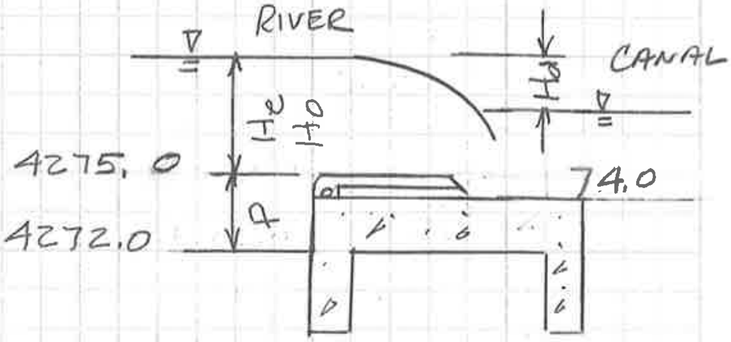
River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Q Left (cfs)	Q Right (cfs)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
126184	2-Yr	4773	4255	4260.75	105.21	70.33	0.000754	1.49	3263.56	852.69	0.12
126184	10-Yr	20000	4255	4264.08	1375.27	3088.04	0.001523	2.99	7237.13	1862.96	0.18
126184	5-Yr	13700	4255	4263.29	487.46	1675.01	0.001176	2.46	5919.38	1466.78	0.16
126184	High Flow	2100	4255	4259.17	3.29	3.65	0.000572	1	2104.83	658.88	0.1
126184	Average	577	4255	4257.63		0.07	0.000311	0.51	1134.63	597.93	0.07
126184	Low	167	4255	4256.69			0.0002	0.28	596.58	552.51	0.05

LAMP RYNEARSON
& ASSOCIATES

Client UP&B Job # 617
Project FEASIBILITY STUDY Calculations for
Made by JDA Date 6-24-16 Checked by Date Sheet 1 of 2

CAPACITY OF NEW GATES UP&B & D&S
ASSUME BOTH GATES SILL = 4275.0

1. HIGH FLOW CONDITION



River W.S. = 4280.51
CANAL W.S. = 4277.05
CREST = 4275.0

$H_c = 5.51$

$H_d = 3.44$

$H_d / H_c = 0.62$

C_s / C_o (FIG. 9-28 Small Dams) = 0.98

$P / H_o = 3 / 5.51 = 0.54$

$C_o = 3.80$ (Fig 9-23 Small dams)

$C_s = 3.8 (.98) = 3.72$

D&S $Q = 3.72 (10) (5.51)^{3/2} = 481$ CFS
POSITION FOR 136 CFS = 2.37' 80.51-2.37= 37%
UP&B $Q = 3.72 (15) (5.51)^{3/2} = 721$ CFS O.K.
POSITION FOR 468 CFS = 4.1' 80.51-4.1 = 76.4 72%

2. AVERAGE FLOW CONDITION

RIVER W.S. = 4278.17
CANAL W.S. = 4276.22
$H_e = 3.17$
$H_d = 1.95$
$H_d/H_e = 0.62$

$C_s/C_o = 0.98$

$P/H_o = 3/3.17 = 0.95$

$C_o = 3.88$ $C_s = 3.88(.98) = 3.8$
D&S $Q = 3.80 (10) (3.17)^{1.5} = 215$ CFS Pos = 1.5 = 66%
UP&B $Q = 3.80 (15) (3.17) = 321$ CFS
POSITION FOR 270 CFS = 2.82 78.17-2.82 = 75.35 93%

LAMP RYNEARSON
& ASSOCIATES

Client UP&B **Job #** 617
Project FEASIBILITY STUDY **Calculations for** ______
Made by JDA **Date** 6-24-16 **Checked by** ______ **Date** ______ **Sheet** 2 **of** 2

3. LOW FLOW CONDITION

RIVER W.S. = 4276.72
CANAL W.S = 4275.24
H_c = 1.72
H_d = 1.48

$H_d / H_c = 0.86$ ∴ NO SUBMERGENCE

$P = 3.6$

$P/H_o = 3.6/1.12 = 3.21$

$C = 3.95$
D&S Q = $3.95(10)(1.72)^{3/2}$ = 89 CFS POS = .42 74%
UPB Q = $3.95(15)(1.72)^{3/2}$ = 134 CFS O.K.

POSITION FOR 97 CFS = 1.39′ 76.72 - 1.39 = 75.53 93%

Project LP#B Project No.
Reference Designed By JOA Date 6-10-16
Reviewed By 1/2

LENGTH OF HYDRAULIC JUMP

NEW DAM ALT. NO. 2
GATES CLOSED

		Q_2	Q_5	Q_{10}	
DISCHARGE (Q)	CFS	4773	13700	24000	
q	CFS/FT	6.70	19.2'	33.7'	
WSE_{US}	FT	4281.11	4282.27	4283.31	
WSE_{DS}	FT	4276.03	4279.31	4281.90	
H	FT	5.1	3.0	1.4	
V_1	FT/S	18.1	13.9	9.5	
D_1	FT	0.37	1.38	3.54	
F_1		5.2	2.1	0.9	
D_2	FT	2.5'	3.5	N/A	$F<1$
⇨ L	FT	15'	15.4'	N/A	$F<1$

$q = Q / \text{LENGTH WEIR} = Q/712'$

$H = WSE_{US} - WSE_{DS}$

$V_1 = \sqrt{2gH}$

$D_1 = q/V_1$

$F_1 = \dfrac{V_1}{\sqrt{gD_1}}$

$$D_2 = D_1\left[\frac{\left(\sqrt{1+8F_1^2}-1\right)}{2}\right]$$

L: FROM FIG. 7 USBR E.M. 25

TOTAL LENGTH OF CONC. APRON = 30' O.K.

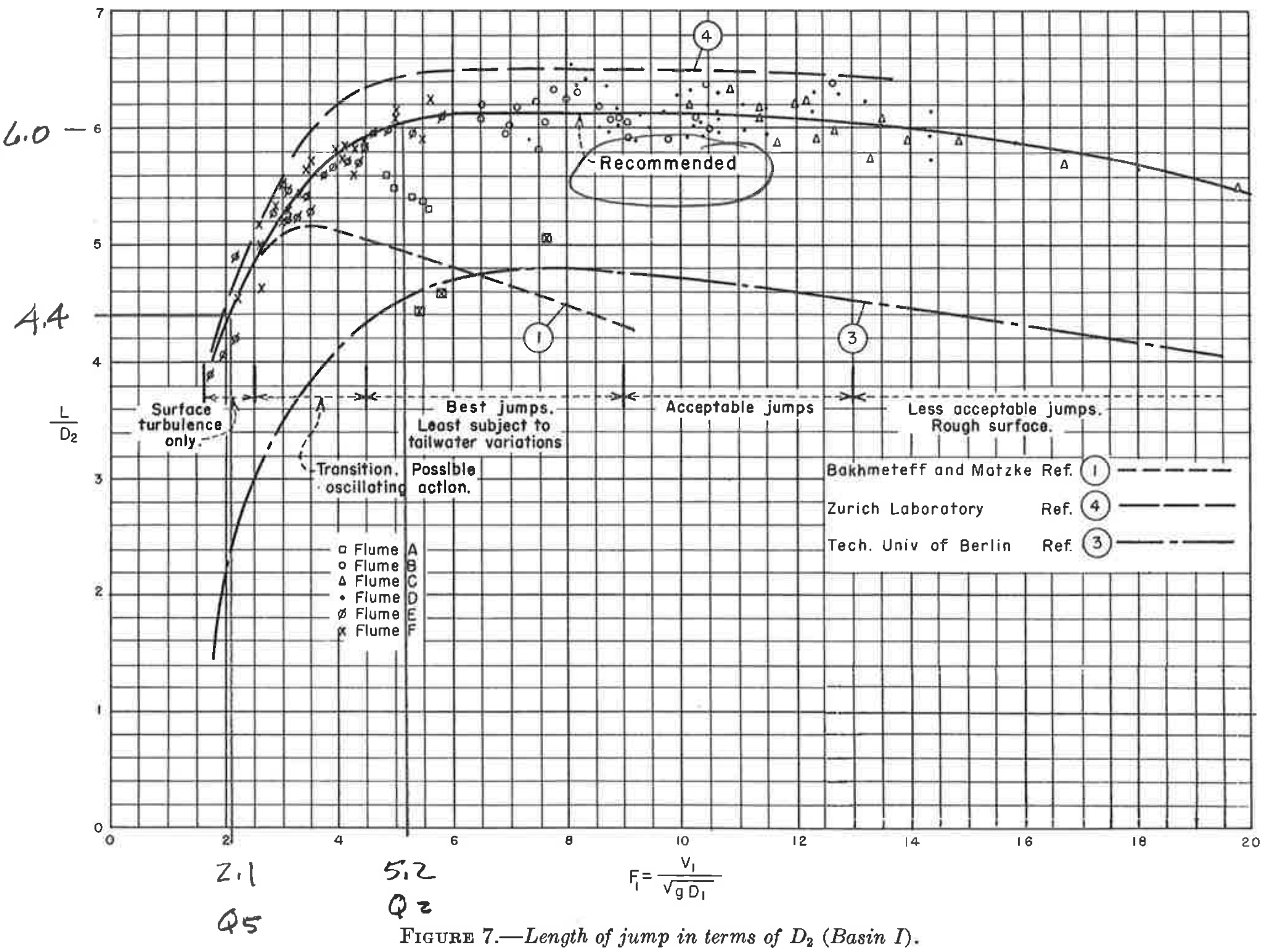


FIGURE 7.—*Length of jump in terms of D_2 (Basin I).*

the Federal Institute of Technology, Zurich, Switzerland, on a flume 0.6 of a meter wide and 7 meters long. The curve numbers are the same as the reference numbers in the "Bibliography" which refer to the work.

As can be observed from Figure 7, the test results from Flumes B, C, D, E, and F plot sufficiently well to establish a single curve. The five points from Flume A, denoted by squares, appear somewhat erratic and plot to the right of the general curve. Henceforth, reference to Figure 7 will concern only the recommended curve, which is considered applicable for general use.

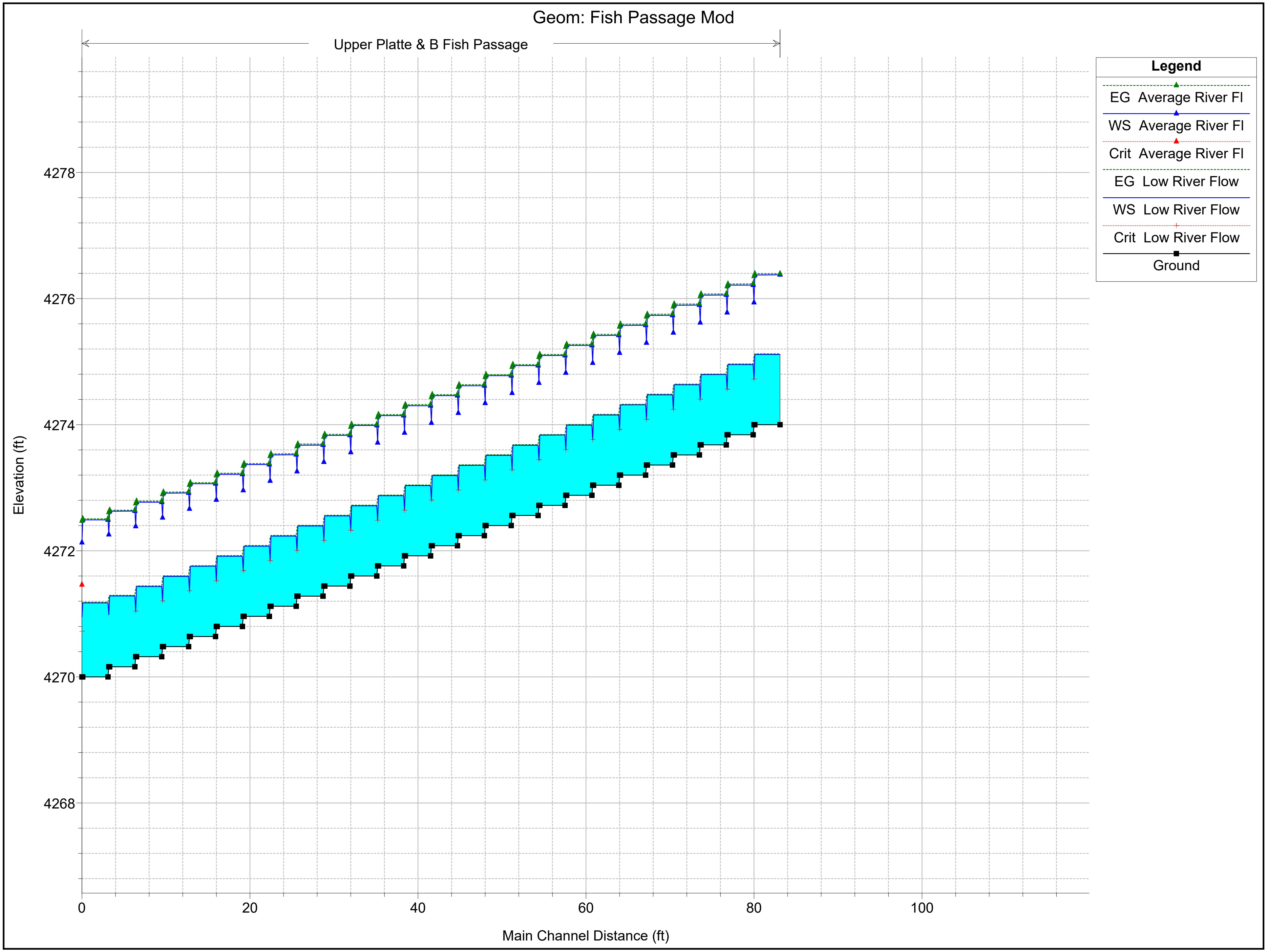
Energy Absorption in Jump

With the experimental information available, the energy absorbed in the jump may be computed. Columns 14 through 18, Table 1, list the computations, and the symbols may be defined by consulting the specific energy diagram in Figure 4. Column 14 lists the total energy, E_1, entering the jump at Section 1 for each test. This is simply the depth of flow, D_1, plus the velocity head computed at the point of measurement. The energy leaving the jump, which is the depth of flow plus the velocity head at Section 2, is tabulated in Column 15. The differences in the values of Columns 14 and 15 constitute the loss of energy, in feet of water, attributed to the conversion, Column 16. Column 18 lists the percentage of energy lost in the jump, E_L, to the total energy entering the jump, E_1. This percentage is plotted with respect to the Froude number and is shown as the curve to the left on Figure 8. For a Froude number of 2.0, which would correspond to a relatively thick jet entering the jump at low velocity, the curve shows the

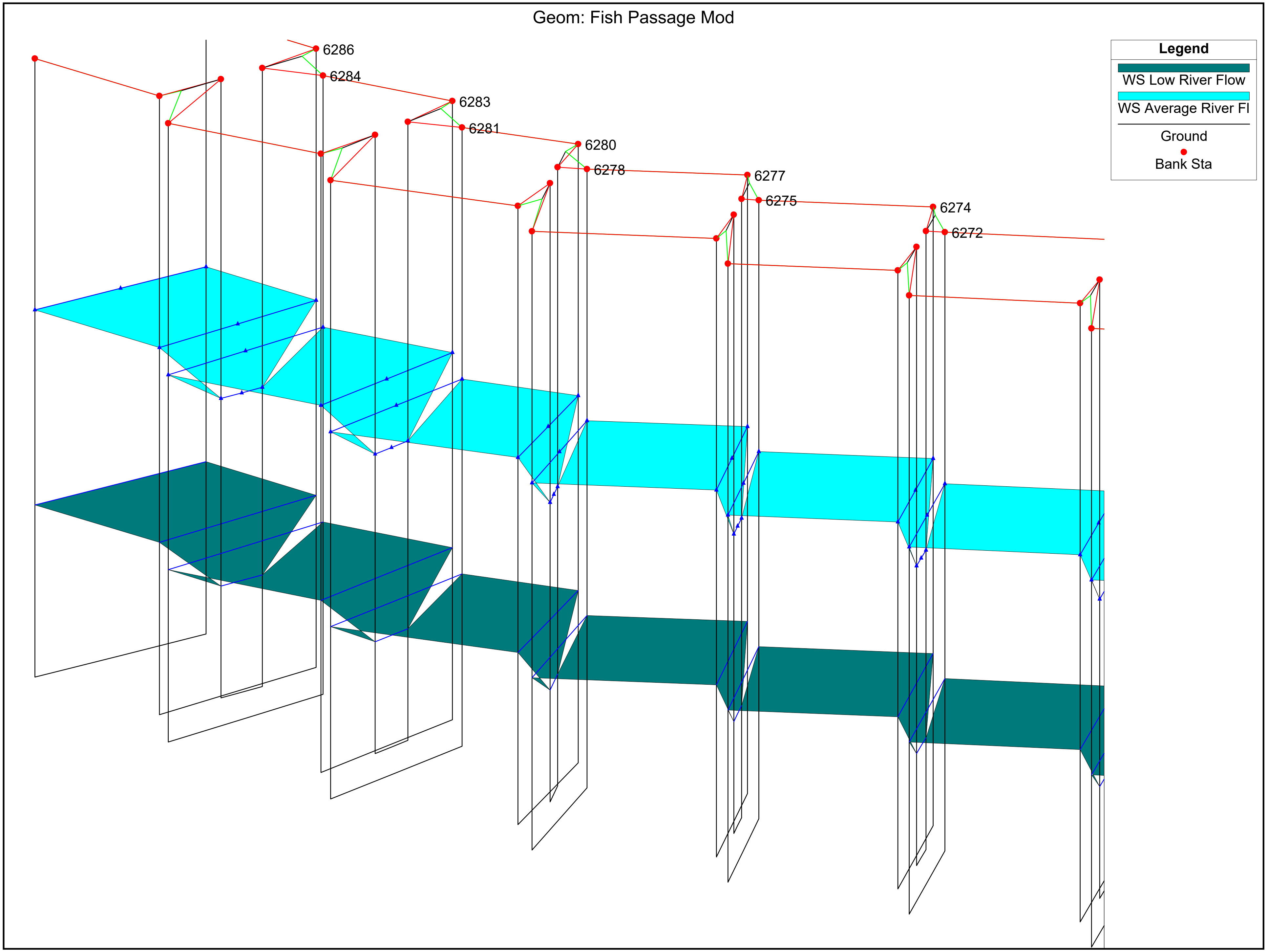
Profile Output Table - Standard Table 1
HEC-RAS Plan: Plan 06   River: Upper Platte & B   Reach: Fish Passage
Low Flow and Average Conditions
Rivers = 1
Hydraulic Reaches = 1
River Stations = 78
Plans = 1
Profiles = 2

Tuncated to list top 10 steps

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Fish Passage	6287	Low River Flow	3.5	4274	4275.11		4275.12	0.000175	0.79	4.46	4	0.13
Fish Passage	6287	Average River F	10	4274	4276.37		4276.39	0.00018	1.05	9.5	4	0.12
Fish Passage	6286	Low River Flow	3.5	4274	4275.11		4275.12	0.000175	0.79	4.45	4	0.13
Fish Passage	6286	Average River F	10	4274	4276.37		4276.39	0.00018	1.05	9.49	4	0.12
Fish Passage	6285	Low River Flow	3.5	4274	4274.72	4274.72	4275.09	0.021588	4.84	0.72	1	1
Fish Passage	6285	Average River F	10	4274	4275.94		4276.35	0.016554	5.17	1.94	1	0.65
Fish Passage	6284	Low River Flow	3.5	4273.84	4274.95		4274.96	0.000175	0.79	4.46	4	0.13
Fish Passage	6284	Average River F	10	4273.84	4276.21		4276.23	0.00018	1.05	9.5	4	0.12
Fish Passage	6283	Low River Flow	3.5	4273.84	4274.95		4274.96	0.000175	0.79	4.45	4	0.13
Fish Passage	6283	Average River F	10	4273.84	4276.21		4276.23	0.00018	1.05	9.49	4	0.12
Fish Passage	6282	Low River Flow	3.5	4273.84	4274.56	4274.56	4274.93	0.021588	4.84	0.72	1	1
Fish Passage	6282	Average River F	10	4273.84	4275.78		4276.19	0.016535	5.16	1.94	1	0.65
Fish Passage	6281	Low River Flow	3.5	4273.68	4274.79		4274.8	0.000175	0.79	4.46	4	0.13
Fish Passage	6281	Average River F	10	4273.68	4276.05		4276.07	0.00018	1.05	9.5	4	0.12
Fish Passage	6280	Low River Flow	3.5	4273.68	4274.79		4274.8	0.000175	0.79	4.45	4	0.13
Fish Passage	6280	Average River F	10	4273.68	4276.05		4276.07	0.00018	1.05	9.49	4	0.12
Fish Passage	6279	Low River Flow	3.5	4273.68	4274.4	4274.4	4274.77	0.021588	4.84	0.72	1	1
Fish Passage	6279	Average River F	10	4273.68	4275.62		4276.03	0.016554	5.17	1.94	1	0.65
Fish Passage	6278	Low River Flow	3.5	4273.52	4274.63		4274.64	0.000175	0.79	4.46	4	0.13
Fish Passage	6278	Average River F	10	4273.52	4275.89		4275.91	0.00018	1.05	9.5	4	0.12



1 in Horiz. = 15 ft 1 in Vert. = 2 ft


Geom: Fish Passage Mod
6286
6284
6283
6281
6280
6278
6277
6275
6274
6272
Legend
WS Low River Flow
WS Average River Fl
Ground
Bank Sta

1/3

LAMP RYNEARSON
& ASSOCIATES
ENGINEERS | SURVEYORS | PLANNERS

Project LP&B Project No. 417
Reference Designed By VDA Date 3-31-16
Reviewed By

BRASSY MINNOW FISH LADDER

1. CRITERIA – CSU FISHWAY DESIGN RECOMMENDATIONS

$V = 1$ F/S MAX

$H_1 = 0.16'$ MAX (WEIR HEIGHT)

$H_2 = 0.66'$ MIN. (POOL DEPTH)

$L = 3'$ (POOL LENGTH)

W.S. NORMAL = 8.0 4280
W.S. MIN. = 5.13' 4277.13

$W = 4'$

$Q = 0.66' (4') (1 F/s) = 2.6$ CFS

2. USE SLOTTED FLUME STEPPED 0.16'

TRY 1' SLOT

$Q = 3.1 (L) H^{3/2}$ $L = 1$, $Q = 2.6$ CFS

$H = 0.89$

$H_a = 0.89$

$H_b = 0.89 - 0.16 = 0.73$

$H_b / H_a = 0.82$ REDUCTION FACTOR = 0.94

$C = 3.1 (0.94) = 2.9$

$H = (2.6 / 2.9 (1))^{0.667} = 0.92$ O.K. $V < 1$ F/S

LAMP RYNEARSON
& ASSOCIATES
ENGINEERS | SURVEYORS | PLANNERS

Project UP&B Project No. 417
Reference Designed By JDA Date 5-31-16
Reviewed By

CHECK RIVER CONDITIONS

3. MAX FLOW

H = 4280.5 - 4274
H = 6.5'

SOLVE FOR Q

$Q = 2.9 (1) (6.5)^{3/2}$

Q = 48 CFS

CHECK W/ HECRAS

RIVER = 2100 CFS DIV. = 604 CFS
H.W. = 4280.48

T.W. = 4274.03
D.S. BOUNDARY = 4274.03
TRIAL & ERROR

Q	W.S.	VEL.
50	4280.17	2.0
55	4280.45	2.1
60	4280.72	2.2
65	4280.99	2.3

Q = 55 CFS V = 2.10 F/S OK

4. LOW FLOW
H = 4275.11 - 4274.0
H = 1.11
$Q = 2.3 (1) (1.11)^{3/2}$

Q = 2.68 CFS

CHECK WITH HECRAS

H.W. = 4275.11 DIV. = 108 CFS
T.W. = 4270.95

D.S. BOUNDARY = 4271.0
TRIAL & ERROR

Q	W.S.	VEL.
3.0	4275.0	0.75
3.5	4275.11	0.79
4.0	4275.22	0.82
4.5	4275.31	0.86

HECRAS Q = 3.5 CFS V = 0.8 F/S OK

5. AVERAGE FLOW CONDITION: RIVER 577 CFS, DIV. 339 CFS

H = 4276.56 - 4274
H = 2.56'
$Q = 2.9 (1) (2.56)^{3/2}$

Q = 11.9 CFS

CHECK WITH HECRAS

H.W. = 4276.56
T.W. = 4272.13

Q	W.S.	VEL
10	4276.37	1.05
15	4277.33	1.13
20	4278.25	1.18
25	4278.74	1.32

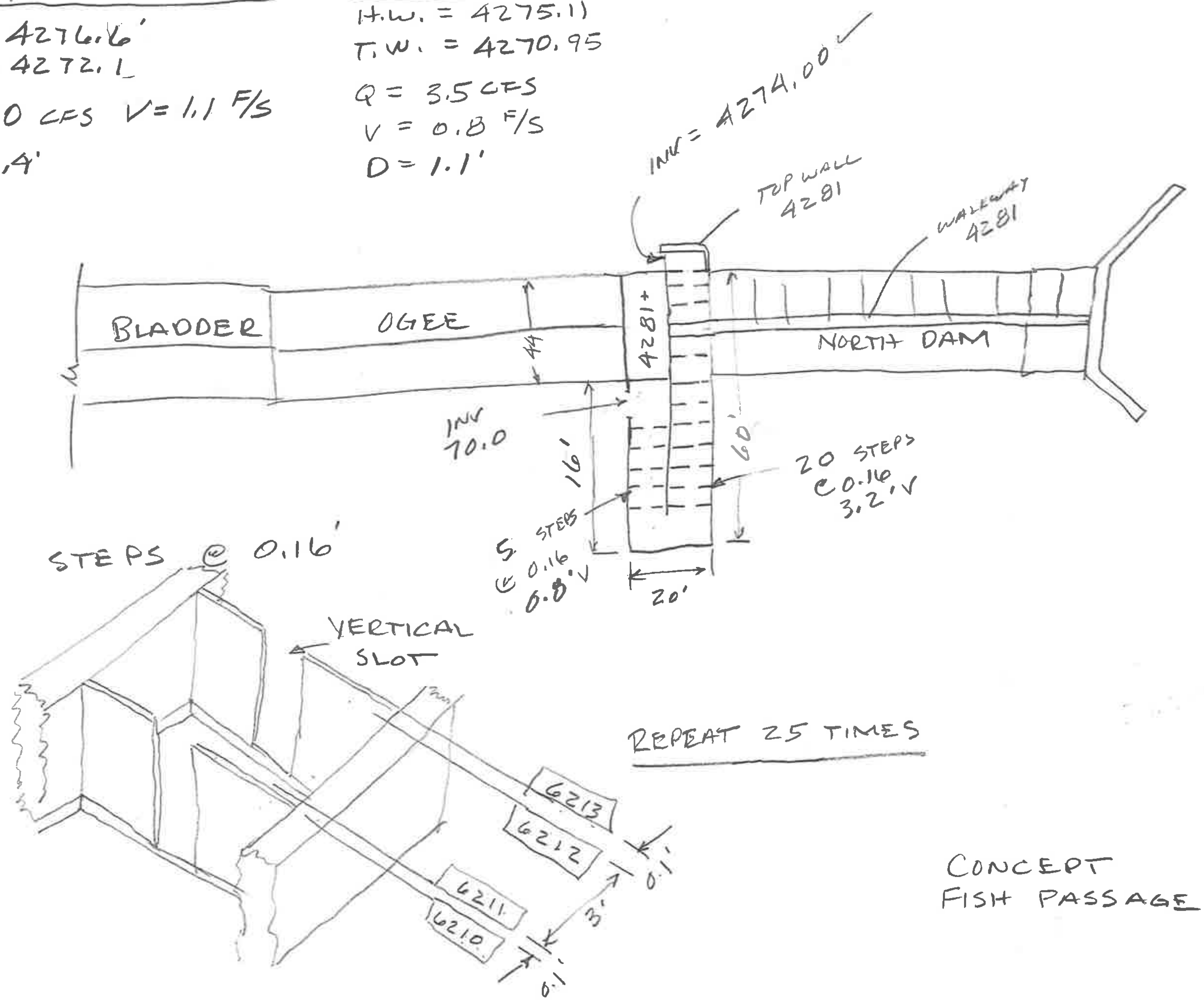
Q = 10 ± CFS V = 1.05 FPS

AVG FLOW CONDITION

H.W. = 4276.6'
T.W. = 4272.1
Q = 10 CFS V = 1.1 F/S
D = 2.4'

LOW FLOW CONDITION

H.W. = 4275.11
T.W. = 4270.95
Q = 3.5 CFS
V = 0.8 F/S
D = 1.1'



REPEAT 25 TIMES

CONCEPT
FISH PASSAGE

Appendix G Historic Data

State of Colorado

Structure Summary Report

HydroBase

Structure Name: **UPPER PLATTE BEAVER CNL** **Water District:** **1** **Structure ID Number:** **515**

Source: South Platte River

	Q10	Q40	Q160	Section	Twnshp	Range	PM
Location:	NW	NE	NE	35	4N	58W	S

Distance From Section Lines: From N/S Line: From E/W Line:

UTM Coordinates (NAD 83): Northing (UTM y): 4458899 Easting (UTM x): 599132 Spotted from PLSS distances from section lines

Latitude/Longitude (decimal degrees): 40.274699 -103.833983

Water Rights Summary: Total Decreed Rate(s) (CFS):	Absolute:	468.3400	Conditional:	234.1700	AP/EX:	37.0000
Total Decreed Volume(s) (AF):	Absolute:	0.0000	Conditional:	0.0000	AP/EX:	0.0000

Water Rights -- Transactions

Case Number	Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority Number	Decreed Amount	Adjudication Type	Uses	Action Comment
CA11195	1895-11-21	1868-04-20	6685.00000	0		15.0000 C	O,TT	1	TB-101 CPD 8/31/1948 PUBLIC SERVICE AUG W-063
CA11195	1895-11-21	1868-04-20	6685.00000	0		15.0000 C	O,TF	1	TB-101 CPD 8-31-1948
CA2283	1895-11-21	1868-04-20	6685.00000	0		15.0000 C	O,TT	1	TB-11 TFR 11-5-1909
CA11195	1883-04-28	1869-05-15	7075.00000	0		5.1700 C	O,TF	1	TB-101 CPD 8-31-1948
CA11195	1883-04-28	1869-05-15	7075.00000	0		5.1700 C	O,TT	1	TB-101 CPD 8/31/1948 PUBLIC SERVICE AUG W-063
CA47394	1883-04-28	1869-05-15	7075.00000	0		5.1700 C	O,TT	1	TB-101 TFR FM GETZ DITCH IN DIST 2 TB-27
CA0433	1895-11-21	1882-06-20	11859.00000	0		50.0000 C	O	1	506 ASP 468,433
CA11195	1895-11-21	1882-06-20	11859.00000	0		50.0000 C	O,TT	1	TB-101 CPD 8/31/1948 ASP 551 PUBLIC SERVICE AUG
CA11195	1895-11-21	1882-06-20	11859.00000	0		50.0000 C	O,TF	1	TB-101 CPD 8-31-1948 ASP 551
CA0433	1895-11-21	1888-04-15	13985.00000	0		164.0000 C	O	1	506
CA11195	1895-11-21	1888-04-15	13985.00000	0		164.0000 C	O,TF	1	TB-101 CPD 8-31-1948
CA11195	1895-11-21	1888-04-15	13985.00000	0		164.0000 C	O,TT	1	TB-101 CPD 8/31/1948 PUBLIC SERVICE AUG W-063
87CW0242	1972-12-31	1972-06-12	44723.00000	0		234.1700 C	S,CA	AR	MADE ABS 02/09/1989
W2968	1972-12-31	1972-06-12	44723.00000	0		234.1700 C	S,C	RA	REC + AUG LTD 12000AF
90CW0183	1990-12-31	1990-12-20	51488.00000	0		37.0000 C	O,EX	1	EXCH FM PREWITT RES
03CW0407	2003-12-31	2006-08-01	57191.00000	0		10.0000 C	O,C,EX	AR	EXCH FM PINNEO ABOVE NORTH STERLING CANAL
03CW0407	2003-12-31	2006-08-01	57191.00000	0		10.0000 C	O,C,EX	AR	EXCH FM PINNEO BELOW NORTH STERLING CANAL
10CW0298	2010-12-31	2010-12-14	58787.00000	0		234.1700 C	S,C	R	

Water Rights -- Net Amounts

Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority/Case Number	Rate (CFS)			Volume (Acre-Feet)		
					Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
1895-11-21	1868-04-20	6685.00000	0	CA11195	15.0000	0	0			
1883-04-28	1869-05-15	7075.00000	0	CA47394	5.1700	0	0			
1895-11-21	1882-06-20	11859.00000	0	CA11195	50.0000	0	0			
1895-11-21	1888-04-15	13985.00000	0	CA11195	164.0000	0	0			
1972-12-31	1972-06-12	44723.00000	0	87CW0242	234.1700	0	0			
1990-12-31	1990-12-20	51488.00000	0	90CW0183	0	0	37.0000			
2003-12-31	2006-08-01	57191.00000	0	03CW0407	0	0	20.0000			
2010-12-31	2010-12-14	58787.00000	0	10CW0298	0	234.1700	0			

Irrigated Acres Summary -- Totals From Various Sources

GIS Total (Acres):	10133.93	Reported:	2010
Diversion Comments Total (Acres):	14000	Reported:	1981
Structure Total (Acres):		Reported:	

Irrigated Acres From GIS Data

Year	Land Use	Acres Flood	Acres Furrow	Acres Sprinkler	Acres Drip	Acres Groundwater	Acres Total
1956	***Year Total***	10476.85	0	0	0	7894.76	10476.85
1956	ALFALFA	1814.46	0	0	0	1345.03	1814.46
1956	CORN	7312.49	0	0	0	5768.14	7312.49
1956	DRY_BEANS	254.90	0	0	0	205.34	254.90
1956	GRASS_PASTURE	751.25	0	0	0	334.60	751.25
1956	SMALL_GRAINS	192.30	0	0	0	135.68	192.30
1956	SUGAR_BEETS	151.45	0	0	0	105.98	151.45
1976	***Year Total***	9925.60	0	489.26	0	8630.80	10414.85
1976	ALFALFA	1665.19	0	25.90	0	1502.68	1691.10
1976	CORN	6995.53	0	154.60	0	6175.98	7150.13
1976	DRY_BEANS	258.16	0	187.83	0	304.30	445.98
1976	GRASS_PASTURE	592.59	0	84.83	0	308.52	677.42
1976	SMALL_GRAINS	230.38	0	0	0	149.42	230.38
1976	SUGAR_BEETS	183.75	0	36.09	0	189.90	219.85
1987	***Year Total***	9765.02	0	838.71	0	8675.76	10603.73
1987	ALFALFA	1479.08	0	235.36	0	1458.00	1714.45
1987	CORN	5572.01	0	420.01	0	5113.83	5992.02
1987	DRY_BEANS	1270.04	0	69.60	0	1243.34	1339.63
1987	GRASS_PASTURE	607.91	0	38.10	0	400.78	646.01
1987	SMALL_GRAINS	645.37	0	26.79	0	266.56	672.16
1987	SUGAR_BEETS	190.62	0	48.85	0	193.25	239.47
1997	***Year Total***	8899.54	0	1216.04	0	8720.03	10115.58
1997	ALFALFA	1893.34	0	614.44	0	1859.98	2507.78
1997	CORN	2363.03	0	307.83	0	2477.93	2670.86
1997	DRY_BEANS	148.86	0	0	0	148.86	148.86
1997	GRASS_PASTURE	402.24	0	0	0	214.43	402.24
1997	SMALL_GRAINS	530.66	0	0	0	390.32	530.66
1997	SUGAR_BEETS	3561.40	0	293.77	0	3628.51	3855.16
2001	***Year Total***	8361.88	0	1660.57	0	8691.83	10022.45
2001	ALFALFA	3174.39	0	1081.51	0	3519.41	4255.90
2001	CORN	3813.97	0	557.01	0	4045.99	4370.98
2001	DRY_BEANS	98.20	0	0	0	98.20	98.20
2001	GRASS_PASTURE	223.31	0	22.04	0	168.15	245.35
2001	SMALL_GRAINS	937.31	0	0	0	745.38	937.31
2001	SUGAR_BEETS	114.70	0	0	0	114.70	114.70
2005	***Year Total***	6522.54	0	3354.03	0	8074.60	9876.57
2005	ALFALFA	2671.06	0	1409.56	0	3320.06	4080.62
2005	CORN	2366.07	0	1670.32	0	3483.36	4036.39
2005	DRY_BEANS	21.05	0	0	0	0	21.05
2005	GRASS_PASTURE	471.90	0	0	0	318.67	471.90
2005	SMALL_GRAINS	868.63	0	116.00	0	733.55	984.63
2005	SUGAR_BEETS	123.83	0	158.15	0	218.95	281.98
2010	***Year Total***	4733.94	0	5399.99	0	8803.92	10133.93
2010	ALFALFA	1746.20	0	1773.58	0	2913.35	3519.78
2010	CORN	1390.77	0	2575.05	0	3750.01	3965.82
2010	GRASS_PASTURE	714.50	0	80.27	0	556.39	794.77
2010	SMALL_GRAINS	114.23	0	11.35	0	96.69	125.57
2010	SUGAR_BEETS	106.89	0	241.68	0	303.72	348.57
2010	WHEAT_FALL	661.36	0	718.06	0	1183.75	1379.42

Diversion Summary in Acre-Feet - Total Water Through Structure

Year	FDU	LDU	DWC	Maxq & Day	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total
1950	1950-04-11	1950-10-31	203	155 06-20	0	0	0	0	0	3019	5710	5358	6740	5705	5002	4820	36355
1951	1951-04-19	1951-10-08	162	180 08-17	0	0	0	0	0	1410	4503	5260	6263	5293	5052	1375	29155
1952	1952-04-29	1952-10-31	186	180 06-18	0	0	0	0	0	309	6163	7617	6772	5923	5062	4516	36362
1953	1953-05-07	1953-10-22	163	158 07-29	0	0	0	0	0	0	3578	4127	6329	5332	5032	3283	27681
1954	1954-04-14	1954-10-20	184	108 08-10	0	0	0	0	0	2503	4027	3954	3269	3301	2549	2737	22339
1955	1955-04-14	1955-10-23	186	95 04-28	0	0	0	0	0	2680	3126	3717	2471	2456	2640	1946	19036
1956	1956-04-16	1956-10-23	180	100 05-30	0	0	0	0	0	1555	1995	2747	2126	2636	2610	2479	16150
1957	1957-06-02	1957-10-07	118	170 06-09	0	0	0	0	0	0	0	5665	5467	5841	5667	1081	23721
1958	1958-05-04	1958-10-12	153	163 06-04	0	0	0	0	0	0	3820	4092	5601	6704	4923	1313	26454
1959	1959-05-13	1959-09-30	134	136 07-13	0	0	0	0	0	0	1178	4497	6298	5802	4348	0	22122
1960	1960-04-17	1960-10-17	181	127 07-28	0	0	0	0	0	1984	3828	5193	6081	3479	3245	1567	25377
1961	1961-05-01	1961-09-24	137	169 08-31	0	0	0	0	0	0	4429	4586	6375	5881	4862	0	26133
1962	1962-04-19	1962-10-10	139	170 04-24	0	0	0	0	0	2360	2446	1329	7016	6899	5038	1103	26190
1963	1963-04-08	1963-10-20	190	100 04-11	0	0	0	0	0	3721	3921	4319	3164	4304	3400	1781	24610
1964	1964-04-18	1964-10-23	186	100 04-30	0	0	0	0	0	1864	3414	4979	3019	2150	2075	2396	19896
1965	1965-04-08	1965-09-22	104	190 08-15	0	0	0	0	0	2936	3721	833	1759	3255	3804	0	16308
1966	1966-04-07	1966-10-14	168	84 08-11	0	0	0	0	0	639	3519	2257	2942	2559	3396	1793	17104
1967	1967-04-02	1967-10-14	159	159 07-28	0	0	0	0	0	3880	3126	0	5506	6605	4505	1478	25099
1968	1968-04-08	1968-10-15	190	175 08-13	0	0	0	0	0	3999	4259	4289	3836	5449	4856	2231	28918
1969	1969-04-11	1969-10-10	182	165 07-01	0	0	0	0	0	2777	5189	5576	7861	5244	2876	357	29879
1970	1970-05-30	1970-10-05	121	190 07-04	0	0	0	0	0	0	591	4947	9130	7224	4655	585	27132
1971	1971-05-15	1971-09-17	126	175 06-25	0	0	0	0	0	0	3376	6224	6310	5699	2821	0	24429
1972	1972-04-04	1972-10-15	193	122 07-29	0	0	0	0	0	3981	4209	5512	4429	4512	3235	1868	27747
1973	1973-05-15	1973-09-08	117	223 06-01	0	0	0	0	0	0	4009	8378	6349	8079	1468	0	28283
1974	1974-04-26	1974-10-15	173	180 06-23	0	0	0	0	0	740	6492	6250	6409	6008	4737	2142	32777
1975	1975-04-15	1975-10-19	177	234 07-20	0	0	0	0	0	2283	4558	4191	8422	7299	5052	2176	33981
1976	1976-04-09	1976-10-14	189	135 07-25	0	0	0	0	0	2598	4981	3808	5474	5703	3949	1250	27763
1977	1977-04-05	1977-10-10	188	110 08-03	0	0	0	0	0	2848	3418	4679	3487	5580	3878	1182	25071
1978	1978-04-06	1978-10-13	181	196 06-28	0	0	0	0	0	2908	2870	5457	6432	5877	4272	1297	29114
1979	1979-04-20	1979-10-29	190	148 08-09	0	0	0	0	0	1704	5365	4566	6514	6619	5290	3424	33481
1980	1980-04-25	1980-10-20	179	207 06-28	0	0	0	0	0	496	3495	8753	8581	8083	3961	2501	35870
1981	1981-04-17	1981-10-16	174	135 08-07	0	0	0	0	0	849	3705	3687	5209	5770	4820	1702	25742
1982	1982-04-05	1982-10-31	205	204 07-06	0	0	0	0	0	2817	4747	3396	7430	6728	5020	3378	33515
1983	1983-05-28	1983-10-12	138	212 07-08	0	0	0	0	0	0	444	3162	9309	8333	5167	1200	27614
1984	1984-05-16	1984-10-08	140	203 07-05	0	0	0	0	0	0	895	5397	8369	9194	4779	821	29455
1985	1985-04-12	1985-10-06	170	157 06-15	0	0	0	0	0	4074	4007	5952	4675	6042	4143	665	29559
1986	1986-05-01	1986-10-10	163	184 06-29	0	0	0	0	0	0	4195	5502	8128	6710	4187	1103	29826
1987	1987-05-01	1987-10-17	164	146 07-19	0	0	0	0	0	0	4337	4026	6994	6218	5234	2469	29279
1988	1987-11-01	1988-10-31	353	153 07-23	864	345	307	288	307	1279	2761	4389	6672	6583	4739	3586	32122
1989	1989-04-17	1989-10-26	184	119 08-23	0	0	0	0	0	2344	4650	3116	5808	5923	4647	3150	29638
1990	1990-04-06	1990-10-31	203	130 08-28	0	0	0	0	0	3172	5310	4203	6149	5042	3804	3193	30873
1991	1991-04-04	1991-10-28	208	142 06-24	0	0	0	0	0	3983	6191	6934	6415	7305	5203	2953	38983
1992	1992-03-04	1992-10-31	242	165 07-04	0	0	0	0	1000	3475	5199	6115	7898	7988	5225	4066	40965
1993	1992-11-01	1993-10-29	208	161	2418	0	0	0	0	383	5800	6153	6772	6526	5254	1816	35121
1994	1994-03-07	1994-10-31	231	134 07-09	0	0	0	0	694	1316	6343	6254	6218	5735	4420	1932	32913
1995	1994-11-01	1995-10-31	211	206 07-15	24	0	0	0	0	2529	2579	4293	9080	10485	5280	1938	36209
1996	1995-11-01	1996-10-29	272	198 07-02	1085	455	0	0	0	3346	5096	6702	7551	7510	5109	3156	40010
1997	1997-03-27	1997-10-31	219	214	0	0	0	0	222	5772	8531	4445	8392	8144	5885	3056	44447
1998	1997-11-01	1998-10-16	233	156 06-28	478	224	0	159	764	936	4721	5357	6302	8402	4750	740	32832
1999	1998-11-01	1999-10-31	255	197	1753	20	0	0	809	1621	3213	6506	9023	5897	4592	2103	35536
2000	1999-11-01	2000-10-25	238	122 06-28	920	0	0	0	165	3191	4665	5423	4947	6099	2285	1672	29368
2001	2001-01-30	2001-10-31	252	153 05-25	0	0	30	1202	778	825	4372	3992	5465	6522	4374	2017	29576
2002	2001-11-01	2002-10-29	235	270 05-27	1087	0	0	0	0	2590	11282	4933	3076	1396	3324	3814	31504

2003	2003-04-17	2003-10-31	186	161	05-01	0	0	0	0	0	2071	6591	2775	7740	6159	4812	4220	34369
2004	2004-04-13	2004-10-31	200	186	07-28	0	0	0	0	0	4038	6629	4419	6478	5864	6537	3973	37938
2005	2005-03-29	2005-10-25	211	189		0	0	0	0	335	4236	7909	8256	6106	5398	4924	3306	40471
2006	2006-01-05	2006-10-31	234	179		0	0	2130	0	1821	3995	4335	4443	5533	5413	4568	4620	36859
2007	2007-01-24	2007-10-31	223	205		0	0	318	0	2075	5431	8752	8488	5450	5955	6085	5475	48027
2008	2007-11-01	2008-10-31	324	161	08-19	176	2069	4545	3959	2653	4903	6366	3640	5361	5854	4686	6303	50514
2009	2008-11-21	2009-10-31	318	183		235	902	203	45	6185	5402	8977	4293	3435	7773	4037	2202	43690
2010	2010-01-30	2010-10-31	267	223		0	0	51	2952	3288	5498	4326	4303	10058	7794	5706	2911	46888
2011	2011-02-22	2011-10-26	246	257	03-12	0	0	0	834	4900	7168	5773	7658	7193	9588	4883	2335	50332
2012	2012-02-13	2012-10-31	262	168		0	0	0	2103	4252	6753	7483	5913	6062	4724	4335	2774	44399
2013	2012-11-01	2013-10-28	257	198	05-16	28	0	0	75	91	1600	7542	8245	5874	4820	5949	4033	38257
2014	2014-02-13	2014-10-31	252	190	07-13	0	0	0	1630	4976	4486	7768	4496	7843	5560	3426	2346	42530
			Minimum:	84		0	0	0	0	0	0	0	0	1759	1396	1468	0	16150
			Maximum:	270		2418	2069	4545	3959	6185	7168	11282	8753	10058	10485	6537	6303	50514
			Average:	167		140	62	117	204	543	2358	4628	4923	6115	5984	4407	2272	31752

65.00 years with diversion records

Notes: The average considers all years with diversion records, even if no water is diverted.
The above summary lists total monthly diversions.
* = Infrequent Diversion Record. All other values are derived from daily records.
Average values include infrequent data if infrequent data are the only data for the year.

Diversion Comments

IYR	NUC Code	Acres Irrigated	Comment
1950		14000	
1951		14000	
1952		14000	
1953		13608	
1954		14000	
1955		13608	
1956		13608	
1957		13608	
1958		13608	
1959		13608	
1960		13608	
1961		13608	
1962		13608	
1963		13608	
1964		13608	
1965		13608	
1966		13608	
1967		13608	
1971		17000	
1972		17000	
1973		13608	
1975		13608	
1976		13608	
1977		13608	
1980		13608	
1981		14000	
2007			S:1,F:0102900,U:A,T:6,G:0102529(RIVERSIDE IRR DIST SHARES)

Note: Diversion comments and reservoir comments may be shown for a structure, if both are available.

State of Colorado

Structure Summary Report

HydroBase

Structure Name: **DEUEL SNYDER CANAL** **Water District: 1** **Structure ID Number: 517**

Source: South Platte River

Location:	Q10	Q40	Q160	Section	Twnshp	Range	PM
		SW	SE	26	4N	58W	S

Distance From Section Lines:	From N/S Line:		From E/W Line:		
UTM Coordinates (NAD 83):	Northing (UTM y): 4459224		Easting (UTM x): 598953		Spotted from PLSS distances from section lines
Latitude/Longitude (decimal degrees):		40.277648		-103.836038	

Water Rights Summary:							
Total Decreed Rate(s) (CFS):	Absolute:	136.4000	Conditional:	31.6000	AP/EX:	12.0000	
Total Decreed Volume(s) (AF):	Absolute:	0.0000	Conditional:	0.0000	AP/EX:	0.0000	

Water Rights -- Transactions

Case Number	Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority Number	Decreed Amount	Adjudication Type	Uses	Action Comment
03CW0222	1895-11-21	1871-04-02	7762.00000	0		13.0000 C	O,TF	1	CHNG USE 5/10/2007
03CW0222	1895-11-21	1871-04-02	7762.00000	0		13.0000 C	O,TT	1AR	CHNG USE 5/10/2007
CA0433	1895-11-21	1871-04-02	7762.00000	0		13.0000 C	O	1	417 MEADOW 4-10 TO 7-10 ASP 495,552
03CW0222	1895-11-21	1874-07-01	8948.00000	0		8.0000 C	O,TF	1	CHNG USE 5/10/2007
03CW0222	1895-11-21	1874-07-01	8948.00000	0		8.0000 C	O,TT	1AR	CHNG USE 5/10/2007
CA7747	1895-11-21	1874-07-01	8948.00000	0		8.0000 C	O,TT	1	TB-81 CPD FM BROWN PYOTT DITCH 6-22-1929
03CW0222	1895-11-21	1884-04-07	12516.00000	0		30.5142 C	O,TF	1	CHNG USE 5/10/2007
03CW0222	1895-11-21	1884-04-07	12516.00000	0		30.5142 C	O,TT	1AR	CHNG USE 5/10/2007
CA0433	1895-11-21	1884-04-07	12516.00000	0		32.0000 C	O	1	417 ASP 495,552
03CW0222	1895-11-21	1888-11-01	14185.00000	0		29.5607 C	O,TF	1	CHNG USE 5/10/2007
03CW0222	1895-11-21	1888-11-01	14185.00000	0		29.5607 C	O,TT	1AR	CHNG USE 5/10/2007
CA7747	1895-11-21	1888-11-01	14185.00000	0		31.0000 C	O,TT	1	TB-81 CPD FM BROWN PYOTT DITCH 6-22-1929
90CW0183	1990-12-31	1990-12-20	51488.00000	0		12.0000 C	O,EX	1	EXCH FM PREWITT RES
03CW0222	2003-12-31	2003-04-23	55995.00000	0		68.0000 C	S,C	AR	
13CW3051	2003-12-31	2003-04-23	55995.00000	0		52.4000 C	S,CA	AR	MADE ABSOLUTE
07CW0122	2007-12-31	2007-05-31	57494.00000	0		16.0000 C	S,C	179AR	
07CW0122	2007-12-31	2007-05-31	57494.00000	0		84.0000 C	O,C,EX	179AR	EXCH FM DEUEL & SNYDER IMPACT REACH
04CW0223	2004-12-31	2008-10-22	58004.00000	0		84.0000 C	O,C,EX	1AR	EXCH FM DEUEL & SNYDER IMPACT REACH EXCESS

Water Rights -- Net Amounts

Adjudication Date	Appropriation Date	Administration Number	Order Number	Priority/Case Number	Rate (CFS)			Volume (Acre-Feet)		
					Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
1895-11-21	1871-04-02	7762.00000	0	03CW0222	13.0000	0	0			
1895-11-21	1874-07-01	8948.00000	0	03CW0222	8.0000	0	0			
1895-11-21	1884-04-07	12516.00000	0	03CW0222	32.0000	0	0			
1895-11-21	1888-11-01	14185.00000	0	03CW0222	31.0000	0	0			
1990-12-31	1990-12-20	51488.00000	0	90CW0183	0	0	12.0000			
2003-12-31	2003-04-23	55995.00000	0	13CW3051	52.4000	15.6000	0			
2007-12-31	2007-05-31	57494.00000	0	07CW0122	0	16.0000	84.0000			
2004-12-31	2008-10-22	58004.00000	0	04CW0223	0	0	84.0000			

Irrigated Acres Summary -- Totals From Various Sources

GIS Total (Acres):	1439.141	Reported: 2010
Diversion Comments Total (Acres):	2600	Reported: 1981
Structure Total (Acres):		Reported:

Irrigated Acres From GIS Data

Year	Land Use	Acres Flood	Acres Furrow	Acres Sprinkler	Acres Drip	Acres Groundwater	Acres Total
1956	***Year Total***	1535.30	0	0	0	1268.59	1535.30
1956	ALFALFA	281.00	0	0	0	214.02	281.00
1956	CORN	1062.51	0	0	0	887.93	1062.51
1956	DRY_BEANS	117.25	0	0	0	103.71	117.25
1956	GRASS_PASTURE	45.90	0	0	0	34.29	45.90
1956	SUGAR_BEETS	28.64	0	0	0	28.64	28.64
1976	***Year Total***	1559.63	0	118.30	0	1606.88	1677.93
1976	ALFALFA	298.47	0	58.92	0	314.83	357.39
1976	CORN	1095.18	0	33.57	0	1111.86	1128.74
1976	DRY_BEANS	117.25	0	0	0	117.25	117.25
1976	GRASS_PASTURE	20.09	0	25.81	0	34.29	45.90
1976	SUGAR_BEETS	28.64	0	0	0	28.64	28.64
1987	***Year Total***	1157.16	0	414.98	0	1442.92	1572.14
1987	ALFALFA	128.84	0	147.91	0	276.74	276.74
1987	CORN	646.64	0	238.12	0	787.42	884.76
1987	DRY_BEANS	122.22	0	0	0	122.22	122.22
1987	GRASS_PASTURE	51.00	0	28.95	0	71.28	79.95
1987	SMALL_GRAINS	150.61	0	0	0	127.40	150.61
1987	SUGAR_BEETS	57.85	0	0	0	57.85	57.85
1997	***Year Total***	1000.06	0	616.35	0	1500.92	1616.41
1997	ALFALFA	212.48	0	255.12	0	405.55	467.61
1997	CORN	259.49	0	325.26	0	584.75	584.75
1997	DRY_BEANS	20.43	0	0	0	20.43	20.43
1997	GRASS_PASTURE	6.70	0	0	0	6.70	6.70
1997	SMALL_GRAINS	130.82	0	0	0	112.12	130.82
1997	SUGAR_BEETS	370.14	0	35.97	0	371.38	406.11
2001	***Year Total***	935.14	0	675.04	0	1491.48	1610.19
2001	ALFALFA	213.73	0	90.85	0	283.85	304.58
2001	CORN	635.11	0	529.01	0	1066.13	1164.11
2001	DRY_BEANS	33.87	0	0	0	33.87	33.87
2001	GRASS_PASTURE	25.22	0	0	0	25.22	25.22
2001	SMALL_GRAINS	27.21	0	55.19	0	82.40	82.40
2005	***Year Total***	760.98	0	782.30	0	1348.88	1543.28
2005	ALFALFA	267.56	0	218.97	0	457.02	486.53
2005	CORN	337.46	0	461.41	0	680.70	798.87
2005	DRY_BEANS	87.02	0	0	0	87.02	87.02
2005	GRASS_PASTURE	25.22	0	55.19	0	80.41	80.41
2005	SMALL_GRAINS	43.72	0	0	0	43.72	43.72
2005	SUGAR_BEETS	0	0	46.73	0	0	46.73
2010	***Year Total***	582.77	0	856.37	0	1405.35	1439.14
2010	ALFALFA	168.95	0	325.68	0	488.08	494.62
2010	CORN	275.41	0	386.95	0	639.15	662.36
2010	GRASS_PASTURE	52.87	0	14.71	0	63.54	67.58
2010	SMALL_GRAINS	38.39	0	0	0	38.39	38.39
2010	SUGAR_BEETS	0	0	44.10	0	44.10	44.10
2010	WHEAT_FALL	47.15	0	84.93	0	132.09	132.09

Diversion Summary in Acre-Feet - Total Water Through Structure

Year	FDU	LDU	DWC	Maxq & Day	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Total
1950	1950-05-01	1950-10-06	128	33 07-08	0	0	0	0	0	0	1045	1313	746	300	883	190	4477
1951	1951-04-24	1951-10-08	157	45 07-01	0	0	0	0	0	179	1309	1353	742	1081	1351	220	6234
1952	1952-04-23	1952-10-31	163	46 06-30	0	0	0	0	0	298	1162	1636	797	337	290	615	5135
1953	1953-05-06	1953-10-22	153	34 08-04	0	0	0	0	0	0	956	1182	817	695	595	298	4543
1954	1954-04-23	1954-10-23	128	25 05-23	0	0	0	0	0	246	865	946	428	175	87	276	3023
1955	1955-06-01	1955-10-23	67	24 08-14	0	0	0	0	0	0	0	468	442	244	0	446	1601
1956	1956-04-12	1956-09-16	114	32 04-16	0	0	0	0	0	875	1335	1097	375	127	77	0	3886
1957	1957-05-28	1957-10-08	130	50 07-02	0	0	0	0	0	0	198	1831	2148	1559	778	216	6730
1958	1958-05-27	1958-09-30	74	50 06-08	0	0	0	0	0	0	169	926	436	438	129	0	2099
1959	1959-05-12	1959-09-30	102	41 06-23	0	0	0	0	0	0	339	1634	855	305	238	0	3372
1960	1960-04-22	1960-10-08	125	36 08-05	0	0	0	0	0	363	881	1432	659	532	528	228	4622
1961	1961-05-07	1961-09-22	122	30 05-14	0	0	0	0	0	0	1043	1194	901	409	540	0	4086
1962	1962-05-01	1962-09-30	114	29 07-10	0	0	0	0	0	0	613	292	976	754	795	0	3429
1963	1963-04-09	1963-09-30	120	24 08-21	0	0	0	0	0	857	1172	797	547	379	286	0	4038
1964	1964-05-01	1964-10-23	95	24 05-05	0	0	0	0	0	0	1256	901	659	71	0	288	3174
1965	1965-04-15	1965-09-19	99	36 05-26	0	0	0	0	0	655	1492	496	331	466	365	0	3804
1966	1966-04-25	1966-10-15	116	21 05-05	0	0	0	0	0	167	1194	367	617	206	272	482	3305
1967	1967-04-16	1967-09-28	83	32 07-17	0	0	0	0	0	726	565	0	764	190	303	0	2549
1968	1968-04-10	1968-10-14	154	34 05-10	0	0	0	0	0	684	960	1063	547	230	674	327	4487
1969	1969-04-11	1969-10-04	147	25 06-30	0	0	0	0	0	837	520	627	532	589	468	48	3620
1970	1970-05-30	1970-09-25	105	29 07-22	0	0	0	0	0	0	83	553	1285	783	853	0	3558
1971	1971-05-15	1971-09-18	116	32 07-03	0	0	0	0	0	0	559	823	1186	458	385	0	3412
1972	1972-04-16	1972-09-22	160	32 06-13	0	0	0	0	0	601	1144	1359	972	442	307	0	4826
1973	1973-05-16	1973-09-08	116	30 06-16	0	0	0	0	0	0	569	1371	1254	962	133	0	4288
1974	1974-05-01	1974-10-31	175	41 07-07	0	0	0	0	0	0	1305	1000	954	655	1974	1434	7321
1975	1975-05-03	1975-10-31	177	33 07-03	0	0	0	0	0	0	855	996	1446	855	1135	637	5923
1976	1976-05-03	1976-10-07	141	34 05-22	0	0	0	0	0	0	772	690	534	488	1047	260	3790
1977	1977-05-13	1977-10-03	123	36 05-30	0	0	0	0	0	0	436	950	682	224	980	28	3301
1978	1978-04-05	1978-10-13	154	34 07-03	0	0	0	0	0	726	891	1105	627	234	528	516	4626
1979	1979-05-05	1979-09-30	149	30 07-09	0	0	0	0	0	0	863	732	817	486	627	0	3525
1980	1980-05-09	1980-09-18	125	33 06-14	0	0	0	0	0	0	680	1117	694	518	661	0	3669
1981	1981-04-29	1981-10-14	169	24 06-22	0	0	0	0	0	36	726	867	492	244	730	371	3465
1982	1982-04-19	1982-10-31	196	36 07-03	0	0	0	0	0	492	1212	744	772	631	720	966	5536
1983	1982-11-01	1983-09-17	116	31 09-02	60	0	0	0	0	0	65	815	889	1242	611	0	3681
1984	1984-05-22	1984-10-07	139	38 08-03	0	0	0	0	0	0	325	865	1478	1424	571	61	4725
1985	1985-04-24	1985-09-08	124	31 06-28	0	0	0	0	0	121	585	1125	674	486	163	0	3154
1986	1986-05-06	1986-10-07	147	45 05-09	0	0	0	0	0	0	982	635	1049	666	496	97	3925
1987	1987-05-01	1987-10-19	147	28 05-04	0	0	0	0	0	0	730	202	518	484	720	415	3068
1988	1988-05-04	1988-09-30	139	38 06-27	0	0	0	0	0	0	541	1079	974	783	413	0	3790
1989	1989-04-18	1989-10-18	154	39 05-04	0	0	0	0	0	726	1656	764	664	706	256	313	5086
1990	1990-04-23	1990-09-23	136	31 06-22	0	0	0	0	0	284	902	700	752	659	436	0	3733
1991	1991-04-10	1991-10-28	182	38 09-11	0	0	0	0	0	583	1095	409	944	1192	1224	700	6147
1992	1992-04-14	1992-10-31	201	33 07-09	0	0	0	0	0	464	1535	960	694	605	655	589	5502
1993	1992-11-01	1993-10-22	187	35 05-18	198	0	0	0	0	0	1305	938	776	468	367	190	4242
1994	1994-04-08	1994-10-10	165	47 06-15	0	0	0	0	0	393	1196	1652	657	444	678	175	5195
1995	1995-05-11	1995-09-27	126	36 05-11	0	0	0	0	0	0	760	502	960	659	629	0	3509
1996	1996-04-09	1996-09-21	166	43 07-09	0	0	0	0	0	1101	1238	1561	1634	1561	446	0	7541
1997	1997-03-28	1997-10-12	178	61 07-29	0	0	0	0	163	849	1390	176	1597	670	1085	428	6359
1998	1998-04-27	1998-10-10	164	49 07-04	0	0	0	0	0	206	1216	1321	1498	1839	1357	91	7527
1999	1999-05-07	1999-09-30	111	36 09-05	0	0	0	0	0	0	813	1093	1369	641	914	0	4830
2000	2000-04-24	2000-10-04	161	37 05-05	0	0	0	0	0	389	1486	1567	984	567	426	77	5496
2001	2001-05-01	2001-10-31	146	41 07-21	0	0	0	0	0	0	607	841	1216	541	161	111	3477
2002	2001-11-01	2002-10-29	112	60 04-26	6	0	0	0	0	359	1196	1269	571	0	101	541	4044

2003	2003-05-01	2003-10-15	147	38	05-10	0	0	0	0	0	0	1303	952	458	216	1537	708	5175
2004	2004-04-05	2004-10-20	172	66		0	0	0	0	0	897	1521	1214	857	1091	1516	973	8070
2005	2005-04-13	2005-10-15	175	50	06-05	0	0	0	0	0	599	1115	1128	683	977	727	522	5750
2006	2006-02-23	2006-10-31	171	33	07-15	0	0	0	75	80	0	1356	1282	707	678	1856	661	6695
2007	2007-01-19	2007-10-24	210	69	04-26	0	0	68	639	94	1087	2101	1367	1258	1055	1372	985	10026
2008	2007-12-20	2008-10-24	200	54	06-27	0	174	143	64	0	0	2159	1261	788	1204	1171	649	7614
2009	2008-12-20	2009-10-31	255	53		0	162	25	23	0	851	1990	1108	1178	1634	1353	1246	9570
2010	2010-03-09	2010-10-31	228	67	06-11	0	0	0	0	1007	956	1562	1208	1669	1593	1228	895	10117
2011	2010-11-01	2011-10-31	231	44	06-22	14	0	0	0	372	1255	1418	1909	1859	1761	1267	1839	11692
2012	2011-11-01	2012-10-31	253	47	09-30	564	0	0	0	869	861	1629	1415	749	98	1107	1633	8926
2013	2012-11-01	2013-10-28	233	53	05-26	11	0	0	0	48	98	1631	1791	962	380	1551	694	7165
2014	2014-02-17	2014-10-31	248	44	06-03	0	0	0	157	1175	1275	1634	1792	1488	1458	921	774	10676
			Minimum:	21		0	0	0	0	0	0	0	0	331	0	0	0	1601
			Maximum:	69		564	174	143	639	1175	1275	2159	1909	2148	1839	1974	1839	11692
			Average:	39		13	5	4	15	59	324	1019	1027	901	675	708	357	5107

65.00 years with diversion records

Notes: The average considers all years with diversion records, even if no water is diverted.
The above summary lists total monthly diversions.
* = Infrequent Diversion Record. All other values are derived from daily records.
Average values include infrequent data if infrequent data are the only data for the year.

Diversion Comments

IYR	NUC Code	Acres Irrigated	Comment
1950		2600	
1951		2600	
1952		2600	
1953		2340	
1954		2600	
1955		2340	
1956		2340	
1957		1432	
1958		2340	
1959		2340	
1960		2340	
1961		2340	
1962		2340	
1963		2340	
1964		2340	
1965		2182	
1966		2182	
1967		2182	
1973		2182	
1975		4182	
1976		2182	
1977		2182	
1980		4182	
1981		2600	

Note: Diversion comments and reservoir comments may be shown for a structure, if both are available.

1895-

NO. 432.

In The Matter Of The Adjudication
Of Priorities Of Water Rights In
Irrigation District No. One.

Book Number Fifteen

Referee's Findings.

Filed in the District
Court, Weld County, C.
November 11 A. D. 1882.

Clerk.

State of Colorado. :
: S. S.
County of Weld. :

In the District Court of the Eighth
Judicial District of the State of
Colorado, within and for the County
of Weld.

::::::::::::::::::::::::::::::::::::::

In the matter of the Adjudication
of Priorities of Water Rights in
Irrigation District Number One.

N O. 4 3 3.

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FINDINGS.

The above entitled cause, having been referred to me, **Christian A.** Bennett, as a referee to take evidence therein and report my findings, I would most respectfully report:

That upon consideration of all the evidence offered in said matter, I find:

That a large number of irrigating ditches and reservoirs have been constructed in said irrigating district, taking their water from the South Platte River, between the mouth of the Cache la Poudre River and the West boundary line of Washington County, and from the streams draining into said portions of the South Platte River. Some of which ditches and reservoirs are situated in each of the counties of Elbert, Arrapahoe, Weld and Morgan.

That the ditches and reservoirs situated in the county of Elbert, and about which evidence was offered in this action, divert their supply of water from Kiowa Creek, a tributary of the South

3rd.-- Ditches situated in the counties of Weld and Morgan, Colorado.

-- DITCHES. --

: :

No.	1.	The	Hoover Ditch,	Is	entitled	to	priority	No.	1.
"	2.	The	P. H. Parsons Ditch,	"	"	"	"	"	2 + 42
"	3.	The	Schultz Ditch,	"	"	"	"	"	3
"	4	"	Deuel & Snyder Ditch,	"	"	"	"	"	4 + 24
"	"	"	Johnson & Edwards Ditch,	"	"	"	"	"	5
"	6	"	Hardin Ditch,	"	"	"	"	"	6
"	7	"	Brown & Pyott Ditch,	"	"	"	"	"	7 + 15
"	8	"	Lone Tree Ditch & Lateral	"	"	"	"	"	8
9	9	"	Tetsel Ditch,	"	"	"	"	"	9 + 21
"	10	"	Corona Ranch Ditch,	"	"	"	"	"	10
"	11	"	Illinois Ditch,	"	"	"	"	"	11
"	12	"	John D. Cornell Ditch,	"	"	"	"	"	12
"	13	"	Putnam Ditch,	"	"	"	"	"	13 + 17
"	14	"	Mimmack Ditch,	"	"	"	"	"	14 + 34
"	15	"	Weldon Valley Ditch,	"	"	"	"	"	15
"	16	"	Isaac D. Miller Ditch,	"	"	"	"	"	16
"	17	"	Beaver Ditch,	"	"	"	"	"	17
"	18	"	Lone Tree Ditch,	"	"	"	"	"	18
"	19	"	Platte & Beaver(Upper D.)	"	"	"	"	"	19
"	20	"	Platte & Beaver, (Lower D.)	"	"	"	"	"	20 + 35
"	21	"	Fort Morgan Canal"	"	"	"	"	"	21 + 35
"	22	"	Canfield Ditch,	"	"	"	"	"	25 + 27
"	23	"	Ward Ditch,	"	"	"	"	"	26

Continued on next page,

originally constructed was 3 & I/2 feet wide on the bottom, with a grade of 6 feet per mile, slope of banks one to one, capable of carrying water I8 inches deep. That said ditch is entitled on priority No. I9. to one and one half cubic feet of water per second of time.

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Ditch No. I9.

That Ditch No. I9 is named the upper Platte and Beaver Ditch, and is entitled to priorities No's 20 and 35. That said ditch is claimed by the Upper Platte & Beaver Canal Company, and is a ditch used for the irrigation of lands and derives its supply of water from the South Platte River, from the South side of the stream. That the headgate thereof is located on the South bank of the South Platte River at a point 4580 feet North, 29 degrees andn23 minutes West, from the S. E. corner of Sec. 37, Township 4 North, Range 58 West in Morgan County, Colorado, and runs thence in an Easterly direction. That the work of construction on said ditch was commenced on June 20th, I882, and was completed about December I882, and was prosecuted with diligence. That said ditch as originally constructed was I5 miles in length, 20 feet wide on the bottom, with a grade of 2.II feet per mile, slope of banks I to I, capable of carrying water 3 & I/2 feet in depth. That said ditch at the time of its construction was owned by the Platte & Beaver Improvement Company, which Company also owned the land lying thereunder and capable of being irrigated therefrom, and which said ditch was built to irrigate. That said Company continued to hold said ditch and lands, or the greater part thereof, until during the year I887, when said lands were divided among the stock holders of said company in severalty, and said ditch and its franchises were subsequently conveyed to the claimant company herein. That while said ditch and lands were so held and owned by the Platte & Beaver Land & Improvement Company from and including the year 1883 and to and including the year 1887, said ditch was used continuously during each irrigating season for the irrigation of a portion of the lands lying thereunder. That during said period the total area of lands irrigated therefrom was about 2000 acres. That said ditch by reason of its construction and said use of waters for irrigation, is entitled on priority No. 20 to 50 cubic feet of water per second of time. That from and including the irrigating season of 1888, a larger area of land was watered from said ditch by the new owners thereof. That said ditch has since been used continuously for the irrigation of lands thereunder. That the total area of land irrigated therefrom has been 9000 acres. That by reason of such additional use of waters therefrom, said ditch is entitled on priority 35 to such an additional amount of water as will flow in a ditch of those dimensions, estimated at 164 cubic feet of water per second of time.

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Ditch No. 20.

That Ditch No 20 is named the Lower Platte & Beaver Ditch and is entitled to priorities No's 22 and 35. That said ditch is claimed by the Lower platte & Beaver Canal Company, and is a ditch used for the irrigation of lands and derives its supply of water from the South platte River, from the South side of the stream, and also from Beaver Creek. That the headgate thereof is located at a point on the South bank of the said South Platte River bearing North 44 degrees, 51 minutes West, 2136 feet from the Southeast corner of Section 35 , Township 4 North, Range 57 West in Morgan County, Colorado, and runs thence in a general Easterly direction. That the work of original construction of this ditch was commenced September 4th, 1882, and was prosecuted with diligence and completed for a

125

No. 2283.

IN DISTRICT COURT OF

WELD COUNTY, COLO.

IN THE MATTER OF ADJUDICATION OF PRIORITIES OF WATER RIGHTS FOR IRRIGATION IN WATER DISTRICT No. 1.

ON PETITION OF THE UPPER PLATTE & BEAVER CANAL CO. TO CHANGE POINT OF DIVERSION OF IRRIGATION PRIORITY No. 1.

CERTIFIED COPY OF

FINDINGS AND DECREE OF

COURT.

Filed in the Office
of the State Engineer

STATE OF COLORADO,)
) ss.
COUNTY OF WELD,)

IN THE DISTRICT COURT.

No. 2283.

IN THE MATTER OF ADJUDICATION OF PRIORITIES OF WATER RIGHTS FOR IRRIGATION IN WATER DISTRICT NO. 1.

ON PETITION OF THE UPPER PLATTE & BEAVER CANAL COMPANY, TO CHANGE POINT OF DIVERSION OF IRRIGATION PRIORITY NO. 1.

FINDINGS AND DECREE OF COURT.

Now on this 5th day of November, 1909, one of the regular juridical days of the November Term, A. D. 1909, of this court, comes said petitioner, The Upper Platte & Beaver Canal Company, by H. N. Haynes, Esq., its attorney, and shows to the Court, on its examining proceedings of record herein and affidavits on file, that notice duly issued by the Clerk of this Court containing copy of order of court, of date the 2nd day of October, 1909, setting this day for hearing of this matter, and for filing of objections or protests thereto, has been duly published, posted and served on all parties entitled to service as required by statute in that behalf, and the court doth find accordingly.

And it appearing to the Court that no persons have filed objections or protests to the petition or the prayer thereof as filed in this matter, on motion of said petitioner, the court proceeds to hear evidence offered by petitioner, both oral and documentary.

Thereupon, upon the close of the evidence and argument by counsel for petitioner, the court being now sufficiently advised in the premises, doth further find as follows:

1. That said petitioner, The Upper Platte & Beaver Canal Company, has entered into contract to purchase from John T. Warren and Clarence T. Neill, that certain water right, priority and appropriation referred to in general decree in said Water District No. 1, rendered by this Court, of date 21st day of November, 1895,

as priority and appropriation No. 1 effected by means of the Hoover Ditch, dating from the 20th day of April, 1868, wherein it was decreed that said Hoover Ditch is used to irrigate lands, derives its water supply from South Platte River on north side thereof, with headgate in northwest quarter of northeast quarter of section 15, township 5 north, range 64 west, in Weld County, Colorado, and that there be allowed to flow in said ditch from said stream for benefit of parties entitled thereto when needed to irrigate lands thereunder, by virtue of appropriation and construction of said ditch and diversion and use of water thereby under said Priority No. 1, 15 cubic feet of water per second of time.

2. That said petitioner, The Upper Platte & Beaver Canal Company, is owner of that certain irrigating canal in said Water District No. 1, known as Upper Platte & Beaver canal, referred to in said decree, being Ditch No. 19 of ditches in said Water District, situated in the counties of Weld and Morgan, in the State of Colorado, with head and headgate located on south bank of South Platte River, in north half of section 27, township 4 north, range 58 west, in Morgan County, Colorado; that said Upper Platte & Beaver canal extends thence in general easterly direction for a distance of about nine miles, to a point where two branches diverge, and is used to irrigate about 12,000 acres of land lying under said two branches in Morgan County, Colorado; that in and by said decree of November 21st, 1895, said Upper Platte & Beaver canal was awarded two irrigation priorities and appropriations, viz.: No. 20, dating from June 20th, 1882, for 50 cubic feet of water per second of time, and No. 33, dating from April 15th, 1888, for an additional flow of 164 cubic feet of water per second of time.

3. That petitioner, for irrigation needs of its stockholders and consumers, has entered into said contract for the purpose of supplementing and increasing its supply of water for irrigation needs of its stockholders and consumers on changing point of

diversion of said water, from headgate of said Hoover ditch to headgate of said Upper Platte & Beaver canal.

4. That all persons now interested in said water appropriation and priority No. 1, desire under said contract of purchase, that said change of point of diversion be granted, to the end that hereafter no water shall be diverted under said Priority No. 1 into said Hoover ditch, but that said 15 cubic feet of water per second of time under said priority, be hereafter diverted in irrigation seasons, into said Upper Platte & Beaver canal, for irrigation of lands irrigated by means thereof and lying thereunder.

5. That said change of point of diversion will not injuriously affect vested rights of any other parties or persons to divert water from said South Platte River in said Water District No. 1, or elsewhere, and that there is a continuous channel, viz.: South Platte river, with constant accretions between the headgate of said Hoover ditch and headgate of said Upper Platte & Beaver canal.

6. That petitioner is entitled to decree as prayed in its petition herein.

WHEREFORE, on motion of H. N. Haynes, Esq., attorney for said petitioner, it is

ORDERED, ADJUDGED AND DECREED by the Court, that said appropriation of water for irrigation heretofore allowed to be diverted and used for irrigation from said South Platte river by decree of this Court dated November 21st, 1895, to the Hoover ditch, to the amount of 15 cubic feet of water per second of time on said Priority No. 1, dating from the 20th day of April, 1868, acquired by construction of said Hoover ditch and by diversion of said water constantly for irrigation uses throughout all irrigation seasons since, shall and can hereafter rightfully, during irrigation seasons, be diverted at and into the headgate of the Upper Platte & Beaver canal of petitioner at its headgate in Morgan County, Colorado, on the south bank of South Platte river in north half of section 27, township 4 north, range 58 west, and thence into, through and along said Upper Platte & Beaver canal for distribution to and irrigation of lands thereunder, and not hereafter into said Hoover ditch or the headgate thereof. Further, that said change of point of diversion as so ordered and decreed, will not injuriously affect vested rights of any others to the use of water.

Further, that the water commissioner of water district No. 1 in the State of Colorado, as well as other water officials having charge of the distribution of water in said water district No. 1, shall hereafter continue to recognize said priority No. 1 as of said date, to-wit, the 20th day of April, 1868, to the extent of 15 cubic feet of water per second of time when there is water in South Platte river available therefor, but hereafter shall permit same to be diverted into the Upper Platte & Beaver canal for irrigation uses of its stockholders and consumers thereunder, and not into said Hoover ditch.

It is further ordered, adjudged and decreed by the Court, that petitioner herein pay all costs taxed herein.

Done in open court this 5th day of November, A. D. 1909.

BY THE COURT,

James E. Garrigues
Judge.

I, Frank Madden, Clerk of the District Court in and for the County of Weld and State of Colorado, do hereby certify the above and foregoing to be a correct copy of decree of Court duly entered and rendered in open court, in case or proceeding numbered 2283, then pending in said court, entitled as therein shown, on the 5th day of November, 1909, being one of the regular juridical days of the November Term, A. D. 1909, of said Court.

WITNESS my hand and the seal of said Court, this 5th day of November, A. D. 1909.

Frank Madden

Clerk of the District Court in
and for the County of Weld,
State of Colorado.

#655

TRANSFER DECREE
WATER DISTRICT No1
FROM
UPPER PLATTE & BEAVER
CANAL
TO
NEW POINT OF DIVERSION

STATE OF COLORADO)
: ss.
COUNTY OF WELD)

IN THE DISTRICT COURT
No. 11195

FILED IN
DISTRICT COURT
WELD CO., COLO.
SEP - 8 1948
A. J. LUTHER,
CLERK.

IN THE MATTER OF WATER RIGHTS FOR IRRIGATION IN WATER DISTRICT NO. 1 IN WATER DIVISION NO. 1 OF THE STATE OF COLORADO.

UPON THE PETITION OF THE UPPER PLATTE AND BEAVER CANAL COMPANY TO CHANGE THE POINT OF DIVERSION OF THE DECREED IRRIGATION APPROPRIATION OF THE UPPER PLATTE & BEAVER CANAL COMPANY FROM THE HEADGATE OF THE UPPER PLATTE & BEAVER CANAL TO A POINT ON ITS PRESENT CANAL XXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX APPROXIMATELY 7680 FEET FROM ITS ORIGINAL POINT OF DIVERSION HEADGATE

COURT FINDINGS AND DECREE

Now on this 31st day of August, 1948, one of the juridical days of the May, 1948 term of said Court, this cause coming on to be heard on petition of the Upper Platte and Beaver Canal Company to change the point of diversion of the decreed irrigation appropriation of the Upper Platte and Beaver Canal Company from the headgate of the Upper Platte and Beaver Canal to a point on its present canal, approximately 7680 feet from its original decreed point of diversion headgate, said petitioner appearing by its attorneys Anderson and Anderson, and no protestants appearing in the premises, and the Court having considered the petition and the proofs and testimony now here taken and adduced in open Court, and being now fully advised in the premises doth make, enter and render its findings of fact and conclusions of law and its final decree as follows:

FINDINGS AS TO JURISDICTION

1. That the petition filed herein on the 15th day of May, 1948, by said petitioner, is in due form and presents matters within the special jurisdiction of this Court to hear and determine application for change of point of diversion of appropriations for immediate irrigation in Water District No. 1, in Irrigation Division No. 1 of the State of Colorado.

2. That on the 15th day of May, 1948, on considering said petition, the Court, pursuant to statute in that behalf, entered an order fixing Tuesday, the 27th day of July, 1948, the same being continued to this date, at the Court House in Greeley, in Weld County, Colorado, when and where, unless hearing in said matter should be adjourned or continued to some later date, it would commence to hear and take evidence regarding said petition, both on behalf of said petitioner and of any interested parties, if any, who should file objections thereto, the Court did order and rule that the Clerk of this Court should cause notice of the time so appointed and of the matters presented in said petition to be published in two public newspapers, one published in Greeley by the Greeley Tribune, in Weld County, Colorado, and one at Brush, by the Brush News-Tribune, in Morgan County, Colorado, for four (4) successive weekly publications; and the Court so finds that publication was made according to its order as of the above date.

3. The Court did rule and order that the Clerk of this Court should mail a copy of the notice, as the statutes in such case provide, ten (10) days previous to the 27th day of July, 1948, to the Deuel & Snyder Improvement Company, with offices at 401 Main Street, Fort Morgan, Colorado, owner of the Deuel & Snyder ditch, the same being the only ditch taking water from the same source being located on the same source between the original point of diversion and the present point of diversion of the Upper Platte and Beaver Canal Company, petitioner herein. The Court finds that said notice has been mailed by the Clerk of the Court, pursuant to the Court's order.

4. The Court further finds that said notice was properly mailed to all persons named in a list furnished by the irrigation division engineer and water commissioner of Water District No. 1, in Water Division No. 1 of the State of Colorado, as the owner and claimant of all ditches, reservoirs and other structures by which water has been diverted or stored during the last year in Water District No. 1, as by statute in such case made and provided.

From the evidence now here taken and adduced in open Court, the Court doth make and render its findings of fact and rule as follows, to-wit:

FINDINGS OF FACT

1. That petitioner, the Upper Platte and Beaver Canal Company, is the owner of, and possesses and controls that certain irrigating ditch and diversion and distribution system known and called as the Upper Platte and Beaver Canal, otherwise designated as Ditch No. 19 of the Upper Platte and Beaver Canal, situate in Morgan County, in Water District No. 1, in Water Division No. 1 of the State of Colorado, together with the headgate, diverting appliances, lateral headgates, structures and appliances connected to and used with said ditch and said diversion and irrigation system as well also,

Priority Nos:

		Date	Cubic Feet Per Second
1	Transfer from Hoover Ditch, Water District No. 1	April 20, 1863	15
16	In Getz Ditch, Water District No. 2, transferred to District No. 1	May 15, 1869	5.17
20		June 20, 1882	50
38		April 15, 1888	164

Effected by means thereof heretofore determined and adjudicated by this Court.

2. That the headgate of said Upper Platte and Beaver Canal Company was decreed, by Decree dated November 21, 1895, as being located at a point as follows, to-wit:

> The headgate of the Upper Platte & Beaver Canal is located on the south bank of the South Platte River at a point 4560 feet North, 29°23' West from the Southeast corner of Section 27, Township 4 North, Range 58 West, Morgan County, Colorado, and that said Upper Platte & Beaver Canal runs thence in an easterly direction, being 20 feet wide on the bottom with a grade of 2.11 feet per mile, slope of banks one to one, capable of carrying water three and a half feet in depth.

And that it is now located at a point and has been since 1937, as follows, to-wit: "Whence the Southeast corner of Section 35, Township 4 North, Range 58 West of the 6th Principal Meridian, Morgan County, Colorado, bears South 13°57' East, 5020.2 feet, being approximately 7680 feet from the original decreed point of diversion".

3. That the only ditch and other structure taking water from the same source between the decreed and the new point of diversion, together with the names and addresses of the owners or claimants thereof so far as known to the petitioner, is as follows:

> The Deuel and Snyder Ditch owned by Deuel and Snyder Improvement Company, whose address is 401 Main Street, Fort Morgan, Colorado.

And that said change of point of diversion as petitioned for by petitioner is a benefit to said Deuel and Snyder Ditch, owned by the Deuel and Snyder Improvement Company, whose address is 401 Main Street, Fort Morgan, Colorado.

4. That the Upper Platte and Beaver Canal is owned and controlled by the Upper Platte and Beaver Canal Company, with offices in the Farmers State Bank Building, Brush, Colorado.

5. The Court further finds that the change of the point of diversion by petitioner will reduce annual maintenance and operation expenses very materially, and will enable the petitioner better and more economically to irrigate its lands which are still subject to beneficial irrigation by application thereto of Priority Rights Nos. 1, 16, 20 and 38, as above described, in the South Platte River Basin, Water District No. 1 of Irrigation Division No. 1 of the State of Colorado, not only in the expenditure of money but in the consumption of water, and that diversion of the water on the above described priorities at the headgate of the Upper Platte and Beaver Canal.

6. The Court further finds that the change of the point of diversion of the Upper Platte and Beaver Canal as petitioned for will not injuriously affect the vested rights of others to the use of water from the South Platte River or its tributaries, but on the contrary will decrease in amount the loss of water on the priorities as above set forth, of the Upper Platte and Beaver Canal Company.

CONCLUSIONS OF LAW

That on the findings of fact above set out, petitioner is entitled to a decree granting change of point of diversion of its said priority right to the use of water aforesaid to the headgate or to its now present headgate without injury to the vested rights of others in Water District No. 1, in Irrigation Division No. 1 of the State of Colorado, said point of diversion being described as follows, to-wit: Located at a point "whence the Southeast corner of Section 35, Township 4 North, Range 58, West of the 6th Principal Meridian, Morgan County, Colorado, bears South 13°57' East, 5020.2 feet, being approximately 7680 feet from the original decreed point of diversion".

THEREUPON, the petition of petitioner for decree in accordance with Findings of Fact and Conclusions, it is ORDERED, ADJUDGED AND DECREED by the Court as follows:

1. That the point of diversion of water from the South Platte River in Water District No. 1 in Irrigation Division No. 1 in the County of Morgan, State of Colorado, from the South Platte River Basin for use of irrigation priority rights Nos. 1, 16, 20 and 38, as above described, in the South Platte River Basin, as decreed by this Court, described as ditch No. 19 of said irrigation district for said water division in the County of Morgan, State of Colorado, be and the same is hereby changed to the present location of the headgate of the Upper Platte and Beaver Canal Company which is located at a point described as follows, to-wit: Located at a point "whence the Southeast corner of Section 35, Township 4 North, Range 58 West of the 6th Principal Meridian, Morgan County, Colorado, bears South 13°57' East, 5020.2 feet, being approximately 7680 feet from the original decreed point of diversion".

2. That said change of point of diversion will not injuriously affect the vested rights of others in and to the use of water in said Water District No. 1 of Water Division No. 1 of the State of Colorado or any water user in the South Platte River Basin.

3. That the State Engineer, the Division Engineer and the Water Commissioner of Irrigation Division No. 1, in Water District No. 1, Water Division No. 1 of the State of Colorado, as aforesaid, and their respective successors in office, agents and employees, be and they, and each of them are ordered hereafter in the distribution of water in said Water District to permit said change of point of diversion of said Priority of Rights Nos. 1, 16, 20 and 38 as above described, and diversion of water thereon from the South Platte River into and through the Upper Platte and Beaver Canal and to enforce the conditions and limitations herein set out.

IT IS FURTHER ORDERED, ADJUDGED AND DECREED by the Court that this Decree shall take effect upon compliance by petitioner with the provisions of the laws of Colorado, viz: By causing certified copies hereof to be filed ~~with~~ in the office of the Irrigation Division Engineer ~~the County Clerk of Morgan County, Colorado~~, and in the office of the State Engineer of the State of Colorado, respectively, and further that all costs of this proceeding shall be paid by the petitioner.

Done in open Court this 8th day of September, 1948, as of the 31st day of August, A. D. 1948.

BY THE COURT:

CLAUDE C. COFFIN,
Judge.

Certificate of Copy

STATE OF COLORADO } ss.
COUNTY OF WELD }

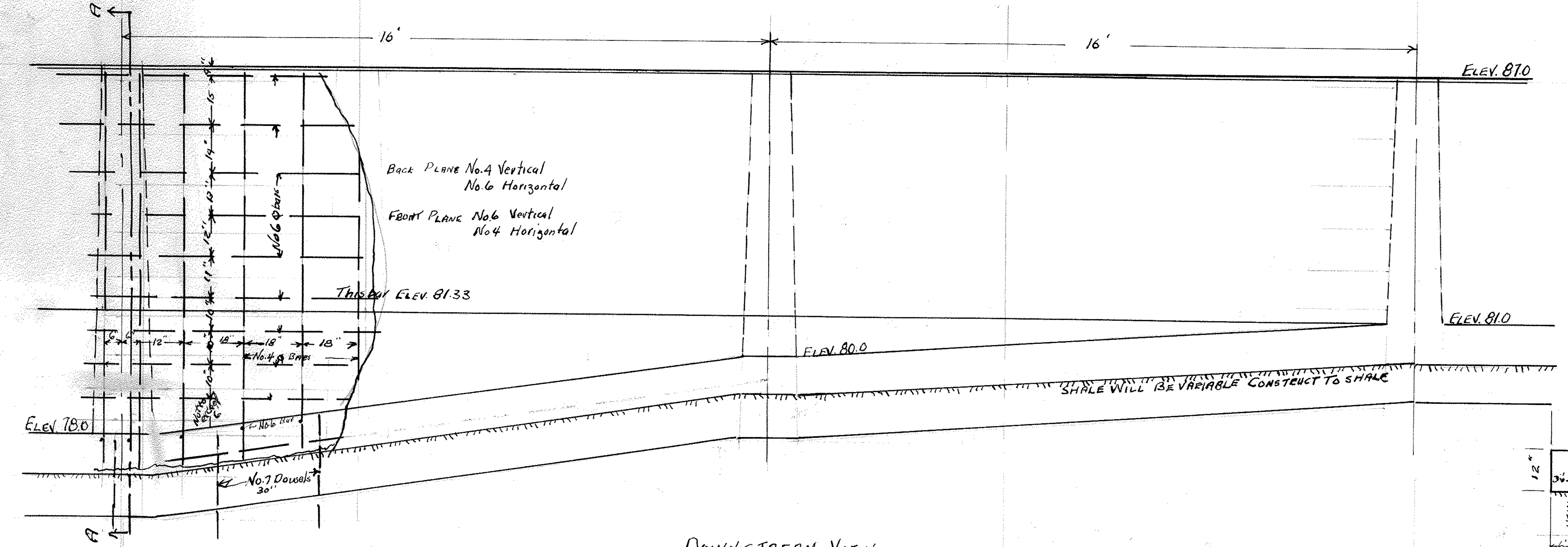
I, A. J. LUTHER, Clerk of the District Court, in and for the aforesaid County and State, do hereby certify that the within and foregoing is a full, true and correct copy of COURT FINDINGS AND DECREE in Case No. 11195, entitled IN THE MATTER OF WATER RIGHTS FOR IRRIGATION IN WATER DISTRICT NO. 1 IN WATER DIVISION NO.1 OF THE STATE OF COLORADO. UPON THE PETITION OF THE UPPER PLATTE AND BEAVER CANALCOMPANY TO CHANGE THE POINT OF DIVERSION OF THE DECREED IRRIGATION APPROPRIATION OF THE UPPER PLATTE & BEAVER CANAL COMPANY FROM THE HEADGATE OF THE UPPER PLATTE & BEAVER CANAL TO A POINT ON ITS PRESENT CANAL APPROXIMATELY 7680 FEET FROM ITS ORIGINAL POINT OF DIVERSION HEADGATE,

as the same appears from the Original Files and Records of this Court, in said cause, in this office now remaining.

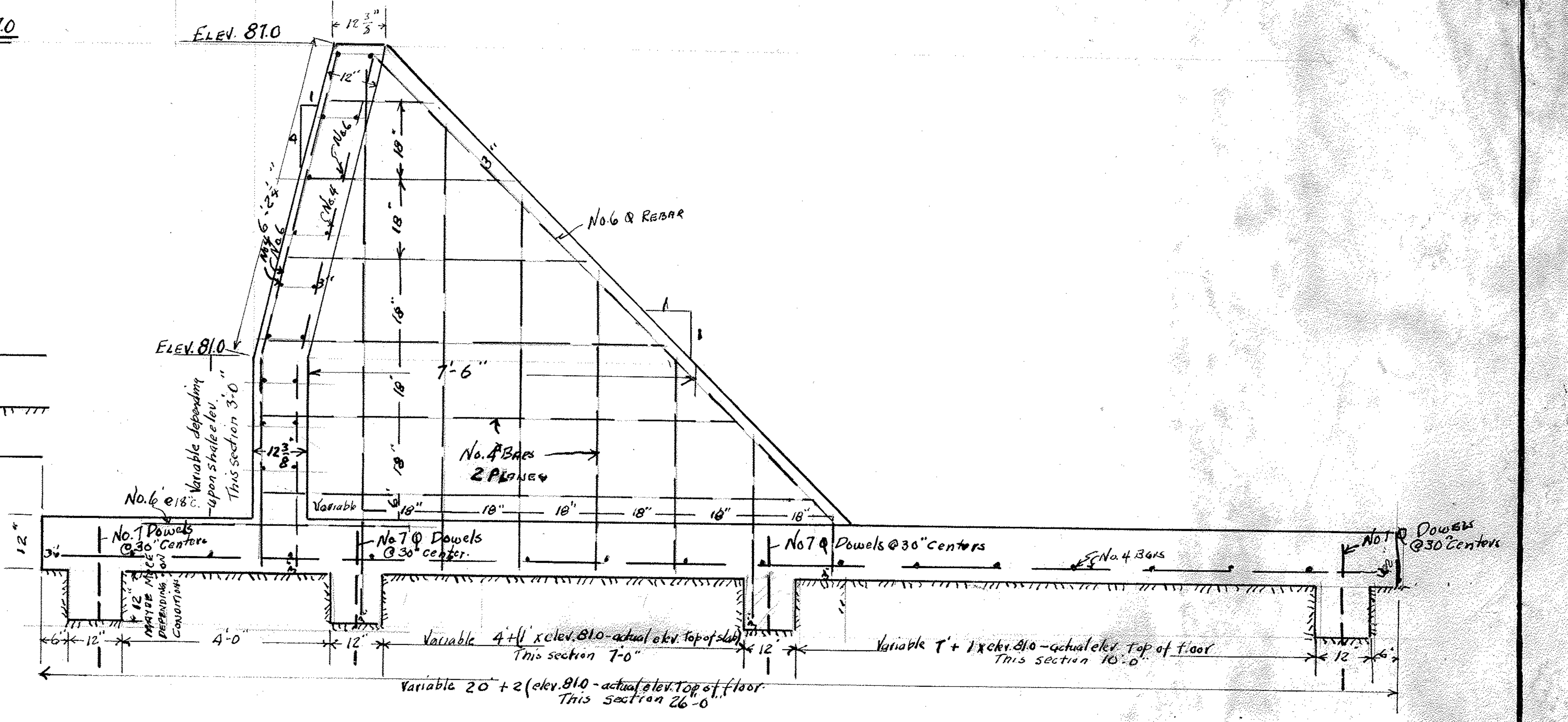
IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed my official seal, at my office in Greeley in said County and State, this 8th day of September, A.D. 1948

A. J. Luther
Clerk of District Court, Weld County, Colorado

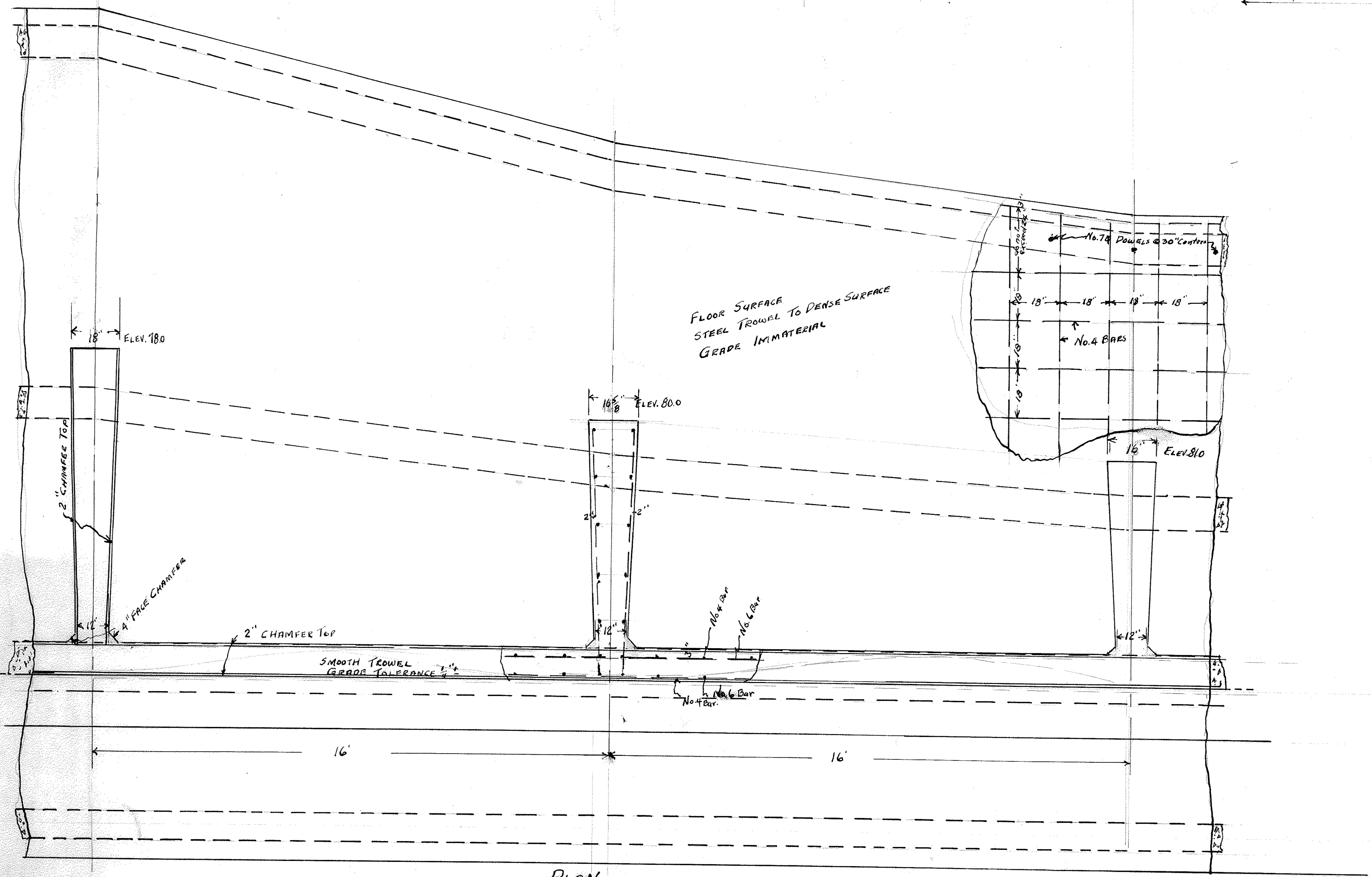
By M. R. Gregg
Deputy



DOWNSTREAM VIEW



SECTION A-A END VIEW



PLAN

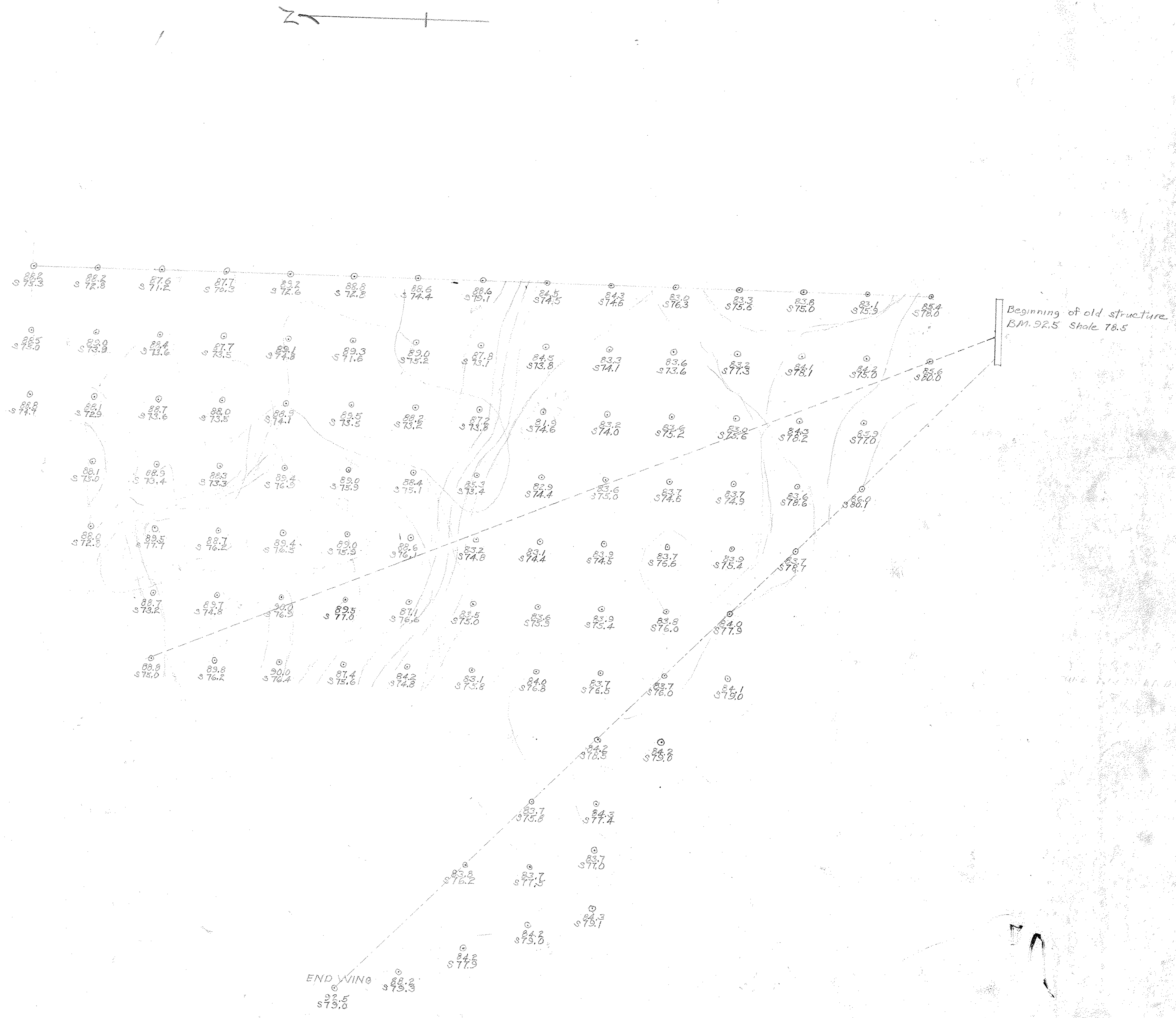
MATERIALS

ITEM		NEW DIVERSION DAM
CONCRETE		1055 cu yd
#4 ⌀ REBAR	44536 Lin ft	29750#
#6 ⌀ do	22520 Lin ft	33825#
#7 ⌀ do	3120 l.f.	6380#
Excavation		10,400 cu yd
		REPAIR NORTH DAM
CONCRETE		47 cu yd.
#4 ⌀ REBAR	3750	2505#
#6 ⌀ do	1750 l.f.	2630#
Excavation		500 cu yds
		REPAIR SOUTH DAM
Concrete		56 cu yd
#4 ⌀ REBAR	1283 l.f.	3860#
#6 ⌀ do	2016	3030#
EXCAVATION		2000 cu yd.
		Job Totals
Concrete		1158 cu yd.
#4 ⌀ Rebar	49563 l.f.	33115#
#6 ⌀ do	26286 l.f.	39485#
#7 do	3120 l.f.	6380#
Total Rebar		78980#
EXCAVATION		12900 cu yds

UPPER PLATTE AND BEAVER CANAL CO.
DIVERSION DAM REPLACEMENT
FLOOD 1965
CONSTRUCTION DETAILS
SCALE: 1/2" = 1'

DESIGNED BY:
DRAWN BY: Cecil J. Osborne
FT. MORGAN, COLORADO REG. PROF. ENGINEER
SEPT. 5, 1965 STATE OF COLORADO

12"
16'6"
18'
9'
13"
1'
Width = 20 + 2 x depth below 81.0
12 3/4
7 1/2"
12"
20' Minum
Minimum Section
4
12 3/4
12"
4
12"
7'-0"
12"
6
4'
4' + 1' for each foot depth below elev 81. Top of slab
Variable
10' Max
7' + 1' for each foot below 81. Top of slab
12"
Variable 20' + 2 x 81 - actual top of slab elev. 26' Max
Maximum Section
South End North Dam
92.5
Temporary Dike
North End South Dam
Old Structure (North End)
BM 92.5
Top of Diversion 87.0 of concrete
Present ground surface
Vertical wall
Son proposed axis
SHALE
This reading on buried concrete slab or shale spall
SHALE 78.5
79.0
81.0
92.0
90.0
88.0
86.0
84.0
82.0
80.0
78.0
76.0
74.0
72.0
70.0
8+00
7+00
6+00
5+00
4+00
3+00
2+00
1+00
0
0° FROM OLD STRUCTURE
22.5° FROM OLD STRUCTURE
45.0° FROM OLD STRUCTURE



UPPER PLATTE AND BEAVER
SHALE SOUNDINGS