



September 17, 2025

To: Andrew Samson, EIT

From: Hazen and Sawyer, Design Engineers

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Parker Water and Sanitation District, Owner

Alex Sofranko, P.E., asofranko@pwsd.org

13939 Ancestry Drive, Parker, CO, 80134

Re: Grading, Erosion, and Sediment Control (GESC) Report for the PWSD Denver Basin Well Site (Badger Gulch Well Site) Development

CERTIFICATION

The Grading, Erosion, and Sediment Control (GESC) report included herein has been prepared under my direct supervision in accordance with the requirements of the Douglas County Grading, Erosion and Sediment Control Criteria Manual, as amended.



Designer's Seal and Signature

Alex Sofranko hereby certifies that the grading, erosion and sediment control facilities for the Denver Basin Wells and Pipeline Phase II project shall be constructed according to the design presented in this report. I understand that the City of Lone Tree does not and will not assume liability for the grading, erosion and sediment control facilities designed and/or certified by my engineer and that the City of Lone Tree reviews GESC plans; but cannot, on behalf of the Denver Basin Wells and Pipeline Phase II project, guarantee that final review will absolve Alex Sofranko and/or their successors and/or assigns of future liability for improper design.

Alex Sofranko, P.E.

A handwritten signature of Alex Sofranko in black ink, written over a horizontal line.

Authorized Signature

NOTE

The Grading, Erosion and Sediment Control Plan included herein has been placed in the City of Lone Tree file for this project and appears to fulfill applicable City of Lone Tree Grading, Erosion and Sediment Control criteria, as amended. Additional grading, erosion and sediment control measures may be required of the permittee(s) due to unforeseen erosion problems or if the submitted GESC Plan does not function as intended. The requirements of this GESC Plan shall run with the land and be the obligation of the permittee(s) until such time as the GESC Plan is properly completed, modified, or voided.

1. Project Description

The Badger Gulch Wells Site and associated offsite raw water transmission main is being constructed due to increased water demand and anticipated future growth in the area. The 5-acre well site is owned and will be operated and maintained by Parker Water and Sanitation District (PWSD). The offsite transmission main will route through future road right-of-ways or a new exclusive PWSD in areas outside of roadways. The project consists of the Badger Gulch Wells site development as well as an 8-inch raw water transmission main that routes from the well site to the existing Ridgeway Well House. The approximate limits of disturbance for the well site and pipeline construction is approximately 6.2 acres.

The site and pipeline are in a part of the Southeast Quarter of Section 13, Township 6 South, Range 67 West of the sixth principal meridian in Lone Tree, Colorado. **Figure 1** below shows the location plan.



Figure 1: Location Plan

2. Existing Site Conditions

The site is currently undeveloped and is surrounded by undeveloped open space. The ground cover consists of a mixture of native grasses and shrubs. Construction activities have occurred in this project site recently for the drilling of the two new wells that will be within the new well site.

Most of the site is within Flood Zone “X” per FEMA Map Panel 08035C0064. Badger Gulch runs along the east side of the site property boundary, and the 100-year flood delineation for the stream briefly extends into the project site boundary as shown on the GESC drawings.

3. Adjacent Areas

The site is currently surrounded by undeveloped open space. Future development will occur in the areas adjacent to the project site as part of the Ridgeway Planned Development, but the details on the future development are unknown at the time of this Grading, Erosion, and Sediment Control (GESC) Report preparation.

4. Soils

The predominant soils series for this site are below:

- “FoB” - Fondis clay loam, 1 to 3 percent slopes, HSG C
- “Lo” - Loamy alluvial land, 1 to 5 percent slopes, HSG C
- “NeE” – Newlin gravelly sandy loam, 8 to 30 percent slopes, HSG B

These soils have a hydrologic soil group classification of B and C. See Appendix B for the Hydrologic Soil Group Map. A Geotechnical Report was also prepared for this project and includes soil boring information. The Geotechnical Report is also included in Appendix B.

5. Areas and Volumes

A total area of 5.8 acres is defined by the limits of disturbance on the drawings, including the limits of disturbance for the offsite pipeline construction. There is grading associated with the well site and blowdown pond construction. The earthwork volume for the site consists of approximately 259 cubic yards (CY) of cut and 44 CY of fill resulting in approximately 215 CY of excess cut that will be hauled off.

6. Erosion and Sediment Control Measures

Numerous BMPs will be used as erosion and sediment control measures for the site. BMPs used are shown in the associated GESC Plans in accordance with the Douglas County Grading, Erosion, and Sediment Control Manual and City of Lone Tree GESC Plan and Report Checklist. The proposed BMPs are as follows, with brief descriptions provided from the Douglas County GESC Manual:

- Construction Fence (CF): Construction Fence consists of orange plastic fencing or other County accepted material attached to support posts and used to delineate Limits of Construction and to control access to the construction site.
- Diversion Ditch (DD): A diversion ditch is a small earth channel used to divert and convey runoff.
- Seeding and Mulching (SM): Seeding and Mulching consists of drill seeding disturbed areas with the approved Douglas County seed mix and crimping in straw mulch to provide immediate protection against raindrop and wind erosion and, as the grass cover becomes established, to provide long-term stabilization of exposed soils.

- **Silt Fence (SF):** Silt Fence is a temporary sediment barrier constructed of woven fabric stretched across supporting posts. The bottom edge of the fabric is placed in an anchor trench that is backfilled with compacted soil.
- **Vehicle Tracking Control (VTC):** The Vehicle Tracking Control provides a stabilized area for vehicle and equipment access. Vehicle Tracking Control consists of a 3 to 6 inch crushed rock pad 12 inches thick at all entrance/exit points for a site that is intended to help strip mud from tires prior to vehicles leaving the construction site.
- **Stabilized Staging area (SSA):** A Stabilized Staging Area consists of stripping topsoil and spreading a layer of 1-1/2 inch gravel rock, or recycled concrete or CDOT Class 6 road base in the area to be used for a trailer, parking, storage, unloading and loading. A Stabilized Staging Area reduces the likelihood that the vehicles most frequently entering a site are going to come in contact with mud.
- **Concrete Washout Area (CW):** A Concrete Washout Area is a shallow excavation with a perimeter berm to contain and isolate concrete truck washout operations.
- **Inlet Protection (IP):** Inlet Protection consists of a reinforced rock berm placed in front of (but not blocking) a curb opening inlet or around an area inlet to reduce sediment in runoff approaching the inlet.
- **Erosion Control Blanket (ECB):** Erosion Control Blanket is a fibrous blanket of straw, jute, excelsior, or coconut material trenched in and staked down over prepared, seeded soil. The blanket reduces both wind and water erosion.
- **Sediment Control Logs (SCL):** A Sediment Control Log consists of a cylindrical bundle of wood, coconut, compost, excelsior, or straw fiber designed to form a semi-porous filter, able to withstand overtopping. The log can be staked into the ground and promotes sediment deposition on its upstream side.

7. Timing/Phasing Schedule

The proposed construction schedule for this project is:

- Install initial BMPs – November 2025
- Begin grading and install interim BMPs – January 2026
- Complete grading, remove initial and interim BMPs, and install final BMPs – November 2026
- The proposed construction is estimated to take 360 days.

8. Permanent Stabilization

Seeding and Mulching (SM) will be provided as permanent stabilization for disturbed soil on site. See project Specifications 31 25 00 – Erosion and Sedimentation Control and 32 90 00 – Final Grading and Landscaping for stabilization and seeding details.

9. Stormwater Management Considerations

Stormwater impacts are anticipated to be minimal for this project. Runoff generally maintains the natural drainage patterns of the existing site, which ultimately drains to Badger Gulch. If any unforeseen



circumstances result in contamination to stormwater runoff, contractor to reference the State CDPHE General Permit No. COR080000 for mitigation.

10. Maintenance

The construction, erosion, and sediment control measures shall be inspected by the contractor on a weekly basis during construction, or more frequently as directed by the Owner. Erosion and sediment control measures shall be inspected after every rain event as required by the City of Lone Tree regulations, supplemented by the Douglas County GESC regulations where needed. The requirements listed in the standard notes and details in the Grading, Erosion, and Sediment Control plans shall also be followed.

In addition to the maintenance requirements listed in the City of Lone Tree regulations, the BMPs shall also be maintained per the State CDPHE General Permit No. COR080000, including but not limited to Part 1, Section B.2

11. Opinion of Probable Cost for Installation and Maintenance of Controls

The opinion of probable cost for the erosion and sediment control measures within City of Lone Tree is \$53,705.58. A detailed cost estimate for erosion and sediment control is provided in Appendix D. Construction costs are not included in the cost opinion.

12. Calculations

No calculations were performed to create this plan set.

Appendices

- A. City of Lone Tree GESC Plan and Report Checklist
- B. NRCS Soils and Geotechnical Engineer Report
- C. Erosion Control Plans
- D. Engineer's Opinion of Probable Costs



Appendix A: City of Lone Tree GESC Plan and Report Checklist



Project: **Badger Gulch Wells Site and Pipeline**

Date: **September 19, 2025**

All Plan Sheets

- | | | | |
|---|-----------------------------|------------------------------|--|
| Yes ☒ | No ☐ | N/A ☐ | 1. Title Block (consistent on all sheets) |
| Yes ☐ | No ☐ | N/A ☐ | 2. Legal Name (Subdivision Name and Filing Number) |
| Yes ☒ | No ☐ | N/A ☐ | 3. Sheet Number |
| Yes ☒ | No ☐ | N/A ☐ | 4. Graphic and Written Scale |
| Yes ☒ | No ☐ | N/A ☐ | 5. North Arrow |
| Yes ☒ | No ☐ | N/A ☐ | 6. Current Date of Plan Preparation |
| Yes ☐ | No ☐ | N/A ☐ | 7. City Acceptance Block (available upon request) |

Cover Sheet

- | | | | |
|---|-----------------------------|------------------------------|--|
| Yes ☒ | No ☐ | N/A ☐ | 1. Project name |
| Yes ☒ | No ☐ | N/A ☐ | 2. Project address |
| Yes ☒ | No ☐ | N/A ☐ | 3. Owner (and Applicant's if different) name and address |
| Yes ☒ | No ☐ | N/A ☐ | 4. Design firm's name and address |
| Yes ☒ | No ☐ | N/A ☐ | 5. Plan sheet index |
| Yes ☒ | No ☐ | N/A ☐ | 6. Original date of preparation and subsequent revisions |
| Yes ☒ | No ☐ | N/A ☐ | 7. The following note:

<div style="margin-left: 40px;"> <p>THE GRADING, EROSION AND SEDIMENT CONTROL PLAN INCLUDED HEREIN HAS BEEN PLACED IN THE CITY OF LONE TREE FILE FOR THIS PROJECT AND APPEARS TO FULFILL APPLICABLE LONE TREE GRADING, EROSION AND SEDIMENT CONTROL CRITERIA, AS AMENDED. ADDITIONAL GRADING, EROSION AND SEDIMENT CONTROL MEASURES MAY BE REQUIRED OF THE PERMITTEES DUE TO UNFORESEEN EROSION PROBLEMS OR IF THE SUBMITTED PLAN DOES NOT FUNCTION AS INTENDED. THE REQUIREMENTS OF THIS PLAN SHALL RUN WITH THE LAND AND BE THE OBLIGATION OF THE PERMITTEES, UNTIL SUCH TIME AS THE PLAN IS PROPERLY COMPLETED, MODIFIED OR VOIDED.</p> </div> |
| Yes ☒ | No ☐ | N/A ☐ | 8. GESC Plan Designer's signature block with name, date, and Professional Engineer registration number. Signature block shall include the following note:

<div style="margin-left: 40px;"> <p>THE GRADING, EROSION AND SEDIMENT CONTROL PLAN INCLUDED HEREIN HAS BEEN PREPARED UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH THE REQUIREMENTS OF THE GRADING, EROSION, AND SEDIMENT CONTROL (GESC) CRITERIA MANUAL OF DOUGLAS COUNTY AS AMENDED.</p> </div> |
| Yes ☐ | No ☐ | N/A ☐ | 9. General Location Map (at a reasonable scale) indicating: <ul style="list-style-type: none"> a. general vicinity of the site location b. major roadway names c. north arrow and scale |



GESC Drawing Index Sheet (if applicable)

For projects that require multiple plan-view sheets to adequately show the project area (based on the specified scale ranges), a single plan-view sheet shall be provided at a scale appropriate to show the entire site on one sheet. Areas of coverage of the multiple blow-up sheets are to be indicated as rectangles on the index sheet.

DUE TO THE SMALL PROJECT SIZE, THE INITIAL, INTERIM, AND FINAL BMPs ARE ALL SHOWN ON THE SAME PLAN.

Initial GESC Plan

Yes ☒	No ☐	N/A ☐	1.	Property Lines
Yes ☒	No ☐	N/A ☐	2.	Existing and proposed easements
Yes ☒	No ☐	N/A ☐	3.	Existing topography at one- or two-foot contour intervals, extending a minimum of 100 feet beyond the property line
Yes ☒	No ☐	N/A ☐	4.	Location of any existing structures or hydrologic features within the mapping limits
Yes ☐	No ☒	N/A ☐	5.	USGS Benchmark used for project SEE DWG C2.
Yes ☒	No ☐	N/A ☐	6.	Limits of construction encompassing all areas of work, including: - Access points, storage and staging areas, borrow areas, stockpiles, and utility tie-in locations in on-site and off-site locations - Stream corridors and other resource areas to be preserved and all other areas outside the limits of construction shall be lightly shaded to clearly show area not to be disturbed.
Yes ☒	No ☐	N/A ☐	7.	Location of stockpiles, including topsoil, imported aggregates, and excess material SEE SSA AREA.
Yes ☐	No ☐	N/A ☒	8.	Location of storage and staging areas for equipment, fuel, lubricant, chemical (and other materials) and waste storage
Yes ☒	No ☐	N/A ☐	9.	Location of borrow or disposal areas SEE SSA AREA.
Yes ☐	No ☐	N/A ☒	10.	Location of temporary roads
Yes ☒	No ☐	N/A ☐	11.	Location, map symbol, and letter callouts of all initial erosion and sediment control BMPs
Yes ☒	No ☐	N/A ☐	12.	Information to be specified for each BMP, such as type and dimensions, as called for in the Standard Notes and Details
Yes ☒	No ☐	N/A ☐	13.	The following note: SEE COVER SHEET OF LONE TREE STANDARD NOTES AND DETAILS (SHEET 1 OF 3) FOR LEGEND OF BMP NAMES AND SYMBOLS.
Yes ☐	No ☐	N/A ☐	14.	Other information as may be reasonably required by Lone Tree



DUE TO THE SMALL PROJECT SIZE, THE INITIAL, INTERIM, AND FINAL BMPs ARE ALL SHOWN ON THE SAME PLAN.

Interim GESC Plan

Yes ☐	No ☐	N/A ☐	1.	Items 1, 2, and 4 through 10 from the Initial GESC Plan
Yes ☒	No ☐	N/A ☐	2.	Existing topography at one- or two-foot contour intervals extending a minimum of 100 feet beyond the property line, as shown on Initial GESC Plan. These contours shall be screened.
Yes ☐	No ☐	N/A ☒	2.	Location of all existing erosion and sediment control measures on site, as shown on the Initial GESC Plan Sheet. These control measures shall be screened. Dimension information for initial stage BMPs shall not be shown.
Yes ☒	No ☐	N/A ☐	3.	Proposed topography at one- or two-foot contour intervals, showing elevations, dimensions, locations, and slope of all proposed grading
Yes ☐	No ☐	N/A ☒	4.	Outlines of cut and fill areas
Yes ☒	No ☐	N/A ☐	5.	Location of all interim erosion and sediment controls, designed in conjunction with the proposed site topography, but also considering the controls designed for the existing topography.
Yes ☒	No ☐	N/A ☐	6.	Locations of all buildings, drainage features and facilities, paved areas, retaining walls, cribbing, water quality facilities, or other permanent features to be constructed in connection with, or as a part of, the proposed work, per approved plat, SIP, RSP, or other improvement plan.
Yes ☒	No ☐	N/A ☐	7.	The following notes: • SEE COVER SHEET OF LONE TREE STANDARD NOTES AND DETAILS (SHEET 1 OF 3) FOR LEGEND OF BMP NAMES AND SYMBOLS. • SHADED BMPs INSTALLED IN THE INITIAL STAGE SHALL BE LEFT IN PLACE IN THE INTERIM STAGE. • ALL INTERIM BMPs, INCLUDING SEEDING AND MULCHING OF DISTURBED AREAS, MUST BE COMPLETED PRIOR TO ISSUANCE OF ANY CURB AND GUTTER PERMITS. • SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINS, AND INLET AND OUTLET PROTECTION.
Yes ☒	No ☐	N/A ☐	8.	Summary of cut and fill volumes
Yes ☐	No ☐	N/A ☐	9.	Other information as may be reasonably required by Lone Tree



DUE TO THE SMALL PROJECT SIZE, THE INITIAL, INTERIM, AND FINAL BMPs ARE ALL SHOWN ON THE SAME PLAN.

Final GESC Plan

- | | | | | |
|---|-----------------------------|---|-----|---|
| Yes ☒ | No ☐ | N/A ☐ | 1. | Items 1, 2, and 5 from the Initial GESC Plan |
| Yes ☒ | No ☐ | N/A ☐ | 2. | Existing topography in areas of proposed contours shall not be shown. |
| Yes ☐ | No ☐ | N/A ☒ | 3. | Existing Initial and Interim BMPs shall be shown (screened). Dimension information shall not be shown. |
| Yes ☒ | No ☐ | N/A ☐ | 4. | Directional flow arrows on all drainage features |
| Yes ☒ | No ☐ | N/A ☐ | 5. | Any Initial or Interim BMPs that are to be removed and any resulting disturbed area to be stabilized |
| Yes ☒ | No ☐ | N/A ☐ | 6. | Location of all Final erosion and sediment control BMPs (including seeding and mulching of any areas not stabilized in the Interim Plan), permanent landscaping, and measures necessary to minimize the movement of sediment off site until permanent vegetation can be established. |
| Yes ☐ | No ☐ | N/A ☒ | 7. | Show area of buildings, pavement, sod, and permanent landscaping (define types) per accepted improvement plan. |
| Yes ☒ | No ☐ | N/A ☐ | 8. | Show seeding and mulching (SM) everywhere except within the limits of buildings and pavement areas. |
| Yes ☐ | No ☐ | N/A ☒ | 9. | Show other BMPs considered by the designer to be appropriate. |
| Yes ☒ | No ☐ | N/A ☐ | 10. | Show the following BMPs to be removed prior to end of construction: <ul style="list-style-type: none"> • Indicate dewatering (DW) to be removed. • Indicate temporary stream crossings (TSC) to be removed. • Indicate stabilized staging area (SSA) to be removed. • Indicate street inlet protection (IP) to be removed. • Indicate vehicle tracking control (VTC) to be removed. • Indicate construction fence (CF) to be removed. |
| Yes ☒ | No ☐ | N/A ☐ | 11. | Include the following notes: <ul style="list-style-type: none"> • SEE COVER SHEET OF LONE TREE STANDARD NOTES AND DETAILS (SHEET 1 OF 3) FOR LEGEND OF BMP NAMES AND SYMBOLS. • SHADED BMPs INSTALLED IN THE INITIAL AND INTERIM GESC PLANS, UNLESS OTHERWISE INDICATED, SHALL BE LEFT IN PLACE UNTIL REVEGETATION ESTABLISHMENT IS APPROVED BY THE CITY. • SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINS, AND INLET AND OUTLET PROTECTION. |
| Yes ☐ | No ☐ | N/A ☒ | 12. | Other information as may be reasonably required by Lone Tree |



GESC Report

- | | | | | |
|---|-----------------------------|---|-----|---|
| Yes ☐ | No ☐ | N/A ☒ | 1. | Name, Address, and Telephone Number of Applicant(s) – The name, address, and telephone number of the Professional Engineer preparing (or supervising the preparation of) the GESC Plan shall also be included, if different from the Applicant's. |
| Yes ☒ | No ☐ | N/A ☐ | 2. | <u>Project Description</u> – A brief description of the nature and purpose of the land-disturbing activity, the total area of the site, the area of disturbance involved, and project location including township, range, section and quarter section, or the latitude and longitude, of the approximate center of the project. |
| Yes ☒ | No ☐ | N/A ☐ | 3. | <u>Existing Site Conditions</u> – A description of the existing topography, vegetation, and drainage; a description of any wetlands on the site; and any other unique features of the property. |
| Yes ☒ | No ☐ | N/A ☐ | 4. | <u>Adjacent Areas</u> – A description of neighboring areas such as streams, lakes, residential areas, roads, etc., which might be affected by the land disturbance. |
| Yes ☒ | No ☐ | N/A ☐ | 5. | <u>Soils</u> – A brief description of the soils on the site including information on soil type and names, mapping unit, erodibility, permeability, hydrologic soil group, depth, texture, and soil structure (this information may be obtained from the soil report for the site, for adjacent sites if acceptable to the County, or the applicable Soil Survey prepared by the Natural Resources Conservation Service). |
| Yes ☒ | No ☐ | N/A ☐ | 6. | <u>Areas and Volumes</u> – An estimate of the quantity (in cubic yards) of excavation and fill involved (indicating a balance onsite), and the surface area (in acres) of the proposed disturbance. |
| Yes ☒ | No ☐ | N/A ☐ | 7. | <u>Erosion and Sediment Control Measures</u> – A description of the methods presented in the GESC Criteria Manual that will be used to control erosion and sediment on the site. |
| Yes ☒ | No ☐ | N/A ☐ | 8. | <u>Timing/Phasing Schedule</u> – A schedule indicating the anticipated starting and completion time periods of the site grading and/or construction sequence, including the installation and removal of erosion and sediment control BMPs. Indicate the anticipated starting and completion time periods of individual project phases. |
| Yes ☒ | No ☐ | N/A ☐ | 9. | <u>Permanent Stabilization</u> – A brief description, including applicable specifications, of how the site will be stabilized after construction is completed. |
| Yes ☒ | No ☐ | N/A ☐ | 10. | <u>Stormwater Management Considerations</u> – Explain how stormwater runoff from and through the site will be handled during construction. |
| Yes ☒ | No ☐ | N/A ☐ | 11. | <u>Maintenance</u> – Any special maintenance requirements over and above what is identified in the standard notes and details. |
| Yes ☒ | No ☐ | N/A ☐ | 12. | <u>Opinion of Probable Cost (City Format)</u> – An opinion of probable costs for erosion and sediment control, including anticipated maintenance during the construction phase, shall be submitted with the GESC Plan. This will be reviewed by City staff and used as a basis for fiscal security. Electronic or paper copies of the spreadsheet to be used for preparing the opinion of probable costs for erosion and sediment control are available upon request. Unit costs used to develop probable erosion and sediment control costs shall be those shown in the spreadsheet. |



Yes ☐	No ☒	N/A ☐	13. <u>Calculations</u> – Any calculations made for the design of such items as sediment basins or erosion control blanket selection.
Yes ☐	No ☐	N/A ☒	14. <u>Other Information</u> – As may be reasonably required by Lone Tree.
Yes ☒	No ☐	N/A ☐	15. <u>The Following Note</u> – “This Grading, Erosion and Sediment Control Plan has been placed in the Lone Tree file for this project and appears to fulfill the applicable Douglas County Grading, Erosion and Sediment Control Criteria, as amended. I understand that additional grading, erosion and sediment control measures may be required of the Permittees, due to unforeseen erosion problems or if the submitted plan does not function as intended. The requirements of this plan shall run with the land and be the obligation of the Permittees until such time as the plan is properly completed, modified or voided.”
Yes ☒	No ☐	N/A ☐	16. <u>Signature Page for Permittees</u> - Acknowledging the review and acceptance of responsibility, and a statement by the Professional Engineer acknowledging responsibility for the preparation of the GESC Plan (available upon request).

Preparer's Signature _____

Date _____

Appendix B: NRCS Soils and Geotechnical Engineer Report



United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National
Cooperative Soil Survey,
a joint effort of the United
States Department of
Agriculture and other
Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for Castle Rock Area, Colorado

Badger Gulch Well Site



July 8, 2025

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<https://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

Preface	2
How Soil Surveys Are Made	5
Soil Map	8
Soil Map (Soil map Badger Gulch).....	9
Legend.....	10
Map Unit Legend (Soil map Badger Gulch).....	11
Map Unit Descriptions (Soil map Badger Gulch).....	11
Castle Rock Area, Colorado.....	13
FoB—Fondis clay loam, 1 to 3 percent slopes.....	13
Lo—Loamy alluvial land.....	14
NeE—Newlin gravelly sandy loam, 8 to 30 percent slopes.....	15
References	17
Glossary	19

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

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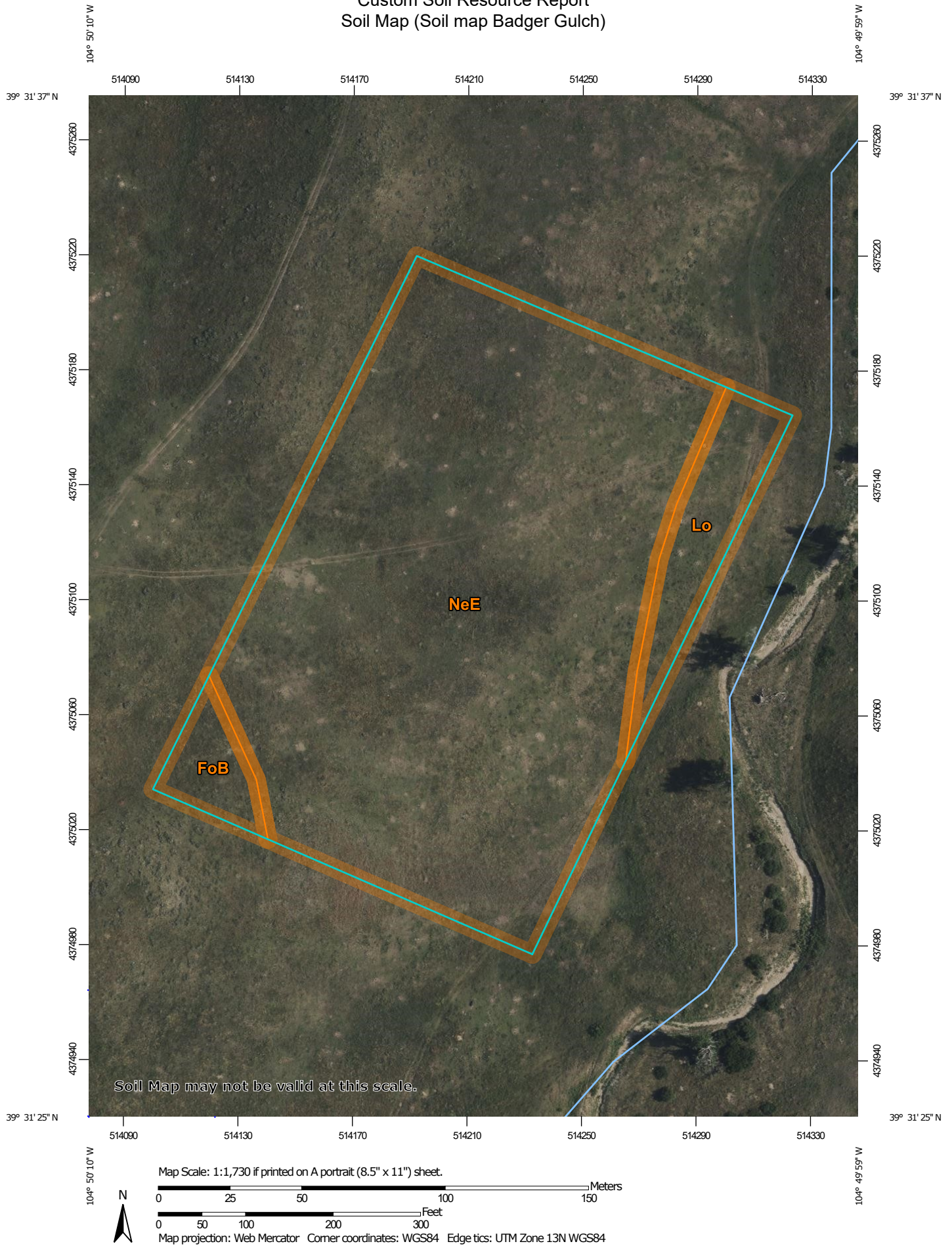
identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

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Soil Map (Soil map Badger Gulch)



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MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil Map Unit Polygons

 Soil Map Unit Lines

 Soil Map Unit Points

Special Point Features

 Blowout

 Borrow Pit

 Clay Spot

 Closed Depression

 Gravel Pit

 Gravelly Spot

 Landfill

 Lava Flow

 Marsh or swamp

 Mine or Quarry

 Miscellaneous Water

 Perennial Water

 Rock Outcrop

 Saline Spot

 Sandy Spot

 Severely Eroded Spot

 Sinkhole

 Slide or Slip

 Sodic Spot

 Spoil Area

 Stony Spot

 Very Stony Spot

 Wet Spot

 Other

 Special Line Features

Water Features

 Streams and Canals

Transportation

 Rails

 Interstate Highways

 US Routes

 Major Roads

 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Castle Rock Area, Colorado
Survey Area Data: Version 17, Aug 29, 2024

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 1, 2023—Sep 1, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Soil map Badger Gulch)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
FoB	Fondis clay loam, 1 to 3 percent slopes	0.3	3.6%
Lo	Loamy alluvial land	0.6	7.5%
NeE	Newlin gravelly sandy loam, 8 to 30 percent slopes	6.6	88.9%
Totals for Area of Interest		7.4	100.0%

Map Unit Descriptions (Soil map Badger Gulch)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate

pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Castle Rock Area, Colorado

FoB—Fondis clay loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: jqyn

Elevation: 5,500 to 6,800 feet

Mean annual precipitation: 15 to 19 inches

Mean annual air temperature: 47 to 50 degrees F

Frost-free period: 120 to 135 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Fondis and similar soils: 80 percent

Minor components: 20 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fondis

Setting

Landform: Ridges, hills, buttes, mesas

Landform position (three-dimensional): Crest

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Eolian deposits over sedimentary rock coarse-silty outwash derived from arkose

Typical profile

H1 - 0 to 7 inches: clay loam

H2 - 7 to 24 inches: clay

H3 - 24 to 60 inches: sandy clay loam

Properties and qualities

Slope: 1 to 3 percent

Depth to restrictive feature: More than 80 inches

Drainage class: Well drained

Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 15 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): 2e

Land capability classification (nonirrigated): 3s

Hydrologic Soil Group: C

Ecological site: R049XB208CO - Clayey Foothill

Hydric soil rating: No

Minor Components

Kutch

Percent of map unit: 7 percent
Hydric soil rating: No

Buick

Percent of map unit: 6 percent
Hydric soil rating: No

Satanta

Percent of map unit: 6 percent
Hydric soil rating: No

Aquic haplustolls

Percent of map unit: 1 percent
Landform: Swales
Hydric soil rating: Yes

Lo—Loamy alluvial land

Map Unit Setting

National map unit symbol: jqzb
Elevation: 7,000 to 8,000 feet
Mean annual precipitation: 17 to 19 inches
Mean annual air temperature: 44 to 46 degrees F
Frost-free period: 115 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Loamy alluvial land: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Loamy Alluvial Land

Setting

Landform: Swales, flood plains
Down-slope shape: Linear
Across-slope shape: Linear

Typical profile

H1 - 0 to 20 inches: sandy loam
H2 - 20 to 40 inches: stratified loamy sand to clay loam
H3 - 40 to 60 inches: sand and gravel

Properties and qualities

Slope: 1 to 5 percent
Drainage class: Well drained
Runoff class: Very low

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Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.20 to 6.00 in/hr)

Depth to water table: About 48 to 72 inches

Frequency of flooding: Frequent

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)

Available water supply, 0 to 60 inches: Moderate (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4w

Hydrologic Soil Group: C

Ecological site: R049XY036CO - Overflow

Hydric soil rating: No

Minor Components

Sampson

Percent of map unit: 7 percent

Hydric soil rating: No

Bresser

Percent of map unit: 7 percent

Hydric soil rating: No

Sandy alluvial land

Percent of map unit: 5 percent

Fluvaquentic haplustolls

Percent of map unit: 1 percent

Landform: Terraces

Hydric soil rating: Yes

NeE—Newlin gravelly sandy loam, 8 to 30 percent slopes

Map Unit Setting

National map unit symbol: jqzg

Elevation: 5,500 to 6,600 feet

Mean annual precipitation: 15 to 19 inches

Mean annual air temperature: 49 to 51 degrees F

Frost-free period: 120 to 135 days

Farmland classification: Not prime farmland

Map Unit Composition

Newlin and similar soils: 85 percent

Minor components: 15 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Newlin

Setting

Landform: Plateaus, mesas, terraces

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Landform position (three-dimensional): Riser

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Unconformable sandy and gravelly and/or mixed source alluvium

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam

H2 - 8 to 17 inches: gravelly sandy clay loam

H3 - 17 to 22 inches: gravelly sandy loam

H4 - 22 to 60 inches: very gravelly sand

Properties and qualities

Slope: 8 to 30 percent

Depth to restrictive feature: More than 80 inches

Drainage class: Well drained

Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.20 to 2.00 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: B

Ecological site: R049XY214CO - Gravelly Foothill

Hydric soil rating: No

Minor Components

Bresser

Percent of map unit: 5 percent

Hydric soil rating: No

Stapleton

Percent of map unit: 4 percent

Hydric soil rating: No

Satanta

Percent of map unit: 4 percent

Hydric soil rating: No

Aquic haplustolls

Percent of map unit: 2 percent

Landform: Swales

Hydric soil rating: Yes

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "[National Soil Survey Handbook](#)."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3

Low: 3 to 6

Moderate: 6 to 9

High: 9 to 12

Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluvies. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology)

from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the "Soil Survey Manual."

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left

behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity*, *normal moisture capacity*, or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the "Soil Survey Manual." The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2

Low: 0.2 to 0.4

Moderately low: 0.4 to 0.75

Moderate: 0.75 to 1.25

Moderately high: 1.25 to 1.75

High: 1.75 to 2.5

Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $1/3$ - or $1/10$ -bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can

occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent

Low: 0.5 to 1.0 percent

Moderately low: 1.0 to 2.0 percent

Moderate: 2.0 to 4.0 percent

High: 4.0 to 8.0 percent

Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan*, *fragipan*, *claypan*, *plowpan*, and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and

promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5

Extremely acid: 3.5 to 4.4

Very strongly acid: 4.5 to 5.0

Strongly acid: 5.1 to 5.5

Moderately acid: 5.6 to 6.0

Slightly acid: 6.1 to 6.5

Neutral: 6.6 to 7.3

Slightly alkaline: 7.4 to 7.8

Moderately alkaline: 7.9 to 8.4

Strongly alkaline: 8.5 to 9.0

Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
 - A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
 - B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
 - C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
 - A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
 - B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where "Rock outcrop" is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which "severely eroded," "very severely eroded," or "gullied" is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^+ to $\text{Ca}^{++} + \text{Mg}^{++}$. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0

Coarse sand: 1.0 to 0.5

Medium sand: 0.5 to 0.25

Fine sand: 0.25 to 0.10

Very fine sand: 0.10 to 0.05

Silt: 0.05 to 0.002

Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated

Prismatic: Vertically elongated and having flat tops

Columnar: Vertically elongated and having rounded tops

Angular blocky: Having faces that intersect at sharp angles (planes)

Subangular blocky: Having subrounded and planar faces (no sharp angles)

Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand

Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field

generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an oven-dry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

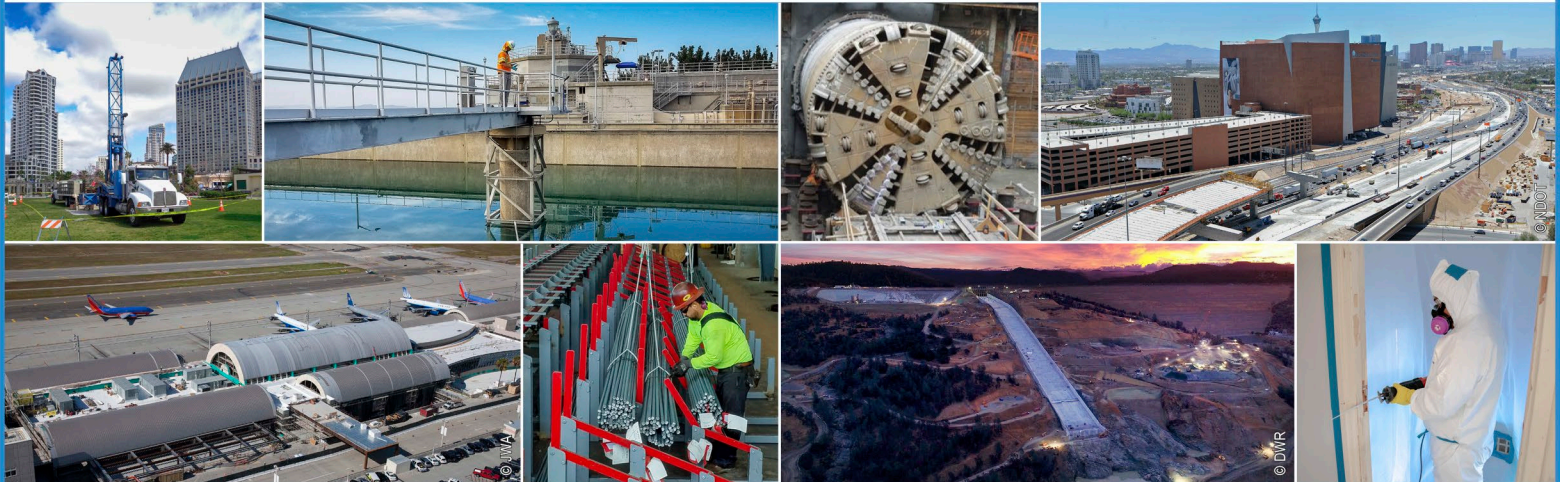
The uprooting and tipping over of trees by the wind.

Geotechnical Evaluation Parker Water & Sanitation District Denver Basin Well Sites Phase II and Pipeline Project Parker, Colorado

Hazen and Sawyer

6251 Greenwood Plaza Boulevard, Suite 275 | Greenwood Village, Colorado 80111

June 30, 2025 | Project No. 503147001



Geotechnical | Environmental | Construction Inspection & Testing | Forensic Engineering & Expert Witness

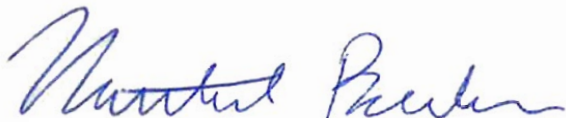
Geophysics | Engineering Geology | Laboratory Testing | Industrial Hygiene | Occupational Safety | Air Quality | GIS

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CONTENTS

1	INTRODUCTION	1
2	SCOPE OF SERVICES	1
3	SITE DESCRIPTION	2
4	PROPOSED CONSTRUCTION	2
5	FIELD EXPLORATION AND LABORATORY TESTING	2
6	GEOLOGY AND SUBSURFACE CONDITIONS	3
6.1	Geologic Setting	3
6.2	Subsurface Conditions	4
6.2.1	Fill Material	4
6.2.2	Alluvium	4
6.2.3	Dawson Formation Bedrock	5
6.3	Groundwater	5
7	GEOLOGIC HAZARDS	5
7.1	Expansive Soils and Bedrock	6
7.2	Compressible Fill Material	6
8	CONCLUSIONS	6
9	RECOMMENDATIONS	7
9.1	Demolition	8
9.2	Earthwork	8
9.2.1	Excavations	8
9.2.2	Temporary Excavations and Shoring	9
9.2.3	Site and Remedial Grading	10
9.2.4	Utility Installation	11
9.2.5	Re-Use of Site Soils	13
9.2.6	Fill Placement and Compaction	13
9.2.7	Imported Soil	14
9.2.8	Controlled Low Strength Material	14
9.3	Equipment Pad Foundations	15
9.4	Modulus of Soil Reaction, E'	16
9.5	Thrust Restraint	16

9.6	Lateral Earth Pressures	16
9.7	Pavement Restoration	17
9.8	Aggregate Surfaced Lot and Roadway	18
9.9	Corrosion Considerations	19
9.9.1	Concrete	19
9.9.2	Buried Metal Pipes	20
9.10	Construction in Cold or Wet Weather	20
9.11	Construction Observation and Testing	21
9.12	Plan Review	21
9.13	Pre-Construction Meeting	21
10	LIMITATIONS	21
11	REFERENCES	23

TABLES

1 – Passive Pressures for Thrust Block Design	16
2 – Recommended Lateral Earth Pressures	17
3 – Corrosion Potential to Steel	20

FIGURES

1A – Ridgeway Pipeline Site Location
1B – Rueter-Hess Pipeline Site Location
2A – Ridgeway Pipeline Boring Locations
2B – Ridgeway Pipeline Boring Locations
2C – Ridgeway Pipeline Boring Locations
2D – Ridgeway Pipeline Boring Locations
3 – Rueter-Hess Pipeline Boring Locations
4 – Cross Section Locations

APPENDICES

A – Boring Logs
B – Laboratory Testing
C – Site Photographs and Descriptions
D – Cross Sections
E – ESAL Estimate

1 INTRODUCTION

In accordance with your authorization and our proposal dated November 8, 2024, we have performed a geotechnical evaluation for the Parker Water and Sanitation District (PWSD) Denver Basin Well Sites Phase II and Pipeline project in Parker, Colorado. The approximate locations of the sites are depicted on Figures 1A and 1B.

The purpose of our study was to evaluate the subsurface conditions and to provide design and construction recommendations regarding geotechnical aspects of the proposed project. This report presents the findings of our subsurface exploration program, results of our laboratory testing, conclusions regarding the subsurface conditions at the sites, and geotechnical recommendations for design and construction of this project.

2 SCOPE OF SERVICES

The scope of our services for the project generally included:

- Review of referenced background information, including aerial imagery, published geologic and maps, in-house geotechnical data, and available topographical information pertaining to the project site and vicinity.
- Performance of a geologic reconnaissance and mark-out of the boring locations at the project site and notification of Utility Notification Center of Colorado for mark-out of publicly owned utilities prior to drilling. Boring locations and elevations were established using a Trimble DA2 antenna with Trimble Catalyst Precision software.
- Drilling logging and sampling of 13 small-diameter exploratory borings along the proposed waterline alignments to depths ranging from approximately 14.5 to 15 feet below ground surface (bgs). Borings B-1 through B-11 were advanced at the proposed Ridgeway Well House Site Phase II and Badger Gulch Pipeline and Borings B-12 and B-13 were performed at the proposed Rueter-Hess Well House Site Phase II and Pipeline. The boring logs are presented in Appendix A. The locations of the borings are presented on Figures 2A-2D and Figure 3.
- Performance of laboratory tests on selected samples obtained from the borings to evaluate engineering properties including in-situ moisture content and dry density, Atterberg limits, percent materials finer than the No. 200 sieve, swell and consolidation potential, direct shear, unconfined compressive strength (UCS), and soil corrosivity characteristics (including pH, resistivity, water-soluble sulfates, and chlorides). The results of the laboratory testing are presented on the boring logs and in Appendix B.
- Compilation and analysis of the data obtained. Site photographs associated with our February 26, 2025 initial site assessment are presented in Appendix C. Cross-sections of the subsurface conditions encountered are presented in Appendix D. Approximate cross-section locations are presented on Figure 4.
- Preparation of this report presenting our findings, conclusions, and geotechnical recommendations regarding design and construction of the project.

3 SITE DESCRIPTION

The project will include the development of two sites located in Parker, Colorado. The proposed Ridgeway Well Site Phase II and Badger Gulch Pipeline (Ridgeway Pipeline) is located north to northeast of the intersection of Ridgeway Parkway and Highnote Avenue. The proposed Rueter-Hess Well Site Phase II and Pipeline (Rueter-Hess Pipeline) is located southeast of the intersection of Chambers Road and Stroh Road. Topography of the Ridgeway Pipeline varies and undulates along the proposed alignment, while topography of the Rueter-Hess Pipeline generally decreases from a high point near Stroh Road.

Past storm line construction activities were evident at the Ridgeway Pipeline and grading operations were underway at the Rueter-Hess Pipeline for surrounding residential developments.

Ninyo & Moore performed an initial site assessment on February 26, 2025, and site photographs and descriptions from this visit are presented in Appendix C.

4 PROPOSED CONSTRUCTION

The proposed project will include the design and construction of approximately 6,500 feet of 8-inch diameter raw waterline connecting the Ridgeway Well Site Phase II with the existing Ridgeway Well House (Hazen and Sawyer, 2025b). The project will also include approximately 500 feet of 8-inch diameter raw waterline connecting the Rueter-Hess Well Site Phase II to existing waterline in Stroh Road (Hazen and Sawyer, 2025a). Proposed construction at each site will also consist of electrical equipment and transformer pads, an aggregated surfaced parking area and access road, a blowdown pond and outflow, and an approximately 12 foot by 20 foot below-grade vault (Hazen and Sawyer, 2025a). The proposed vaults will bear approximately 10 feet bgs.

We assume the proposed waterline will be located between depths of approximately 5 to 7 feet bgs. Utility construction will consist of standard open cut trenching and will not require trenchless operations.

5 FIELD EXPLORATION AND LABORATORY TESTING

On March 7, 10, and 11, 2025, Ninyo & Moore conducted subsurface exploration services along the subject alignments to evaluate the existing subsurface conditions and to collect soil and bedrock samples for visual observation and laboratory testing. The evaluation consisted of drilling, logging, and sampling of 13 small-diameter exploratory borings along the proposed

alignments. Borings B-1 through B-11 were advanced at the Ridgeway Pipeline and Borings B-12 and B-13 were performed at the Rueter-Hess Pipeline. The borings were advanced using a truck-mounted drill rig equipped with four-inch diameter, continuous-flight, and solid-stem augers. The borings were advanced to depths ranging from approximately 14.5 to 15 feet bgs. The approximate boring locations at the Ridgeway Pipeline are presented on Figures 2A through 2D and boring locations at the Rueter-Hess Pipeline are presented on Figure 3. Boring coordinates and ground elevations were measured in the field using a Trimble Model DA2-BT survey unit with a global navigation satellite system output of NAD83 (2011) and referencing Geoid model GEOID18. Boring coordinates and elevations are included on the boring logs in Appendix A. Relatively undisturbed and disturbed soil samples were collected at selected intervals. Photographs and descriptions of drilling activities are presented in Appendix C.

The soil and bedrock samples collected from our drilling activities were transported to the Ninyo & Moore laboratory for geotechnical laboratory analysis. Selected samples were analyzed to evaluate engineering properties including in-situ moisture content and dry density, Atterberg limits, percent fines passing the No. 200 sieve, direct shear, UCS, swell/consolidation, and soil corrosivity characteristics (pH, resistivity, water-soluble sulfates, and chlorides). The results of the in-situ moisture content and dry density tests are presented on the boring logs in Appendix A. A description of each laboratory test method and the remainder of the laboratory test results are presented in Appendix B.

6 GEOLOGY AND SUBSURFACE CONDITIONS

The geology and subsurface conditions at the site are described in the following sections.

6.1 Geologic Setting

The sites are located in Parker, Colorado, approximately 16 miles east of the Rocky Mountains, within the Colorado Piedmont section of the Great Plains Physiographic Province. The Laramide Orogeny uplifted the Rocky Mountains during the late Cretaceous and early Tertiary Periods. Subsequent erosion deposited sediments east of the Rocky Mountains. As a result of regional uplift approximately 5 to 10 million years ago, streams and rivers down-cut and excavated into the Great Plains forming the Colorado Piedmont section (Trimble, 1980).

The surficial geology of the site vicinity, which lies in the Parker Quadrangle, is mapped by Maberry and Lindvall (1972) as Pleistocene loess and alluvium. Alluvial deposits mapped within the site vicinity are generally considered to be some of the oldest surficial units in the quadrangle. Loess is mapped overlying the older alluvial deposits consisting of silt and clay,

commonly mixed with fine sand. Based on site observations, Ninyo & Moore believes that most of the near surface native soils within the project vicinities were deposited by alluvial processes.

Bedrock mapped as the Dawson Formation underlies the surficial soils within the site vicinity. The Dawson Formation in the site vicinity is composed of coarse arkosic sandstone and contains common beds of greenish-gray-to olive green sandy claystone.

6.2 Subsurface Conditions

Our understanding of the subsurface conditions at the project site is based on our field exploration, laboratory testing, review of published geologic maps, historic aerial imagery, and our experience with the general geology of the area. The following sections provide a generalized description of the subsurface materials encountered. More detailed descriptions are presented on the boring logs in Appendix A. Cross Sections A-A', B-B' and C-C', presented in Appendix D, illustrate changing subsurface conditions between Borings B-1 and B-4, Borings B-4 and B-10, and Borings B-10 and B-11, respectively. The approximate cross section locations are presented on Figure 4.

6.2.1 Fill Material

Fill was encountered at the surface in Borings B-1, B-6, B-7, B-12, and B-13. The fill materials encountered generally consisted of light to brown, dry to moist, lean clay with various amounts of sand and gravel.

Varying thickness of fill may be encountered along the proposed alignments in areas that were not explored. Information regarding ground preparation, remedial excavation, and the degree of compaction during placement, is unknown to this firm. As a result, the fill material is considered undocumented.

6.2.2 Alluvium

Alluvial deposits were encountered at the surface in Borings B-2, B-3 through B-5, and B-8 through B-11 and below fill in Borings B-1, B-6, B-7, B-12 and B-13. The alluvium extended to the borings' termination depths of approximately 15 feet bgs in Borings B-1 through B-4, B-6 through B-8, and B-13. In the remaining borings, bedrock was encountered below alluvium and the alluvial deposits extended to depths ranging from approximately 2 to 14 feet bgs.

The alluvium encountered generally consisted of various shades of brown, dry to moist, stiff to hard, fat to lean clay with various amounts of sand as well as loose to medium dense, clayey to relatively clean sand. Alluvium was also found to have varying amounts of gravel.

Based on the results of the laboratory testing, selected samples of the alluvial deposits had in-place moisture contents between approximately 3.3 and 26.4 percent, and dry densities ranging between approximately 80.5 and 120.3 pounds per cubic foot (pcf).

6.2.3 Dawson Formation Bedrock

Bedrock mapped as the Dawson Formation was encountered in Boring B-5 as well as Borings B-9 through B-12. Bedrock was encountered at depths of approximately 2 to 14 feet bgs and extended to the borings' termination depths of approximately 14.5 to 15 feet bgs. Bedrock depths encountered in the Borings B-5 and B-9 through B-12 at the Ridgeway Pipeline correspond to approximate bedrock elevations ranging between approximately 5,975.2 and 6,023.8 feet, while bedrock depth encountered in Boring B-12 at the Rueter-Hess Pipeline corresponds to an approximate bedrock elevation of 6,183.3 feet.

The Dawson Formation generally classified as weakly to strongly cemented, sandstone and moderately soft to hard, claystone.

Based on the results of the laboratory testing, selected samples of the bedrock had in-place moisture contents between approximately 8.2 and 32.1 percent, and dry densities ranging between approximately 86.1 and 102.9 pcf.

6.3 Groundwater

Groundwater was not encountered during drilling, however, groundwater levels can fluctuate due to seasonal variations in precipitation, irrigation, groundwater withdrawal or injection, and other factors. In addition, perched water can develop within higher permeability soils following periods of heavy or prolonged precipitation or at the overburden and bedrock interface. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project.

7 GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site including expansive soils and bedrock and compressible and collapsible soils.

7.1 Expansive Soils and Bedrock

One of the more significant geologic hazards in the Front Range area is the presence of swelling clays in bedrock or surficial deposits. Wetting and drying of bedrock or surficial deposits containing swelling clays can result in expansion and collapse of those units, which can cause major damage to structures. A review of a Colorado Geological Survey map delineating areas based on their relative potential for swelling in the Front Range by Hart (1973-1974) indicates that the soil and bedrock in the site vicinity can exhibit up to high swell potential.

To assess the swell potential of the subsurface soils and bedrock, we collected relatively undisturbed samples for one-dimensional swell/consolidation tests, conducted at surcharge pressures that closely resemble representative field conditions, in accordance with guidelines outlined in the American Society for Testing and Materials (ASTM) D4546.

Selected samples were tested for swell/consolidation against surcharge pressures of 500 pounds per square foot (psf). The selected samples tested exhibited swell potentials up to 3.4 percent. Based on these results, the soils expected to be encountered during project development are considered to have a low to moderate swell potential. Remedial grading recommendations are provided in this report to reduce the impacts of the site soils with low to moderate swell potential.

7.2 Compressible Fill Material

Compression of fill material encountered in our borings could occur due to new loads imparted by equipment pads, aggregate surfaced parking and drive lanes, and other improvements. As a result, remedial grading recommendations are provided in this report to reduce the impacts of the existing fill material.

8 CONCLUSIONS

Based on the results of the subsurface evaluation, laboratory testing, and data analyses, it is our opinion that the proposed project is feasible from a geotechnical standpoint, provided the recommendations presented herein are implemented and appropriate construction practices are followed. Geotechnical design and construction considerations for the proposed project include the following:

- Fill was encountered at the surface in Borings B-1, B-6, B-7, B-12, and B-13. The fill materials encountered generally consisted of light to brown, dry to moist, lean clay with various amounts of sand and gravel. The fill material is considered undocumented.
- Alluvial deposits were encountered at the surface in Borings B-2, B-3 through B-5, and B-8 through B-11 and below fill in Borings B-1, B-6, B-7, B-12 and B-13. The alluvium extended

to the borings' termination depths of approximately 15 feet bgs in Borings B-1 through B-4, B-6 through B-8, and B-13. In the remaining borings, bedrock was encountered below alluvium and the alluvial deposits extended to depths ranging from approximately 2 to 14 feet bgs. The alluvium encountered generally consisted of various shades of brown, dry to moist, stiff to hard, fat to lean clay with various amounts of sand as well as loose to medium dense, clayey to relatively clean sand. Alluvium was also found to have varying amounts of gravel.

- Bedrock mapped as the Dawson Formation was encountered in Boring B-5 as well as Borings B-9 through B-12.
 - Bedrock was encountered at depths of approximately 2 to 14 feet bgs and extended to the borings' termination depths of approximately 14.5 to 15 feet bgs. Bedrock depths encountered in the Borings B-5 and B-8 through B-11 at the Ridgeway Pipeline correspond to approximate bedrock elevations ranging between approximately 5,975.2 and 6,023.8 feet, while bedrock depth encountered in Boring B-12 at the Rueter-Hess Pipeline corresponds to an approximate bedrock elevation of 6,183.3 feet.
 - The Dawson Formation generally classified as weakly to strongly cemented, sandstone and moderately soft to hard, claystone.
- Groundwater was not encountered during drilling; however, perched water can develop within higher permeability soils following periods of heavy or prolonged precipitation or at the overburden and bedrock interface. The possibility of groundwater level fluctuations and perched water should be considered when developing the design and construction plans for the project.
- Our evaluation of the excavation characteristics of the on-site materials is based on the results of the subsurface exploration, our site observations, and our experience with similar materials. The on-site surface and near-surface soils may generally be excavated with moderate- to heavy-duty earthmoving or excavation equipment in good operating condition. Excavation of Dawson Formation bedrock may be difficult and heavy-duty excavating equipment and the use of special equipment (i.e. single-shank rippers) or other rock breaking means may be needed.
- Remedial grading should be performed below site improvements and aggregate surfaced roadways as described in Section 9.2.3.
- Based on our laboratory data and our experience with similar materials at adjacent sites, the sulfate content of the tested soils presents a negligible risk of sulfate attack to concrete.
- Based on our laboratory data and our experience with similar materials at adjacent sites, the soils at the site may present severe corrosion potential to ferrous metals. Therefore, special consideration should be given to the use of heavy gauge, corrosion-protected, underground steel pipe, if any are planned. As an alternative, plastic pipe could be considered. A corrosion specialist should be consulted for further recommendations.

9 RECOMMENDATIONS

Based on our understanding of the proposed construction, the following sections present our geotechnical recommendations for design and construction of the proposed pipeline alignments.

Ninyo & Moore should be notified and given an opportunity to reevaluate our recommendations if the proposed construction is altered.

9.1 Demolition

The subject project will include partial demolition of existing pavements at utility crossings and potentially abandoned utilities. Remnants from the demolition activities should be removed from the site. Demolition of the existing improvements should include rerouting, removal, or in-place abandonment of underground utilities. Utilities should be adequately capped or rerouted at the in accordance with the requirements of the governing authorities and the recommendations of the geotechnical consultant at the time of demolition. Abandoned underground utility pipes under the proposed pipeline alignments should be removed from the site, or, if the pipes are left in place, they should be filled with flowable fill, such as grout or controlled low strength material (CLSM). The contractor should take adequate precautions to reduce the potential for damage to existing utilities that are to remain in service.

Though not anticipated, if existing underground utility pipes will be left in place under the proposed pipeline alignment, these should be discussed on a case-by-case basis with the project Geotechnical Engineer and the design team. Additional site-specific evaluations and data analysis will be needed to address these conditions.

9.2 Earthwork

The following sections provide our earthwork recommendations for this project. In general, PWSD and/or project specific specifications are expected to apply unless otherwise noted.

9.2.1 Excavations

Our evaluation of the excavation characteristics of the on-site materials is based on the results of the subsurface exploration, our site observations, and our experience with similar materials. The site soils should generally be excavated with medium- to heavy-duty earthmoving or excavation equipment in good operating condition. Excavation of Dawson Formation bedrock may be difficult and heavy-duty excavating equipment and the use of special equipment (i.e. single-shank rippers) or other rock breaking means may be needed. The excavation difficulties and wear and tear on the equipment will increase as the cementation of the sandstone bedrock layers and lenses increase. The earthwork contractor should anticipate encountering difficult excavation conditions, including increased wear and tear on equipment, within the bedrock at this site.

Equipment and procedures that do not cause significant disturbance to the excavation bottoms should be used. Excavators and backhoes with buckets having large claws to loosen the subgrade material should be avoided when excavating the bottom 6 to 12 inches of excavations as such equipment may disturb the excavation bases.

If the excavation subgrade becomes disturbed, it should be scarified, moisture-conditioned, and compacted or stabilized before placing pipe bedding material.

Groundwater was not encountered within the borings advanced for this study, and therefore is not anticipated to be a constraint during site excavations. However, groundwater levels will fluctuate due to seasonal variations from precipitation, irrigation, groundwater withdrawal or injection, and other factors. In addition, perched groundwater may develop or be encountered within higher permeability alluvium or at the overburden soil and bedrock interface, especially after prolonged precipitation or snow-melt events.

The contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with Occupational Safety and Health Administration (OSHA, 2005) guidelines, for employees working in an excavation that may expose employees to the danger of moving ground. If material is stored or equipment is operated near an excavation, stronger shoring should be used to resist the extra pressure due to superimposed loads.

9.2.2 Temporary Excavations and Shoring

The near-surface soils encountered in the exploratory borings were comprised predominantly of interlayered cohesive and cohesionless soils. In our opinion, temporary slopes in the near-surface fill and alluvial soils should be stable at a slope ratio of approximately 1:1 (horizontal[H]:vertical[V]) or flatter. Temporary slopes should be evaluated in the field by a competent person in accordance with OSHA guidelines. The near-surface soils are considered Type B soils, as evaluated by OSHA. Temporary excavations should conform to OSHA regulations.

The formational materials (Dawson Formation bedrock) at the site should generally be considered Type A soil, where inclinations of 3/4(H):1V or flatter can be considered.

The contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with OSHA regulations, for employees working in excavations that may expose them to the danger of moving ground. Reducing the inclination of the sidewalls of the excavations, where feasible, may increase the stability of

the excavations. If construction or earth material is stored, or equipment is operated near an excavation, flatter slope geometry or shoring should be used during construction.

In areas where the proximity of the existing improvements limit the construction of temporary slopes, design and construction of temporary shoring or bracing systems will be needed to complete the pipeline excavations. Shoring or bracing systems should be designed for the contractor by a professional engineer registered in the State of Colorado. In addition to lateral earth pressures, shoring design should include surcharge loads exerted by adjacent existing structure foundations, construction equipment, construction traffic, material stockpiles, etc. located within a 1:1 (H:V) plane extending upward from the toe of the excavation. Shoring design should discuss the anticipated top deflection of the shoring components. The deflection of the temporary shoring components will translate into a triangular-shaped wedge of settlement perpendicular to the shoring. Depending on the anticipated top deflection of the shoring components, settlement of buried utility lines and exterior flatwork located within close proximity (approximately 10 feet or more) of the temporary shoring should be anticipated.

9.2.3 Site and Remedial Grading

Prior to grading, the ground surface in proposed improvement areas should be cleared of any surface obstructions, debris, asphalt, topsoil, organics (including vegetation), and other deleterious degradable and decomposable material. Materials generated from clearing operations should be removed from the site and disposed of at a legal dump site. Obstructions that extend below finish grade, if present, should be removed and the resulting holes filled with compacted soil or cement slurry, in accordance with the recommendations of the geotechnical consultant.

Equipment pads may be placed on 24 or more inches of moisture conditioned and compacted engineered fill, with 12 or more inches of moisture-conditioned and compacted engineered fill below the turn-down edges. The limits of this moisture-conditioned and engineered fill should extend laterally 12 or more inches beyond the turndown edges.

The below-grade vaults may be placed on 12 or more inches of moisture conditioned and compacted engineered fill. The limits of this moisture-conditioned and engineered fill should extend laterally 12 or more inches beyond the vault.

Aggregate surfaced parking and roadways may be placed on 12 or more inches of moisture conditioned and compacted engineered fill.

Engineered fill and aggregate surfaced roadways should be moisture-conditioned, placed, and compacted in accordance with the recommendations set forth in Section 9.2.6.

Depending on the time of year construction occurs, unstable subgrade conditions may be encountered during general construction operations. Subgrade conditions should be observed by Ninyo & Moore during construction. Where unstable subgrade conditions develop, stabilization measures will need to be employed. Stabilization methods should be provided by the grading contractor, as needed, and may include the use of geogrids, geotextiles, pushing oversized rock into the subgrade, and chemical stabilization. The subgrade stabilization methods proposed should be discussed with the geotechnical engineer prior to implementation. The stabilization method selected should consider the effects of such stabilization on future utility installation and/or repair work.

The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations, and care should be taken to maintain the moisture content of the subgrade prior to construction of equipment pads, vaults, aggregate surfaced roads, or other improvements. If the subgrade should become desiccated, saturated, frozen, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompact prior to equipment pad or structure construction.

The geotechnical consultant should be retained to observe the remedial excavations, and the elevations of the excavation bottoms should be surveyed by the project civil engineer prior to fill placement.

9.2.4 Utility Installation

The contractor should take care to achieve and maintain adequate compaction of the backfill soils around valve risers and other vertical pipeline elements where settlements commonly are observed. Additionally, excavation bottoms should be firm and unyielding prior to pipe bedding material and pipe placement. Use of CLSM should be considered in lieu of compacted soil backfill for areas with low tolerances for surface settlements. This would also reduce the permeability of the utility trenches.

Trench width, pipe bedding materials, placement, and compaction should meet the specifications of the pipe manufacturer and applicable municipal standards. Notwithstanding, the trench width should be a minimum of 2 feet and 4 inches wide to allow for bedding placement and embedment placement (PWSD, 2017) and trench subgrade conditions should be observed by Ninyo & Moore prior to bedding and pipe placement.

Bedding shall be at least 6 inches thick below the pipe and 12 inches above the pipe (PWSD, 2017). PWSD standards specify that bedding material should consist of squeegee sand for pipes with diameters less than 20 inches. Squeegee should have 100 percent passing the No. 3/8-inch sieve and between 0 and 3 percent passing the No. 200 sieve (PWSD, 2016). Materials proposed for use as pipe bedding should be tested for suitability prior to use.

Trench backfill, regardless of location, should be moisture-conditioned, placed, and compacted in accordance with the recommendations set forth in Section 9.2.6.

Special care should be exercised to avoid damaging the pipe or other structures during the compaction of the backfill. In addition, the underside (or haunches) of the buried pipe should be supported on bedding material that is compacted as described above. This may need to be performed with placement by hand or small-scale compaction equipment.

Surface drainage should direct water away from utility trench alignments. Where topography, site constraints or other factors limit or preclude adequate surface drainage or as added precaution, the granular bedding materials should be surrounded by non-woven filter fabric (e.g., TenCate Mirafi® 140N or the equivalent) to reduce migration of fines into the bedding which can result in severe, isolated settlements.

Development of site grading plans should consider the subsurface transfer of water in utility trenches and the pipe bedding. Coarse-grained pipe bedding materials with little or no fines can function as efficient conduits for re-distribution of natural and applied waters in the subsurface. Cut-off walls in utility trenches or other water-stopping measures should be considered to reduce the rates and volumes of water transmitted along utility alignments and toward buildings, pavements and other structures where excessive wetting of the underlying soils will be damaging. Incorporation of water cut-offs and/or outlet mechanisms for saturated bedding materials into development plans could be beneficial to the project. These measures also will reduce the risk of loss of fine-grained backfill soils into the bedding material with resultant surface settlement. Cut-off walls could be constructed using 2 or more feet thick clay earth material or 1 or more feet thick CLSM extending 12 or more inches into undisturbed soil on each side and bottom of the trench, and extending 2 or feet above the utility pipe. The placement locations for such cut off walls should be decided by the Project Civil Engineer based on susceptibility of the utility bedding to water intrusion. Cut off walls could be considered for the Ridgeway Pipeline at Stations 40+00, 44+75, 50+00, and 64+00 to reduce velocity of subsurface water transmitted along the utility alignments (Hazen and Sawyer, 2025c).

9.2.5 Re-Use of Site Soils

Site soils generated from on-site excavation activities that are free of deleterious materials and organic matter, and do not contain particles larger than 3 inches in nominal diameter, can generally be used as engineered fill and trench backfill.

If excavated formational materials are to be used as engineered fill, significant processing (i.e. disking in an open area) of these materials will be needed to break-down the bedrock to 3-inch or smaller fragments prior to placement.

Fragments of rock, cobbles, and inert construction debris (e.g., concrete or asphalt) larger than 3 inches in diameter may be incorporated below the anticipated utility installation depths. A Geotechnical Engineer should be consulted regarding appropriate recommendations for usage of such materials on a case-by-case basis when such materials have been observed during earthwork. Care should be taken to avoid nesting of oversized materials during placement. Recommendations provided in Section 203 of the current the Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction should be followed during the placement of oversized material.

Additional evaluation and laboratory testing should be performed during earthwork activities to better evaluate the suitability of the on-site soils for re-use as backfill. An evaluation of the potential for contamination by hazardous materials was beyond the scope of this study and the possibility of restrictions on full material importation and re-use due to environmental factors was not studied.

9.2.6 Fill Placement and Compaction

Fine-grained, cohesive soils (CL or CH) used as engineered fill for site improvements or trench backfill should be moisture-conditioned to moisture contents between optimum and 3 percent over optimum moisture content. Granular soils (SC, SP-SC, SP, and imported soils) used as engineered fill should be moisture-conditioned to moisture contents within 2 percent of optimum moisture content. Fill should be compacted to a relative compaction of 95 percent or more as evaluated by ASTM D698.

The fill should be compacted by appropriate mechanical methods. Lift thickness for fill will be dependent upon the type of compaction equipment utilized. Backfill should be placed in lifts not exceeding 8 inches in loose thickness in areas compacted by other-than hand

operated machines. Backfill should be placed in lifts not exceeding 6 inches in loose thickness in areas compacted by hand operated machines.

Fill materials should not be placed, worked, rolled while they are frozen, thawing, or during poor/inclement weather conditions.

Compaction areas should be kept separate, and no lift should be covered by another until relative compaction and moisture content within the recommended ranges are obtained.

9.2.7 Imported Soil

Imported soil to be used as trench backfill should be free of organic material and other deleterious materials should have a very low to low expansion potential (less than 1 percent against a surcharge pressure of 500 psf when remolded at optimum moisture content). Imported fill should have between approximately 15 and 40 percent passing the No. 200 sieve and should have a plasticity index of 15 or less.

Import soil in contact with ferrous metals should have low corrosion potential. Import material in contact with concrete should have soluble sulfate content less than 0.1 percent.

We further recommend that proposed import soils be evaluated by the project's geotechnical consultant at the borrow source for its suitability prior to importation to the project site. Import soil should be moisture-conditioned and placed and compacted in accordance with the recommendations set forth in Section 9.2.6.

9.2.8 Controlled Low Strength Material

PWSD may require use of flowable fill in roadway cuts. Use of CLSM should be considered in lieu of compacted fill for areas with low tolerances for surface settlements, for excavations that extend below the groundwater table and in areas with difficult access for compaction equipment. CLSM consists of a fluid, workable mixture of aggregate, Portland cement, and water. CLSM should be placed in lifts of 5 feet or less with a 24-hour or more curing period between each lift.

The use of CLSM has several advantages:

- A narrower excavation can be used where shoring is present, thereby minimizing the quantity of soil to be excavated and possibly reducing disturbance to the nearby traffic;
- Compaction requirements do not apply;
- There is less risk of damage to improvements since little compaction is needed to place CLSM;

- CLSM can be batched to flow into irregularities in excavation bottoms and walls; and
- The number of workers needed inside the trench excavation is reduced.

The CLSM mix design should be submitted for review prior to placement. The 28-day strength of the material should be no less than 50 pounds per square inch (psi) and no more than 150 psi. CLSM should be observed and tested by the geotechnical consultant.

9.3 Equipment Pad Foundations

The at-grade equipment pads may be supported on raft slabs with turndown edges. Soils underlying foundations should be moisture conditioned, and compacted in accordance with the recommendations presented in Section 9.2.3 of this report.

The at-grade equipment pads and below-grade vaults may be designed using an allowable bearing pressure of 2,000 psf for static conditions. The bearing capacity may be increased by one-third when considering loads of short duration such as wind or seismic forces. Foundations may be designed using an ultimate coefficient of friction of 0.35, where the total frictional resistance equals the coefficient of friction times the dead load.

For slab design, a design modulus of subgrade reaction, **k**, of 125 pounds per square inch per inch of deflection (psi/inch) may be used for the subgrade soils in evaluating deflections for the slab. This value is based on a unit square foot area and can be adjusted for large slabs. Adjusted values of the modulus of subgrade reaction, **K_b**, can be obtained from the following equation for slabs of various widths (where B is the width of the foundation in feet):

$$K_b = k[(B+1)/2B]^2 \quad (\text{psi/inch})$$

Perimeter slab turndowns should extend 36 or more inches below the lowest exterior finished grade (for frost protection). The total and differential settlements under static loading conditions corresponding to the allowable bearing capacity are estimated to be approximately 1-inch and ½-inch, respectively.

Joints should be observed periodically, particularly during the first several years after construction. Utility penetrations should be provided with positive bond breaks that allow 2 or more inches of differential movement. The Structural Engineer should account for this potential differential settlement through use of sufficient control joints, appropriate reinforcing, or other means.

9.4 Modulus of Soil Reaction, E'

The modulus of soil reaction (E') is an empirical value used to evaluate initial flexible pipe horizontal deflection caused by the weight of the backfill over the pipe, and is related to the nature and degree of compaction of the pipe bedding and embedment material and the stiffness of the native soils (Bureau of Reclamation, 1977). The depth of cover is assumed to be approximately 5 to 7 feet over the pipe crown, and the soils encountered at these depths generally consisted of interlayered clay and sand. For flexible PVC pipe, Ninyo & Moore recommends an E' value of 1,000 psi. This value assumes pipe embedment is compacted to a relative compaction of 95 percent or more as evaluated by ASTM D698.

9.5 Thrust Restraint

Thrust forces will develop at the bends in the waterline when alignment changes occur. Thrust blocks or restrained joints can be considered for thrust restraint.

Assuming a negligible amount of movement at the pipe bends, passive earth pressures listed in the following table for fine-grained soil, coarse-grained soil, and bedrock along the proposed alignment may be used for thrust block design.

Table 1 – Passive Pressures for Thrust Block Design	
Soil Condition	Passive Pressure (pcf)
Fine-grained Soil (CH, CL)	100
Coarse-grained Soil (SC, SP-SC, SP)	150
Dawson Formation Bedrock	300

If restrained joints are considered, coefficient of friction (μ) between the soil and the pipe can be used for restrained joint design. The μ will depend on the type of pipe, or fitting, and the material surrounding the pipe. Ninyo & Moore suggests a μ ranging from 0.2 to 0.3 depending on pipe smoothness. However, the pipe manufacturer should be consulted for this parameter.

9.6 Lateral Earth Pressures

Earth pressures are used to compute the lateral forces acting on below-grade walls. These pressures can be classified as at-rest, active, and passive. The direction and magnitude of the soil/wall movement just before failure affects the resulting pressure condition. At-rest conditions exist when there is no movement, such as for a restrained wall. Active stresses are exerted when the wall moves out and the soil moves toward the wall away from the soil mass, thereby

mobilizing the shear strength of the soil. Passive stresses exist when the wall moves toward the soil mass.

The recommended equivalent fluid pressures in Table 2 assumes an angle of internal friction (ϕ) of 28 degrees and a unit weight of 120 pcf for engineered fill. The values listed below are for static conditions and horizontal backfill.

Table 2 – Recommended Lateral Earth Pressures			
Soil Condition	Active Pressure (pcf)	At-rest Pressure (pcf)	Passive Pressure (pcf)
Engineered Fill (Horizontal)	40	64	330

The use of heavy compaction equipment adjacent to below-grade walls could result in lateral earth pressures well in excess of those predicted in Table 2. We recommend that the upper 24 inches of soil that is not protected by pavement or a concrete slab, be neglected when calculating passive resistance. This zone, where applicable, should be backfilled with cohesive soils to minimize infiltration of surface water into the backfill. For passive resistance, a value of 330 psf per foot of depth may be used, up to a maximum passive pressure of 2,000 psf. This is assuming the ground is horizontal for a distance of 10 feet or three times the height generating the passive pressure. For frictional resistance to lateral loads, we recommend that an ultimate coefficient of friction of 0.35 be used between site soils and concrete.

Measures should be taken so that moisture does not build up behind the below-grade walls. Below-grade walls should be dampproofed or waterproofed in accordance with the recommendations of the project architect and structural engineer. To reduce the potential for water- and sulfate/salt-related damage to the foundation walls and efflorescent development, particular care should be taken in selection of the appropriate type of waterproofing material to be utilized and in the application of this material.

9.7 Pavement Restoration

Where pavement patching is needed over the proposed waterline, new asphaltic concrete pavement should match or exceed the existing section, but should be no less than 6 inches thick (PWSD, 2017). Aggregate base course (ABC) encountered during waterline installation at existing roadways should match or exceed the existing thickness.

The AC pavement shall consist of a bituminous plant mix composed of a mixture of high-quality aggregate and bituminous material, which meets the requirements of a job-mix formula and

Town of Parker requirements established by a qualified engineer. The asphalt material used should be based on a SuperPave Gyratory Design Revolution of 75. Lower lifts should be constructed using an asphalt mix Grading S or SG and asphalt cement binder grade PG 58-28. The top lift should be constructed using an asphalt mix Grading SX and asphalt cement binder grade PG 64-22. Pavement layer thickness should be between 2 and 4 inches for the lower lifts and 1½ to 2 inches for the top lift. The Geotechnical Engineer should be retained to review the proposed pavement mix designs, grading, and lift thicknesses prior to construction.

Subgrade soils below AC pavement and ABC should be firm and unyielding. Subgrades that are exposed to the elements may need additional moisture conditioning and compaction, prior to pavement or ABC placement.

The ABC material placed beneath pavements should meet the criteria of CDOT Class 6 aggregate base. Requirements for CDOT Class 6 aggregate base can be found in Section 703 of the current CDOT Standards and Specifications for Road and Bridge Construction (2023). The ABC should be moisture-conditioned to moisture contents within 2 percent of optimum moisture content and compacted to a relative compaction of 95 percent or more as evaluated by ASTM D698.

9.8 Aggregate Surfaced Lot and Roadway

We understand that aggregate is being placed at the well sites and for the access roadways. Lots and roadways constructed with aggregate are subject to seasonal moisture fluctuations, which affects the stability and strength of the subgrade soils.

Specific traffic loadings for these areas were not available at the time of this report preparation. However, we understand the aggregate surfaced roadway and equipment lot will service standard automobile traffic, as well as occasional use by heavy vehicles such fire trucks and dump trucks for maintenance and emergency access. As a result, an equivalent 18-kip single-axle (ESAL) load value of 10,000 for a 20-year design life was assumed. This estimate includes occasional fire truck and dump truck traffic. The associated estimated traffic volume and ESAL calculation is presented in Appendix E.

The ABC structural section was developed in general accordance with the AASHTO Low-Volume Road design procedure. Based on the subsurface conditions and assumed traffic loading, we recommend the ABC surfaced areas used for the well site lots and roadways should be constructed with 8 or more inches of CDOT Class 6 ABC. The CDOT Class 6 ABC should be placed on improved subgrade as described in Section 9.2.3.

The prepared subgrade should be protected from the elements prior to ABC placement. Subgrades that are exposed to the elements may need additional moisture conditioning and compaction, prior to ABC placement.

Immediately prior to installation of the ABC, the subgrade should be proof rolled with a heavily loaded, pneumatic tired vehicle and checked for moisture. Areas that show excessive deflection during proof rolling should be excavated and replaced and/or stabilized. Areas allowed to pond prior to paving may need to be re-worked prior to proof rolling.

The collection and diversion of surface drainage away from the aggregate roadway is vital to satisfactory performance. The surface drainage systems should be carefully designed to facilitate removal of the water from the ABC and subgrade soils. Allowing surface waters to pond on the parking areas and access road will cause a decrease in subgrade support, loss of fines, potholes, washboarding, and other surface defects.

ABC roadways and lots will require recurring maintenance, including periodic grading or subgrade stabilization, as needed to remediate potholes, washboarding, and other defects. The cost associated with maintenance should be included in a maintenance program.

9.9 Corrosion Considerations

The corrosion potential of on-site soils to concrete and buried metal was evaluated in the laboratory using selected samples obtained from the exploratory borings. Laboratory testing was performed to assess the effects of sulfate on concrete and the effects of soil resistivity on buried metal. Results of these tests are presented in Appendix B. Recommendations regarding concrete to be utilized in the construction and for buried metal pipes are provided in the following sections.

9.9.1 Concrete

The test for water-soluble sulfate content of the soils was performed using CDOT Test Method CP-L 2103 Method B. Based on Table 601-2 of the CDOT 2023 Standard Specifications for Road and Bridge Construction, the on-site soils represent a Class 0 severity of sulfate exposure to concrete on a scale that ranges between Class 0 and Class 3. Therefore, we recommend that the cement used for this project should meet one of the below outlined requirements.

- ASTM C150 Type I, II, III or V
- ASTM C595 Type IL, IP, IP(MS), IP(HS) or IT

9.9.2 Buried Metal Pipes

The corrosion potential of the on-site materials was analyzed to evaluate its potential effects on buried metals. Corrosion potential was evaluated using the results of laboratory testing of samples obtained during the subsurface evaluation that were considered representative of soils at the subject site.

Minimum resistivity was measured ranging from 130 and 1,490 ohm-cm within the selected samples. The results of the laboratory testing indicate the on-site materials could have severe to very severe corrosivity potential to ferrous metals based on the criteria in Table 3. Therefore, special consideration should be given to the use of heavy gauge, corrosion protected, underground steel pipe, if any are planned. As an alternative, plastic pipe could be considered. A corrosion specialist should be consulted for further recommendations.

Table 3 – Corrosion Potential to Steel	
Resistivity (Ohm-cm)	Corrosivity Potential to Steel
0 - 500	Very Severe
500 – 2,000	Severe
2,000 – 10,000	Moderate
10,000 – 30,000	Mild
>30,000	Low

9.10 Construction in Cold or Wet Weather

During construction, the measure should be taken such that surface water can drain readily away from excavations. It is important to avoid ponding of water in or near excavations. Water that accumulates in excavations should be promptly pumped out or otherwise removed and these areas should be allowed to dry out before resuming construction. Berms, ditches, and similar means should be used to decrease stormwater entering the work area and to efficiently convey it away.

Earthwork activities undertaken during the cold weather season may be difficult and should be done by an experienced contractor. Fill should not be placed on top of frozen soils. The frozen soils should be removed prior to the placement of fill or other construction material. Frozen soil should not be used as engineered fill or backfill. The frozen soil may be reused (provided it meets the selection criteria) once it has thawed completely. In addition, compaction of the soils may be more difficult due to the viscosity change in water at lower temperatures.

If construction proceeds during cold weather, pavement should not be placed on frozen subgrade soil. Frozen soil should either be removed from beneath pavement, or thawed and

recompacted. To limit the potential for soil freezing, the time passing between excavation and construction should be minimized. Blankets, straw, soil cover, or heating may be used to discourage the soil from freezing.

9.11 Construction Observation and Testing

A qualified geotechnical consultant should perform appropriate observation and testing services during construction and trench backfill operations. These services should include observation of any soft, loose, or otherwise unsuitable soils, evaluation of subgrade conditions where soil removals are performed, evaluation of the suitability of proposed borrow materials for use as fill, evaluation of the stability of open temporary excavations, evaluation of the results of any subgrade stabilization or dewatering activities, and performance of observation and testing services during placement and compaction of backfill soils or pavement placement.

The geotechnical consultant should also perform observation and testing services during placement of concrete or asphalt concrete. If another geotechnical consultant is selected to perform observation and testing services for the project, we request that the selected consultant provide a letter to the owner, with a copy to Ninyo & Moore, indicating that they fully understand our recommendations and that they are in full agreement with the recommendations contained in this report. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

9.12 Plan Review

The recommendations presented in this report are based on the provided preliminary plans (Hazen and Sawyer, 2025a and 2025b) and on the findings of our geotechnical evaluation. When finished, project plans and specifications should be reviewed by the geotechnical consultant prior to submitting the plans and specifications for bid. Additional field exploration and laboratory testing may be needed upon review of the project design plans.

9.13 Pre-Construction Meeting

We recommend a pre-construction meeting be held. The owner or the owner's representative, the architect, the contractor, and the geotechnical consultant should be in attendance to discuss the plans and the project.

10 LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with the current practice and

the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

11 REFERENCES

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FIGURES

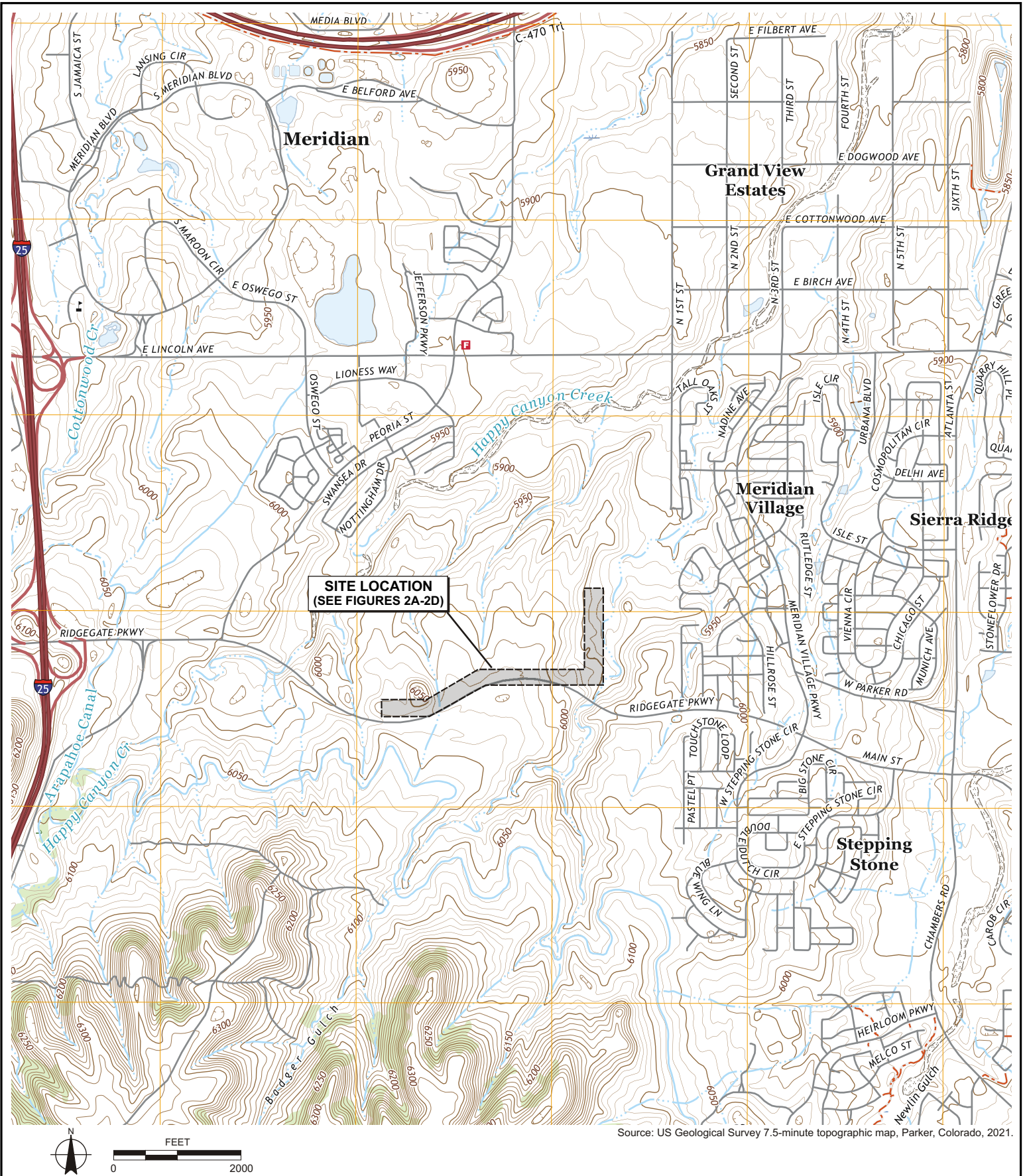
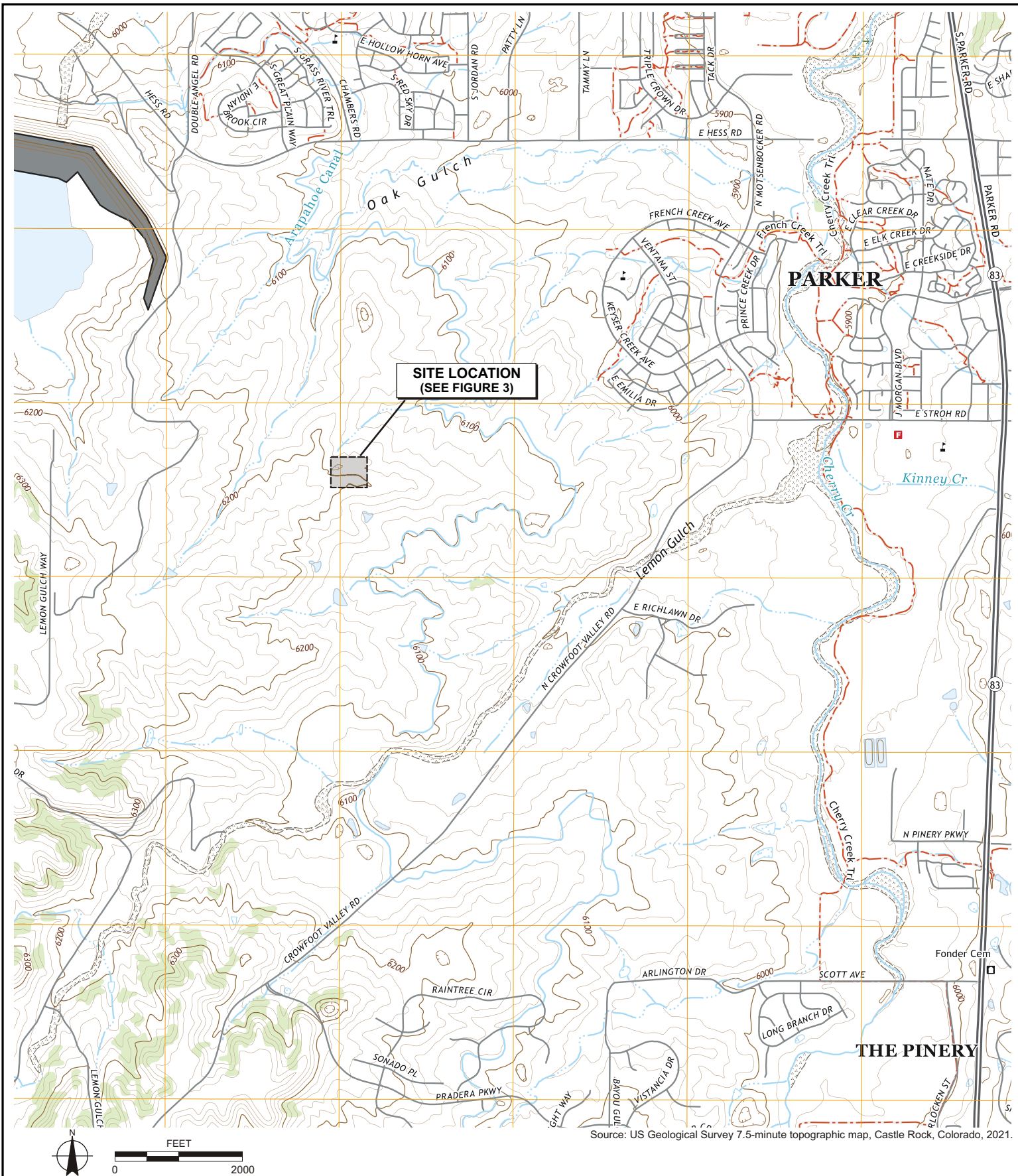


FIGURE 1A

RIDGEGATE PIPELINE SITE LOCATION

DENVER BASIN WELL SITES PHASE II AND PIPELINE PROJECT
PARKER, COLORADO

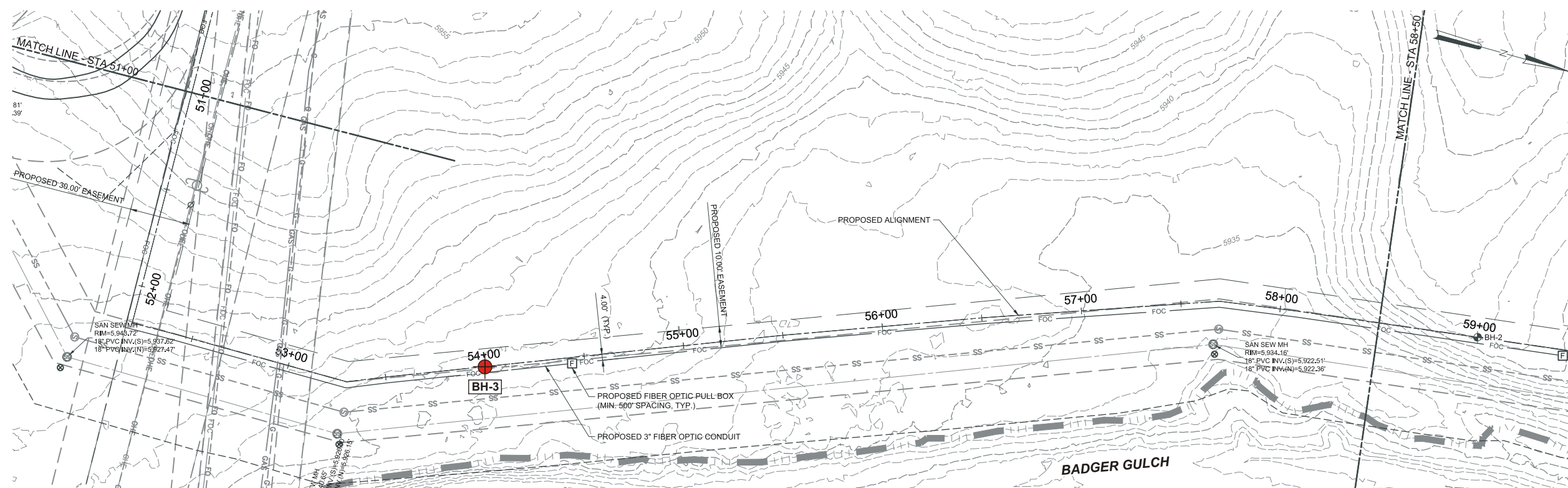
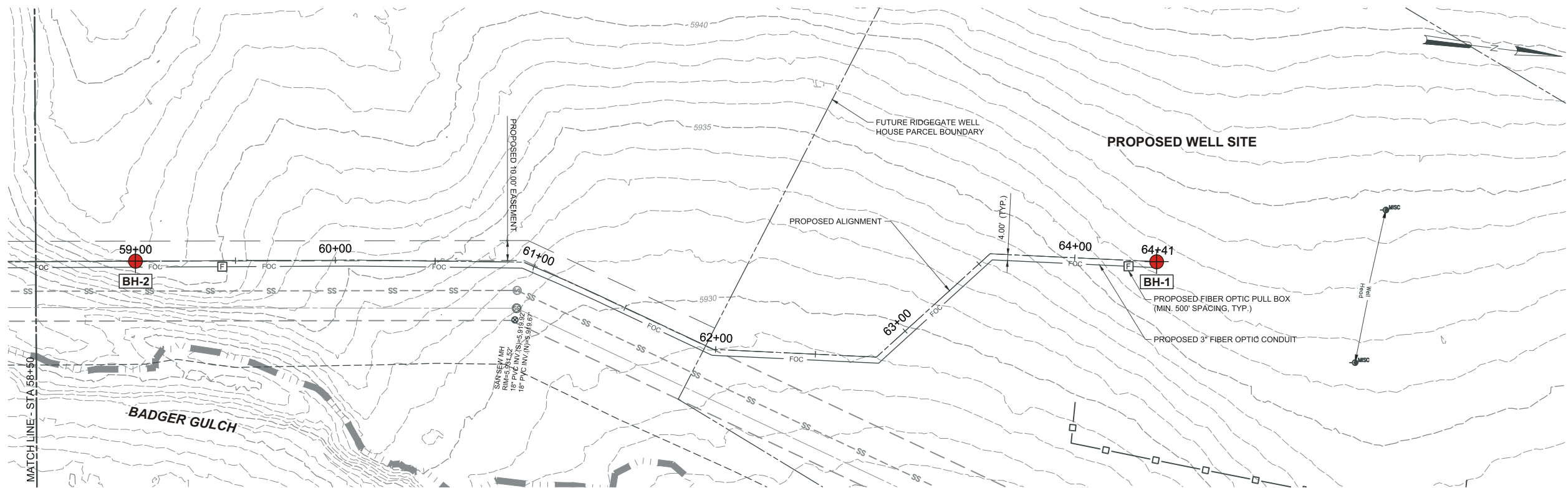


NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

FIGURE 1B

RUETER-HESS PIPELINE SITE LOCATION

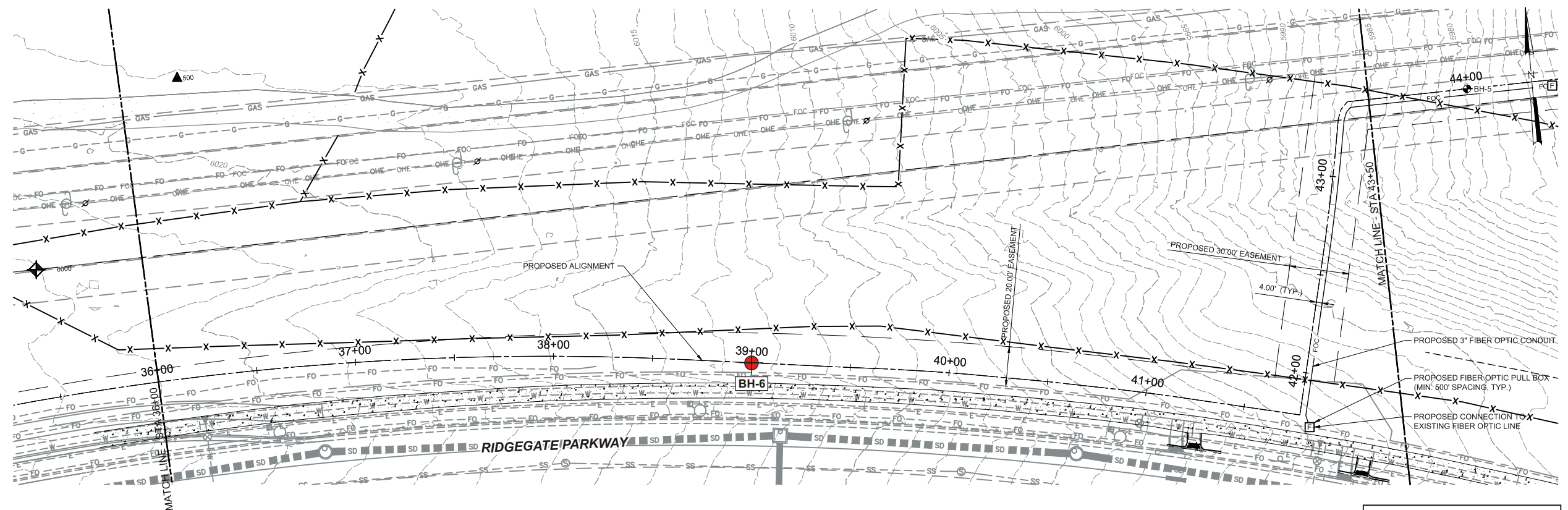
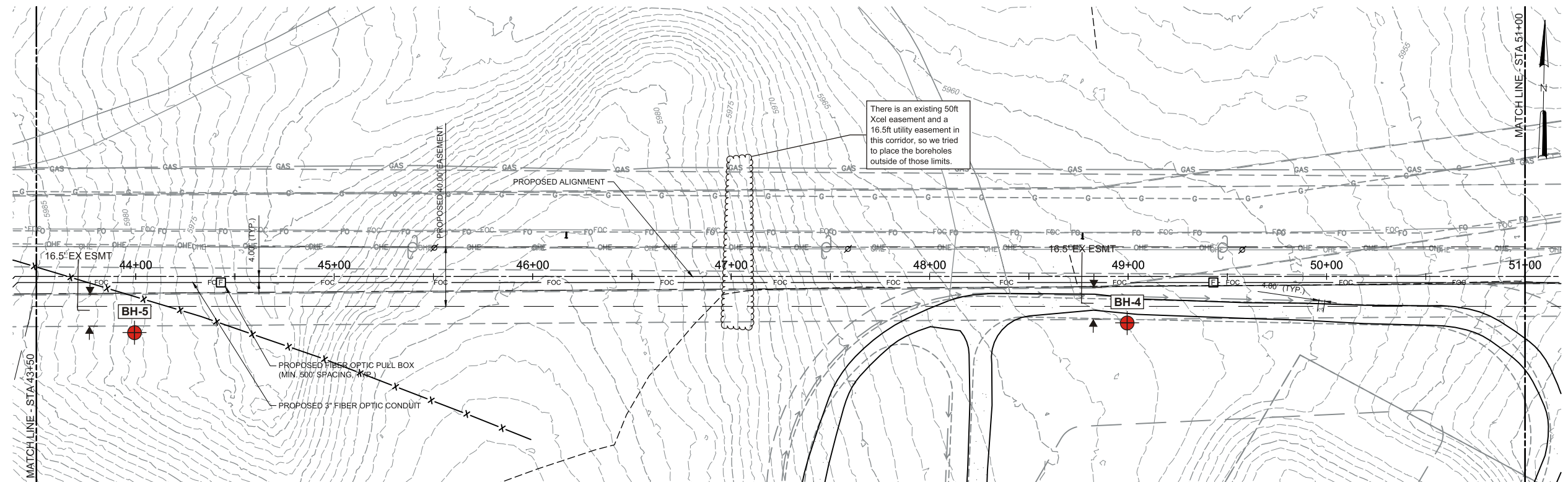
DENVER BASIN WELL SITES PHASE II AND PIPELINE PROJECT
PARKER, COLORADO



SOURCE: HAZEN AND SAWYER, 03/25.
NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

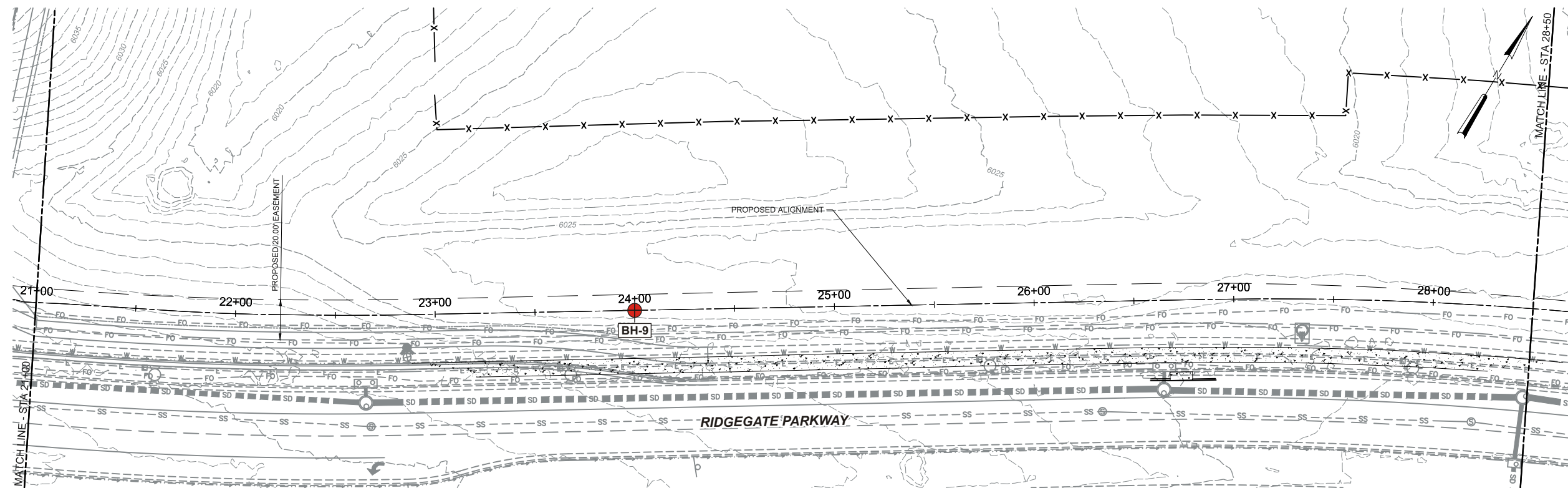
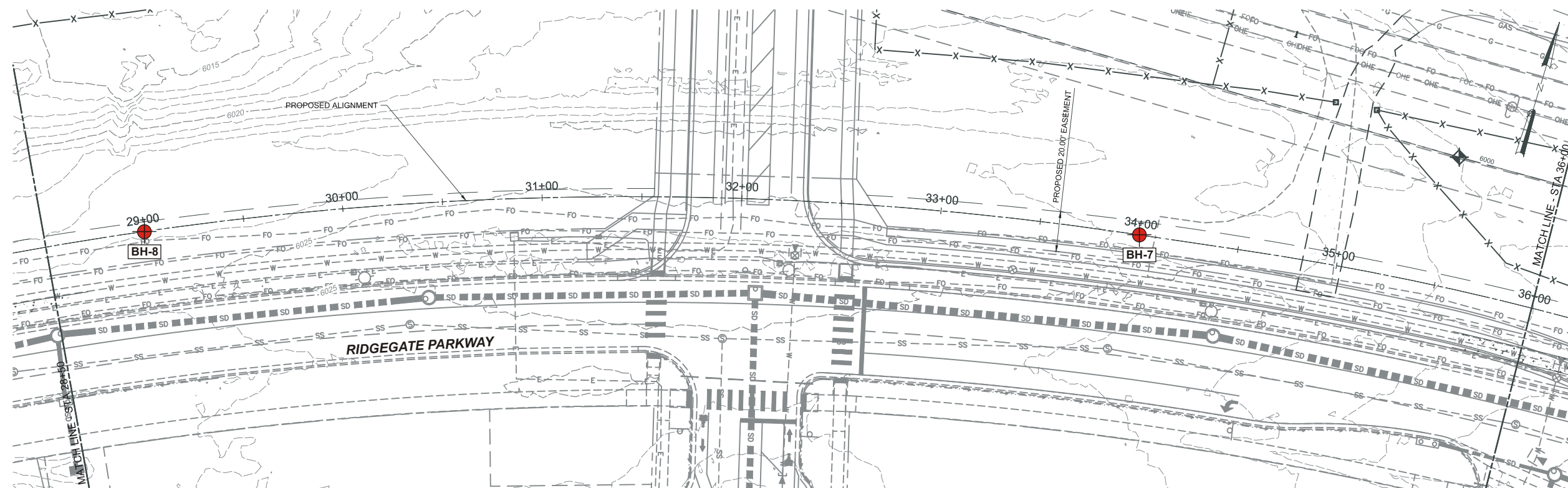
LEGEND	
BH-13	Boring Location

bsm file no: 3147bm0425a



SOURCE: HAZEN AND SAWYER, 03/25.
NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.



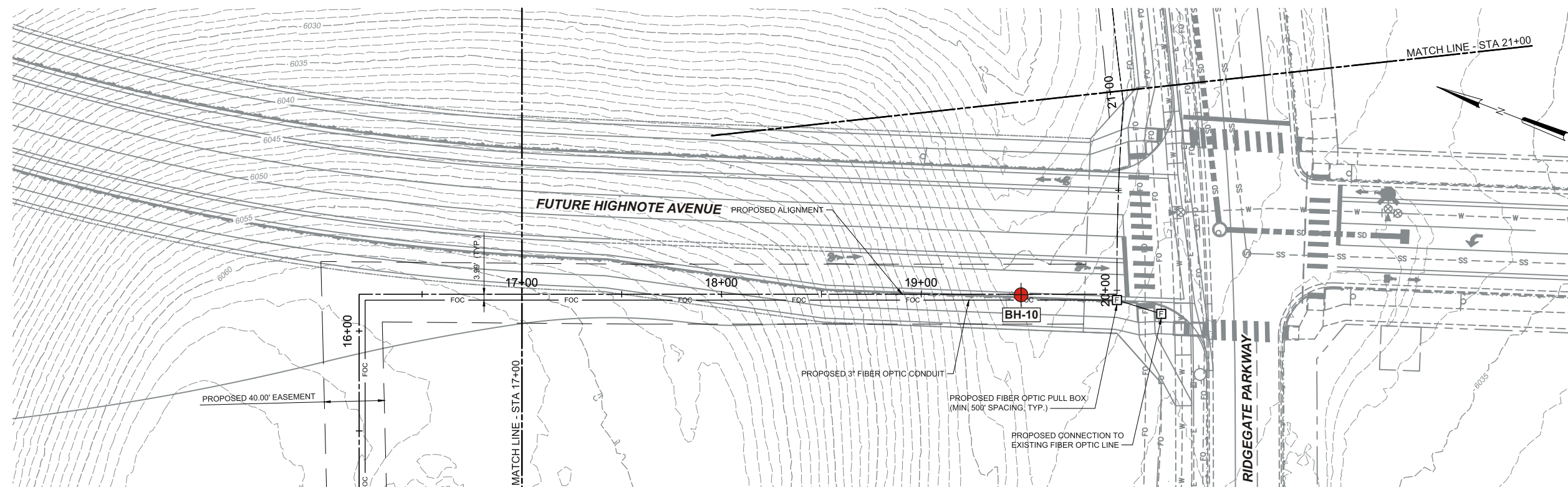
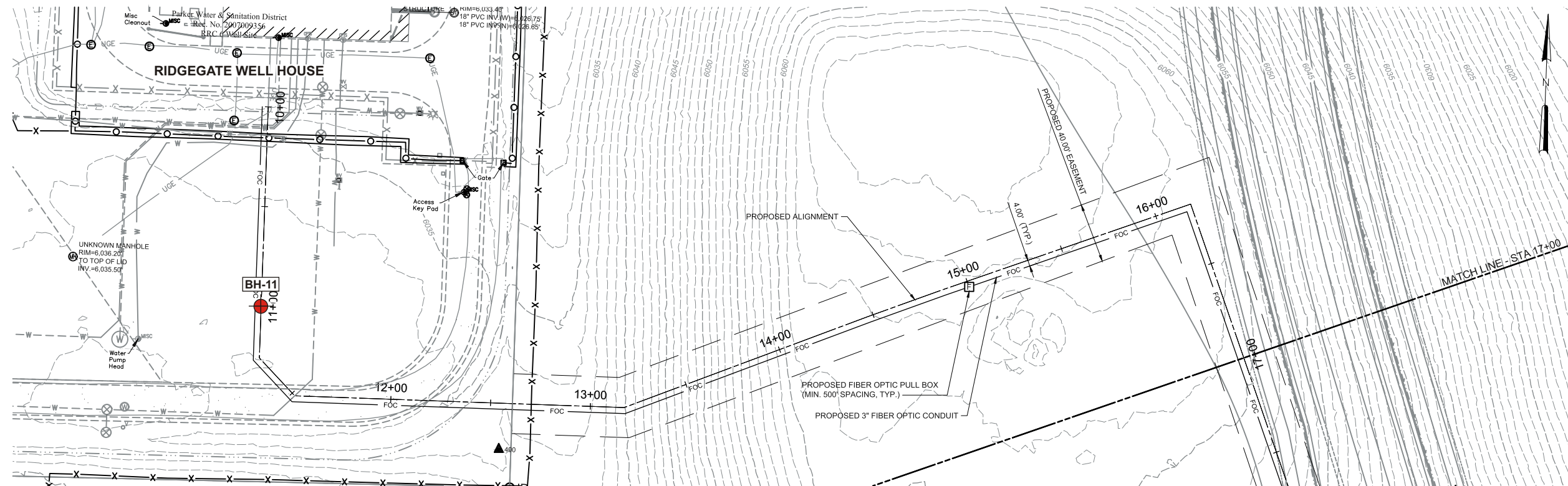


SOURCE: HAZEN AND SAWYER, 03/25.
NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

BH-13 Boring Location

bsm file no: 3147bm0425c



SOURCE: HAZEN AND SAWYER, 03/25.
NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND	
BH-13	Boring Location



Source: NAVTEQ, 10/19/23.



NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

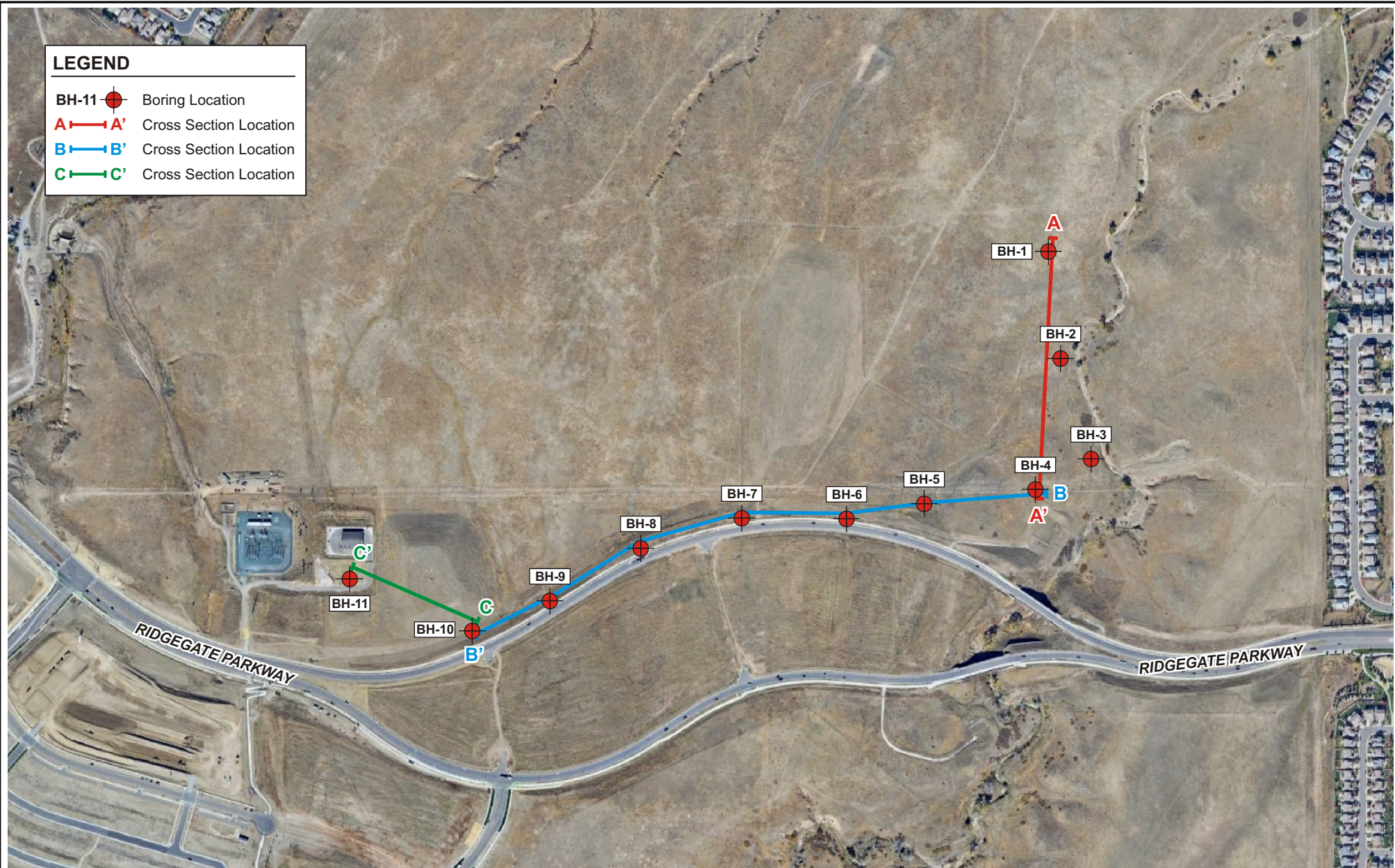
FIGURE 3

RUETER-HESS PIPELINE BORING LOCATIONS

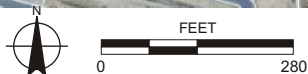
DENVER BASIN WELL SITES PHASE II AND PIPELINE PROJECT
PARKER, COLORADO

LEGEND

- BH-11  Boring Location
- A  A' Cross Section Location
- B  B' Cross Section Location
- C  C' Cross Section Location



Source: NAVTEQ, 10/19/23.



NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

FIGURE 4

CROSS SECTION LOCATIONS

DENVER BASIN WELL SITES PHASE II AND PIPELINE PROJECT
PARKER, ARIZONA



APPENDIX A

Boring Logs

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples

Disturbed soil samples were obtained in the field using the following methods.

Bulk Samples

Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

Field Procedure for the Collection of Ring-lined Samples

Ring-lined soil samples were obtained in the field using the following methods.

The California Drive Sampler

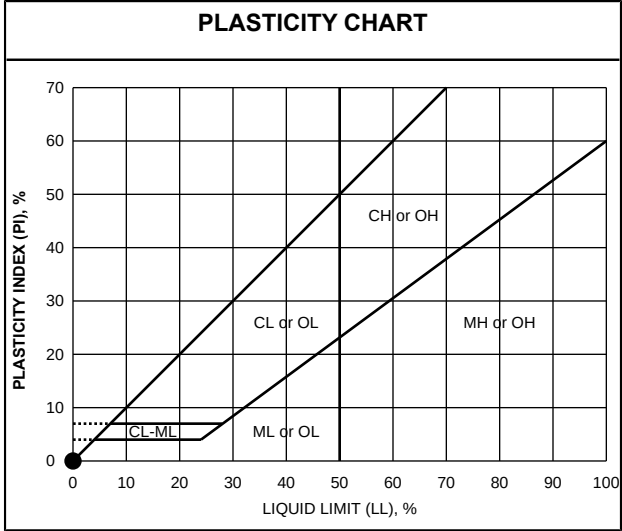
The sampler, with an external diameter of 2.4 inches, was lined with four 4-inch long, thin brass rings with inside diameters of approximately 1.9 inches. The sample barrel was driven into the ground with the weight of a hammer in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer, and the number of blows per foot of driving are presented on the boring logs as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass liners, sealed, and transported to the laboratory for testing.

BORING LOG EXPLANATION SHEET

DEPTH (feet)	BULK DRIVEN	BLOWS/FOOT	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SYMBOL	USCS	
							Bulk sample.
							Modified Split-Barrel Drive Sampler
							2-inch inner diameter split-barrel drive sampler.
							No recovery with modified split-barrel drive sampler, or 2-inch inner diameter split-barrel drive sampler.
							Sample retained by others.
5							Standard Penetration Test (SPT).
							No recovery with an SPT.
							Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
							No recovery with Shelby tube sampler.
							Continuous Push Sample.
10							Groundwater encountered during drilling.
							Groundwater measured after drilling.
						SM	MAJOR MATERIAL TYPE (SOIL): Solid line denotes unit change.
							Dashed line denotes material change
15						CL	Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Shear Bedding Surface
20							The total depth line is a solid line that is drawn at the bottom of the boring.

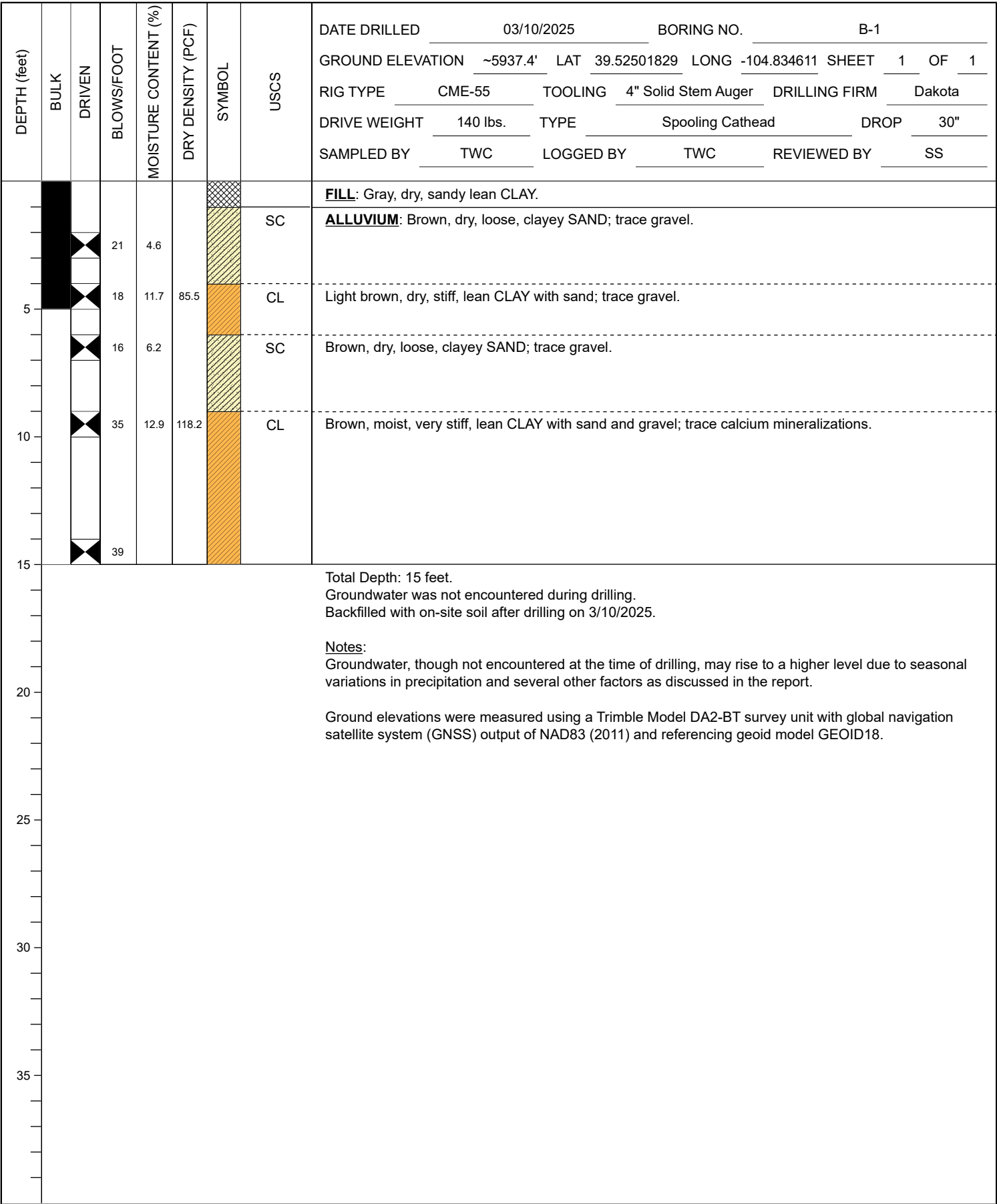
SOIL CLASSIFICATION CHART PER ASTM D 2488						
PRIMARY DIVISIONS			SECONDARY DIVISIONS			
			GROUP SYMBOL		GROUP NAME	
COARSE-GRAINED SOILS more than 50% retained on No. 200 sieve	GRAVEL more than 50% of coarse fraction retained on No. 4 sieve	CLEAN GRAVEL less than 5% fines		GW	well-graded GRAVEL	
				GP	poorly-graded GRAVEL	
		GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines		GW-GM	well-graded GRAVEL with silt	
				GP-GM	poorly-graded GRAVEL with silt	
				GW-GC	well-graded GRAVEL with clay	
				GP-GC	poorly-graded GRAVEL with clay	
			GRAVEL with FINES more than 12% fines		GM	silty GRAVEL
				GC	clayey GRAVEL	
				GC-GM	silty, clayey GRAVEL	
	SAND 50% or more of coarse fraction retained on No. 4 sieve	CLEAN SAND less than 5% fines		SW	well-graded SAND	
				SP	poorly-graded SAND	
		SAND with DUAL CLASSIFICATIONS 5% to 12% fines		SW-SM	well-graded SAND with silt	
				SP-SM	poorly-graded SAND with silt	
				SW-SC	well-graded SAND with clay	
				SP-SC	poorly-graded SAND with clay	
		SAND with FINES more than 12% fines		SM	silty SAND	
				SC	clayey SAND	
				SC-SM	silty, clayey SAND	
	FINE-GRAINED SOILS 50% or more passes No. 200 sieve	SILT and CLAY liquid limit less than 50%	INORGANIC		CL	lean CLAY
					ML	SILT
					CL-ML	silty CLAY
			ORGANIC		OL (PI > 4)	organic CLAY
					OL (PI < 4)	organic CLAY
			SILT and CLAY liquid limit 50% or more	INORGANIC		CH
		MH			elastic SILT	
ORGANIC				OH (plots on or above 'A'-line)	organic CLAY	
				OH (plots below 'A'-line)	organic SILT	
Highly Organic Soils			PT	Peat		

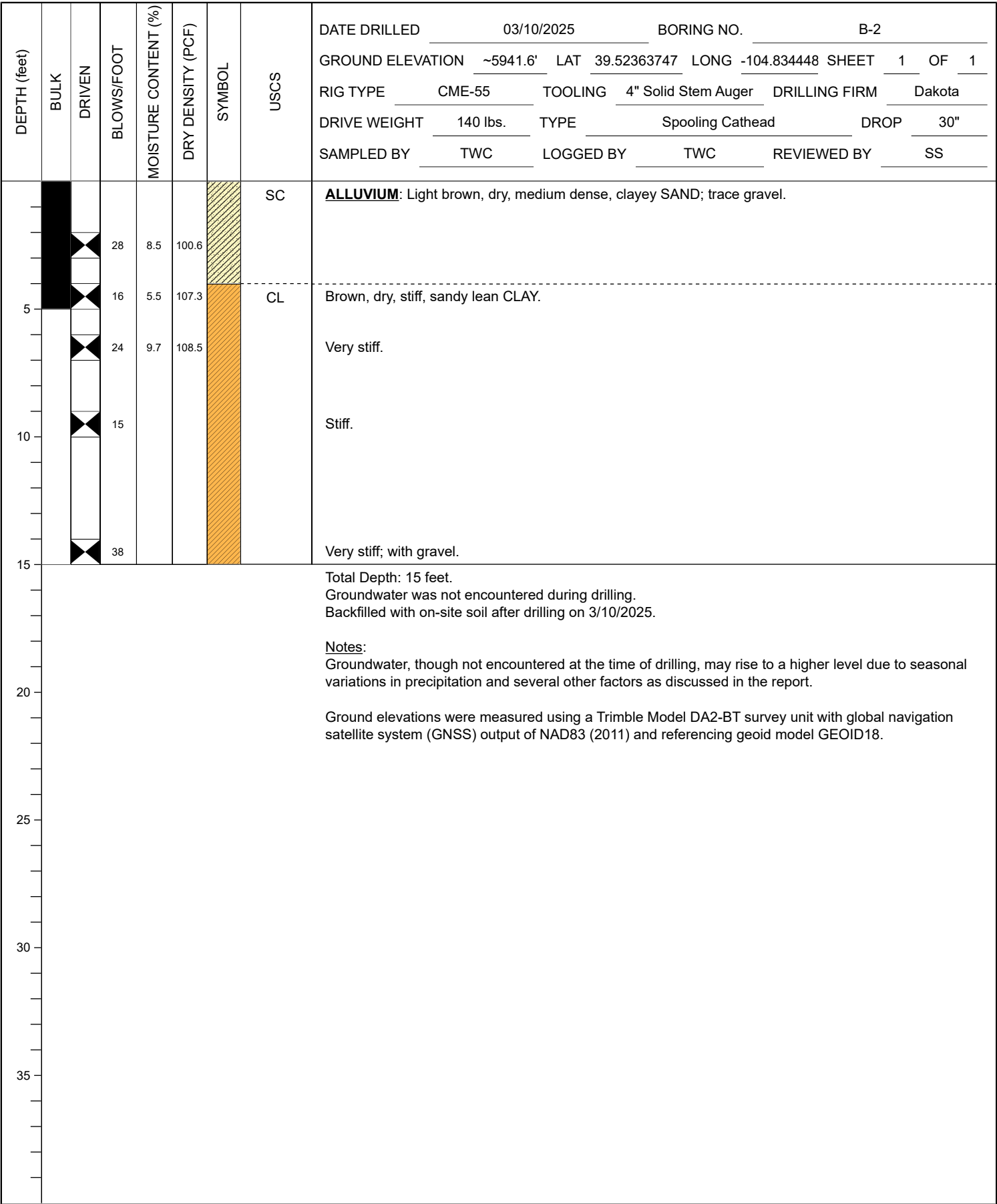
GRAIN SIZE			
DESCRIPTION	SIEVE SIZE	GRAIN SIZE	APPROXIMATE SIZE
Boulders	> 12"	> 12"	Larger than basketball-sized
Cobbles	3 - 12"	3 - 12"	Fist-sized to basketball-sized
Gravel	Coarse	3/4 - 3"	Thumb-sized to fist-sized
	Fine	#4 - 3/4"	Pea-sized to thumb-sized
Sand	Coarse	#10 - #4	Rock-salt-sized to pea-sized
	Medium	#40 - #10	Sugar-sized to rock-salt-sized
	Fine	#200 - #40	Flour-sized to sugar-sized
Fines	Passing #200	< 0.0029"	Flour-sized and smaller

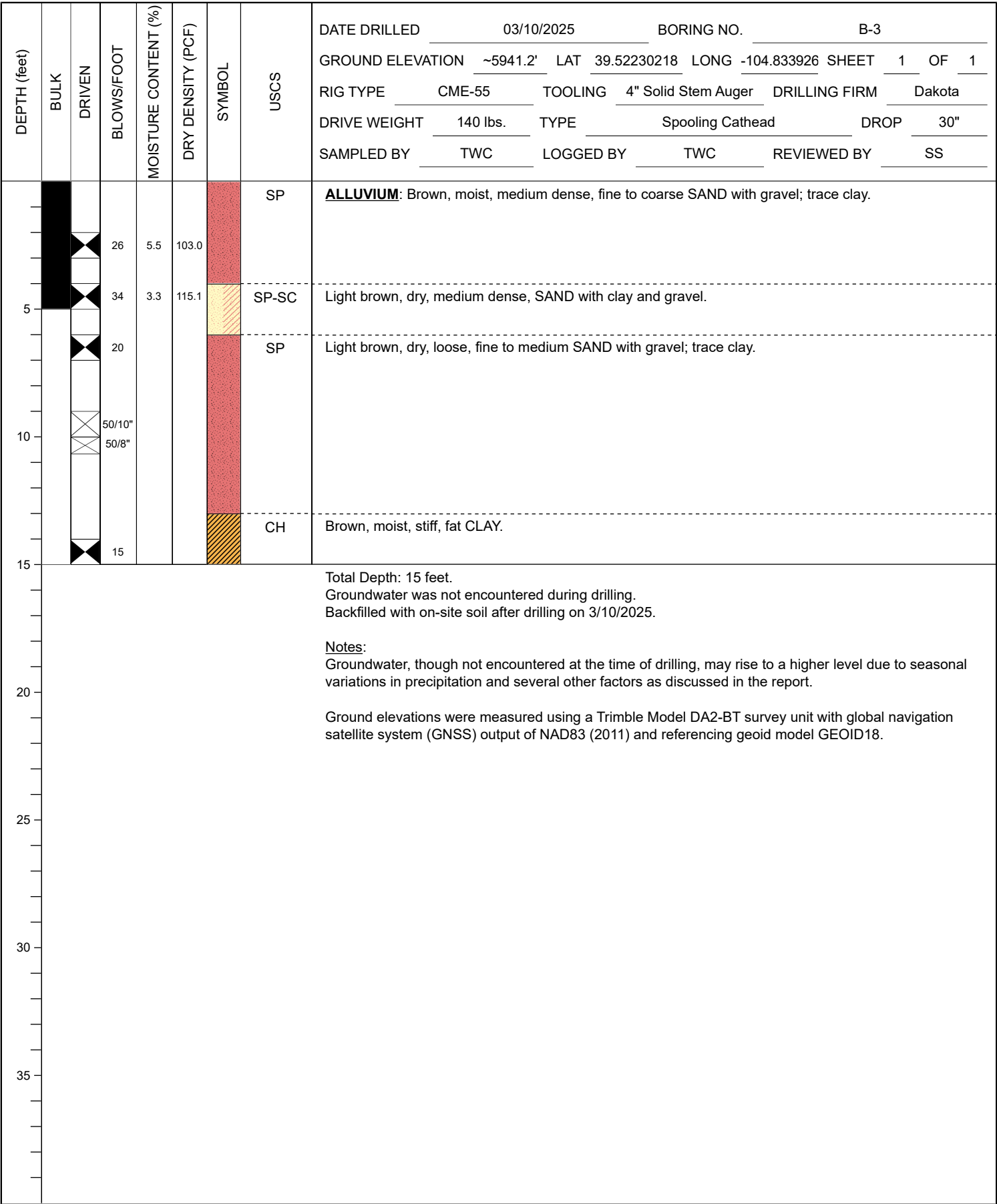


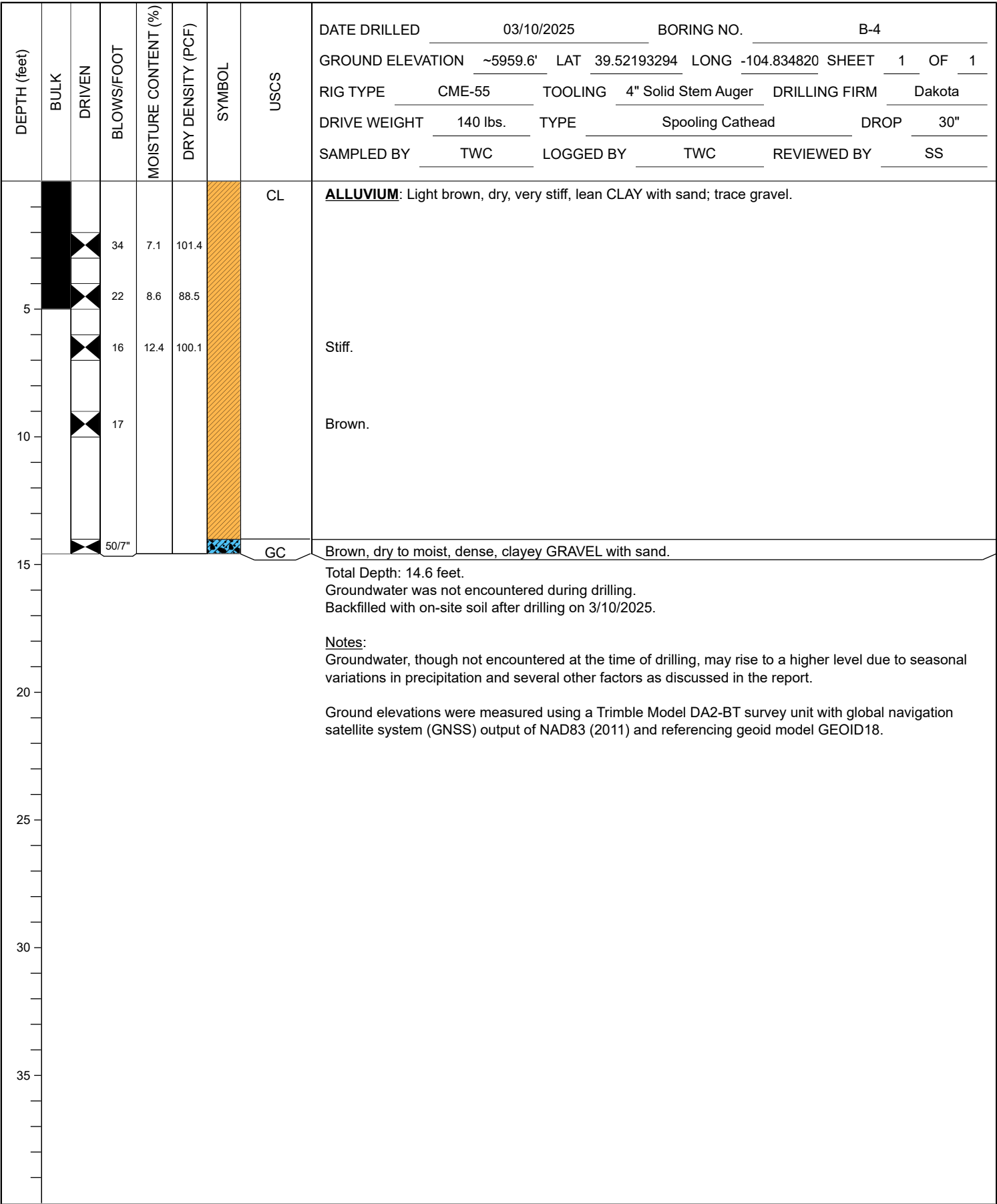
APPARENT DENSITY - COARSE-GRAINED SOIL				
APPARENT DENSITY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	SPLIT BARREL (blows/foot)	SPT (blows/foot)	SPLIT BARREL (blows/foot)
Very Loose	≤ 4	≤ 8	≤ 3	≤ 5
Loose	5 - 10	9 - 21	4 - 7	6 - 14
Medium Dense	11 - 30	22 - 63	8 - 20	15 - 42
Dense	31 - 50	64 - 105	21 - 33	43 - 70
Very Dense	> 50	> 105	> 33	> 70

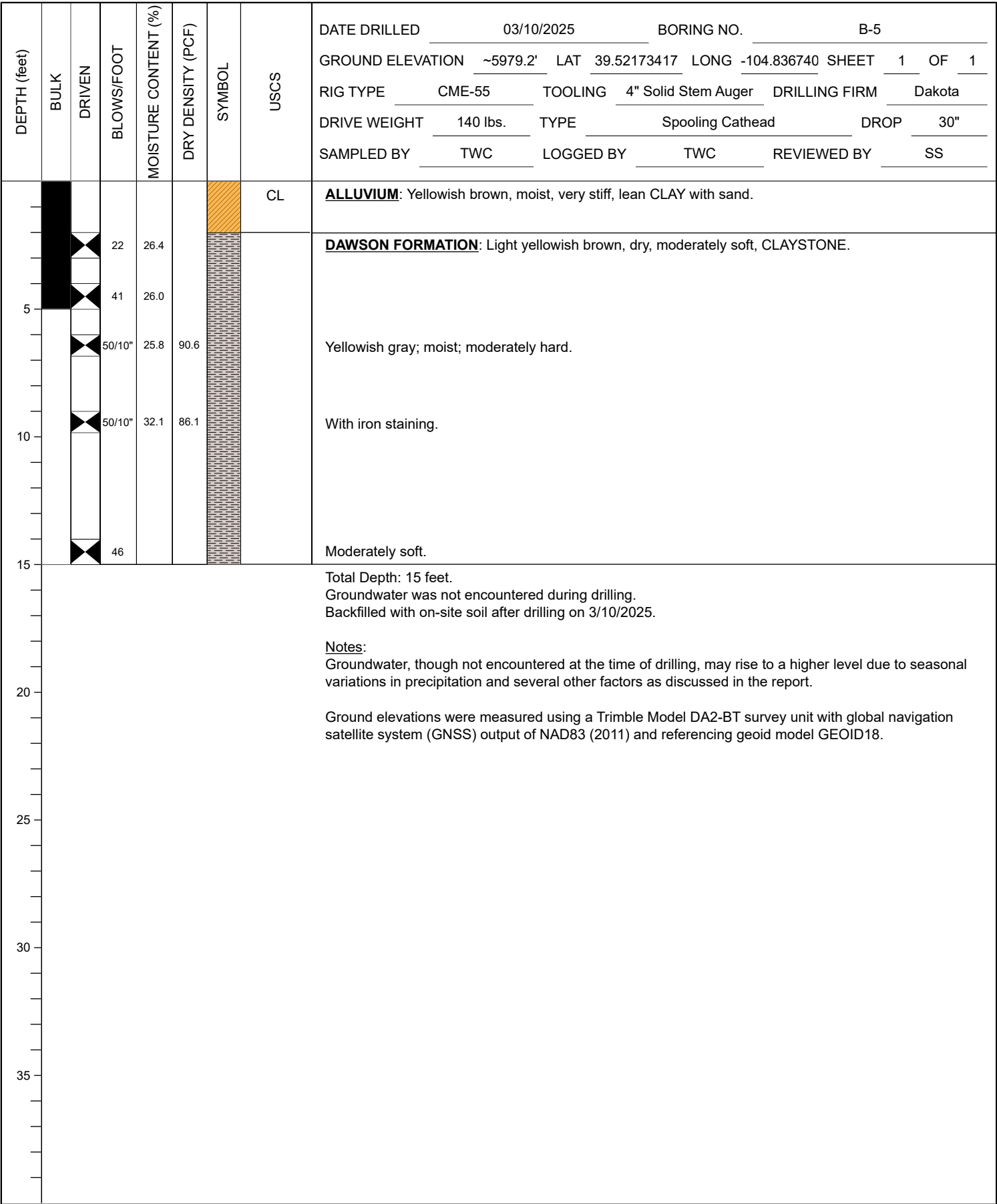
CONSISTENCY - FINE-GRAINED SOIL				
CONSISTENCY	SPOOLING CABLE OR CATHEAD		AUTOMATIC TRIP HAMMER	
	SPT (blows/foot)	SPLIT BARREL (blows/foot)	SPT (blows/foot)	SPLIT BARREL (blows/foot)
Very Soft	< 2	< 3	< 1	< 2
Soft	2 - 4	3 - 5	1 - 3	2 - 3
Firm	5 - 8	6 - 10	4 - 5	4 - 6
Stiff	9 - 15	11 - 20	6 - 10	7 - 13
Very Stiff	16 - 30	21 - 39	11 - 20	14 - 26
Hard	> 30	> 39	> 20	> 26











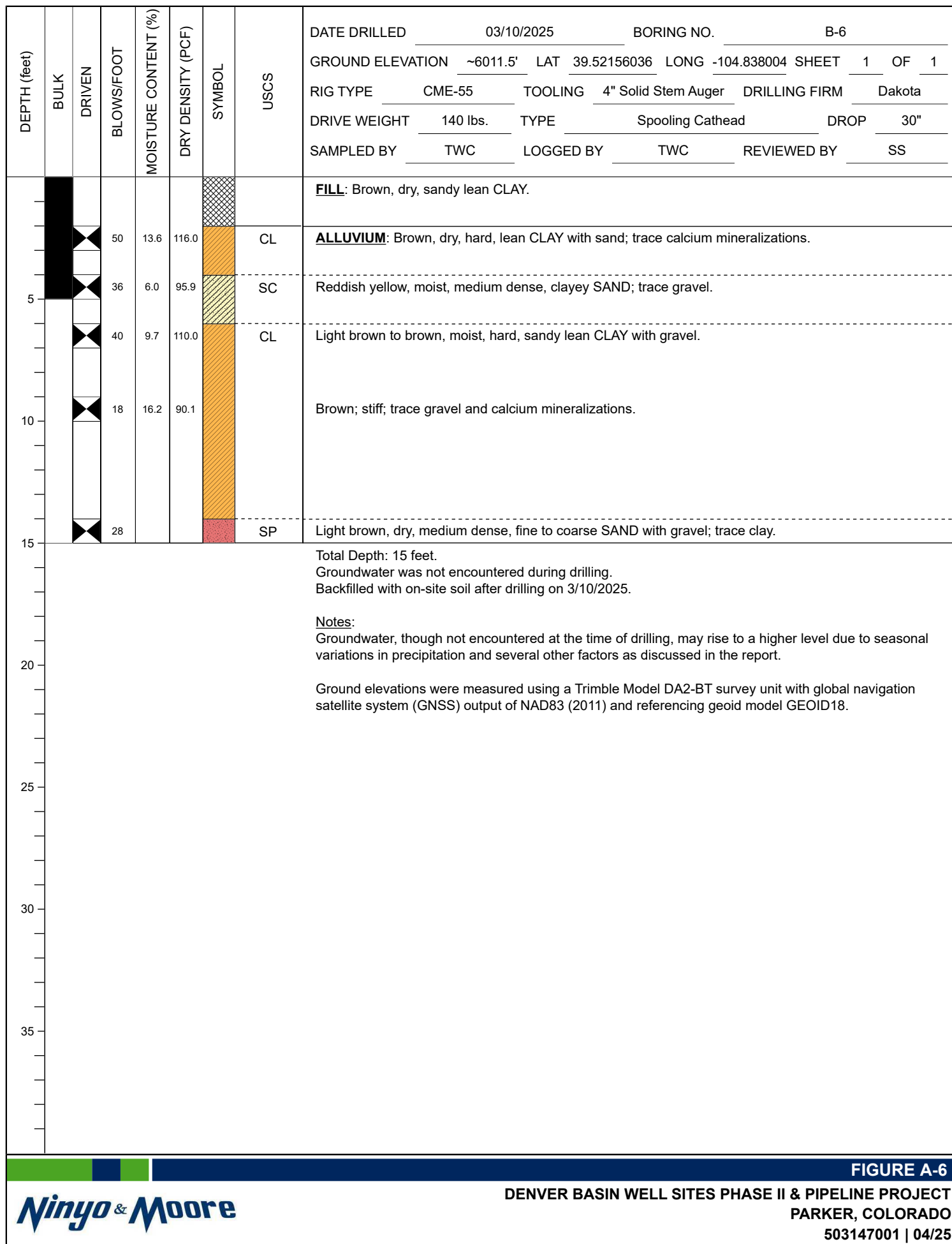


FIGURE A-6

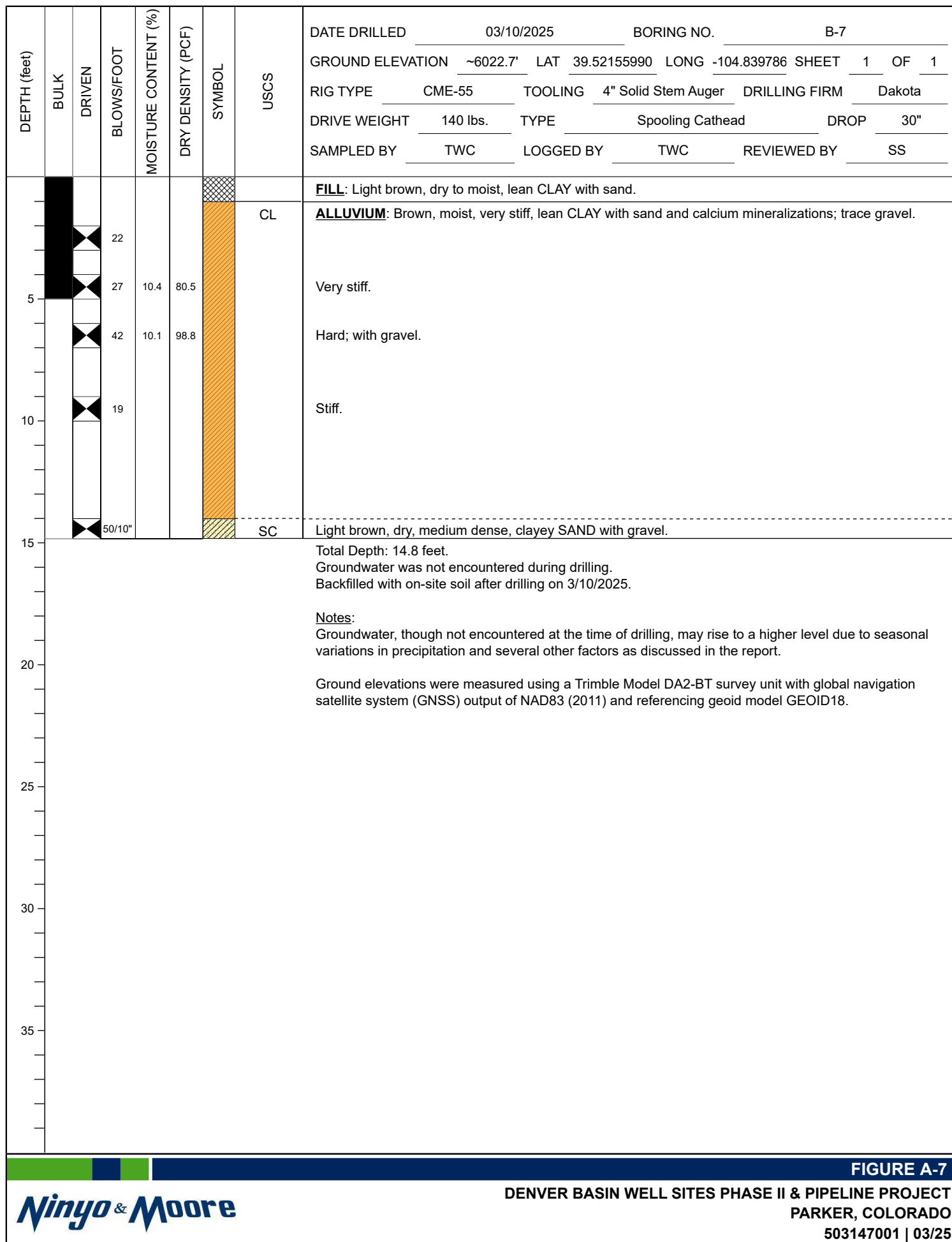
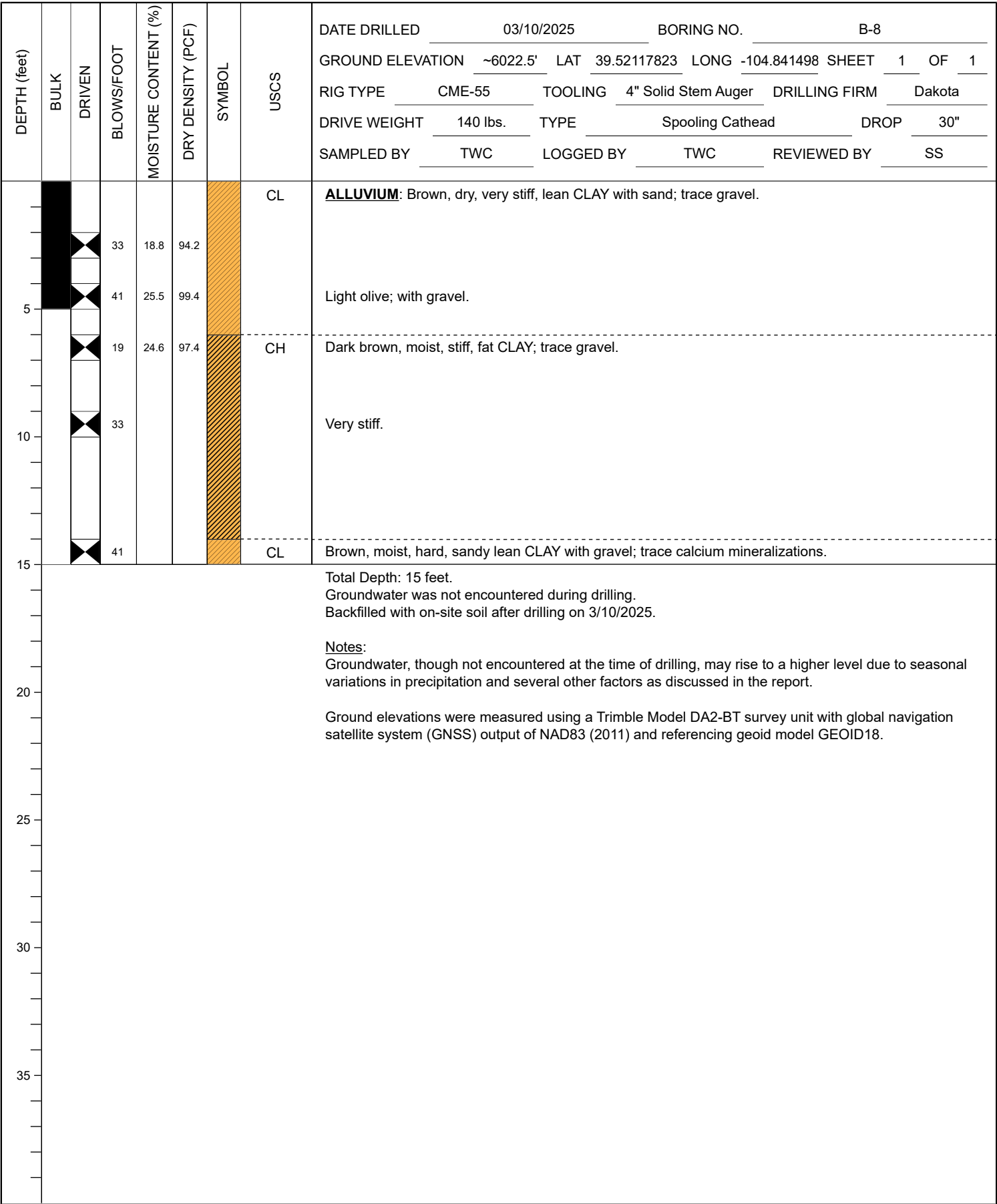


FIGURE A-7



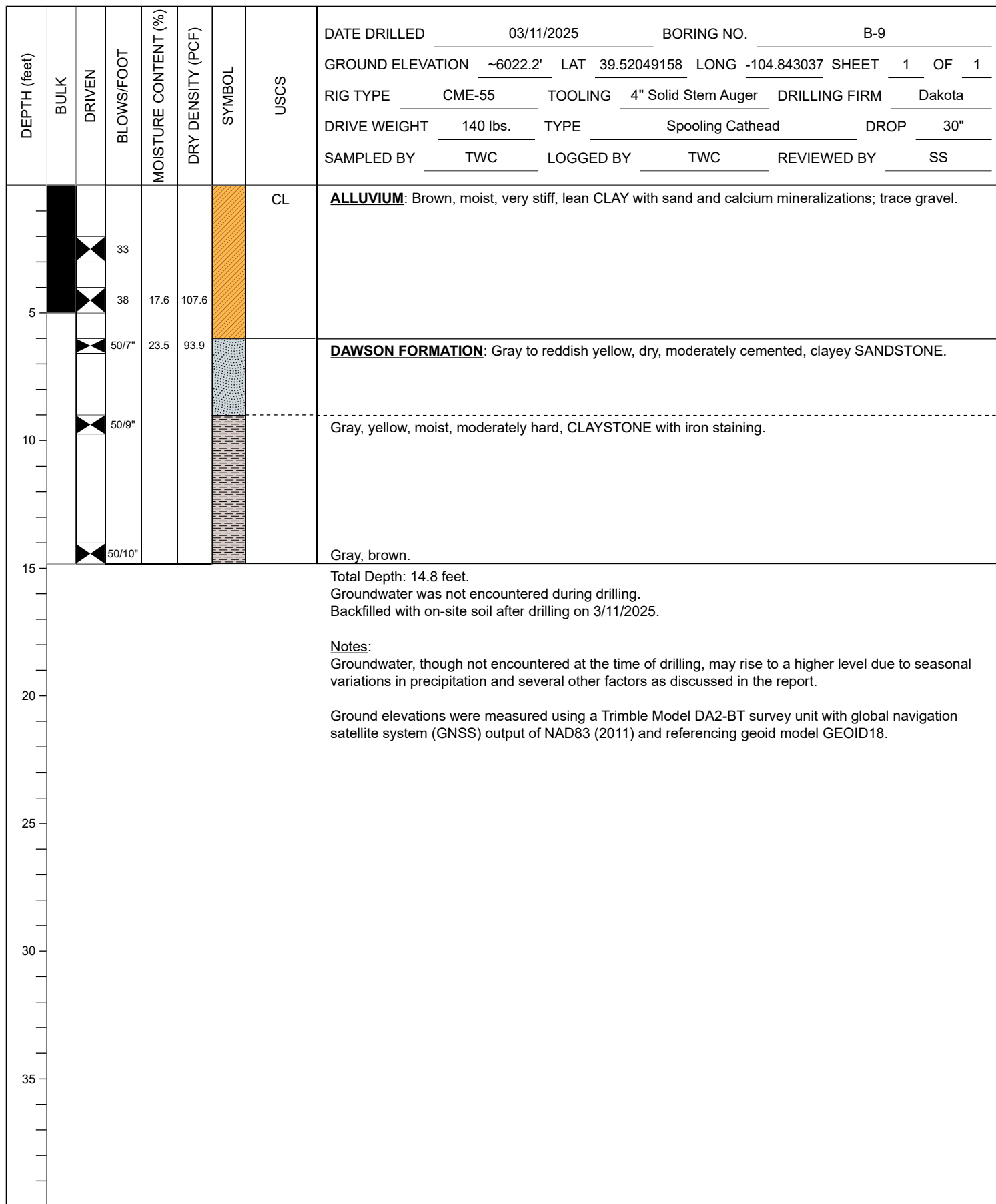
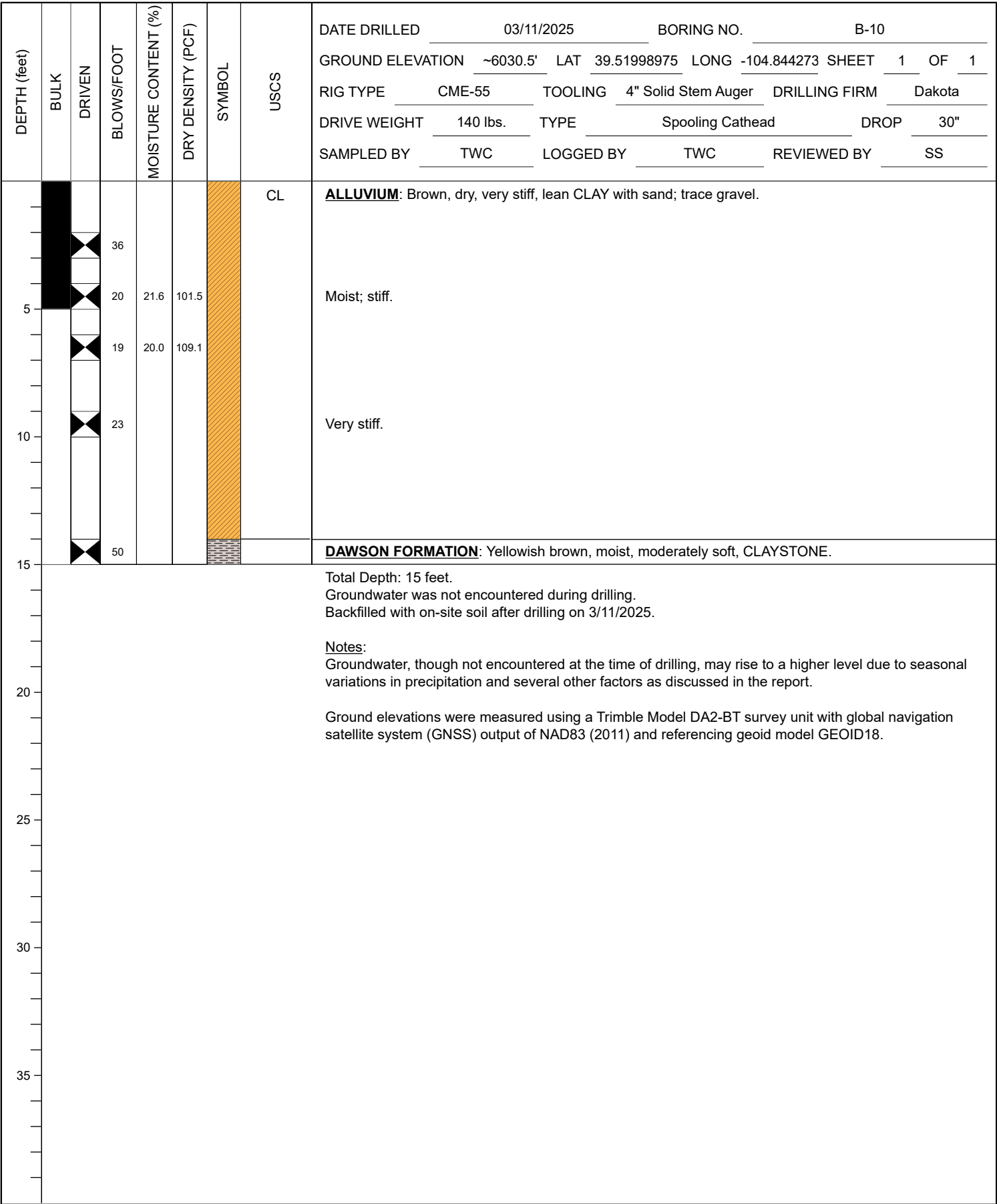


FIGURE A-9



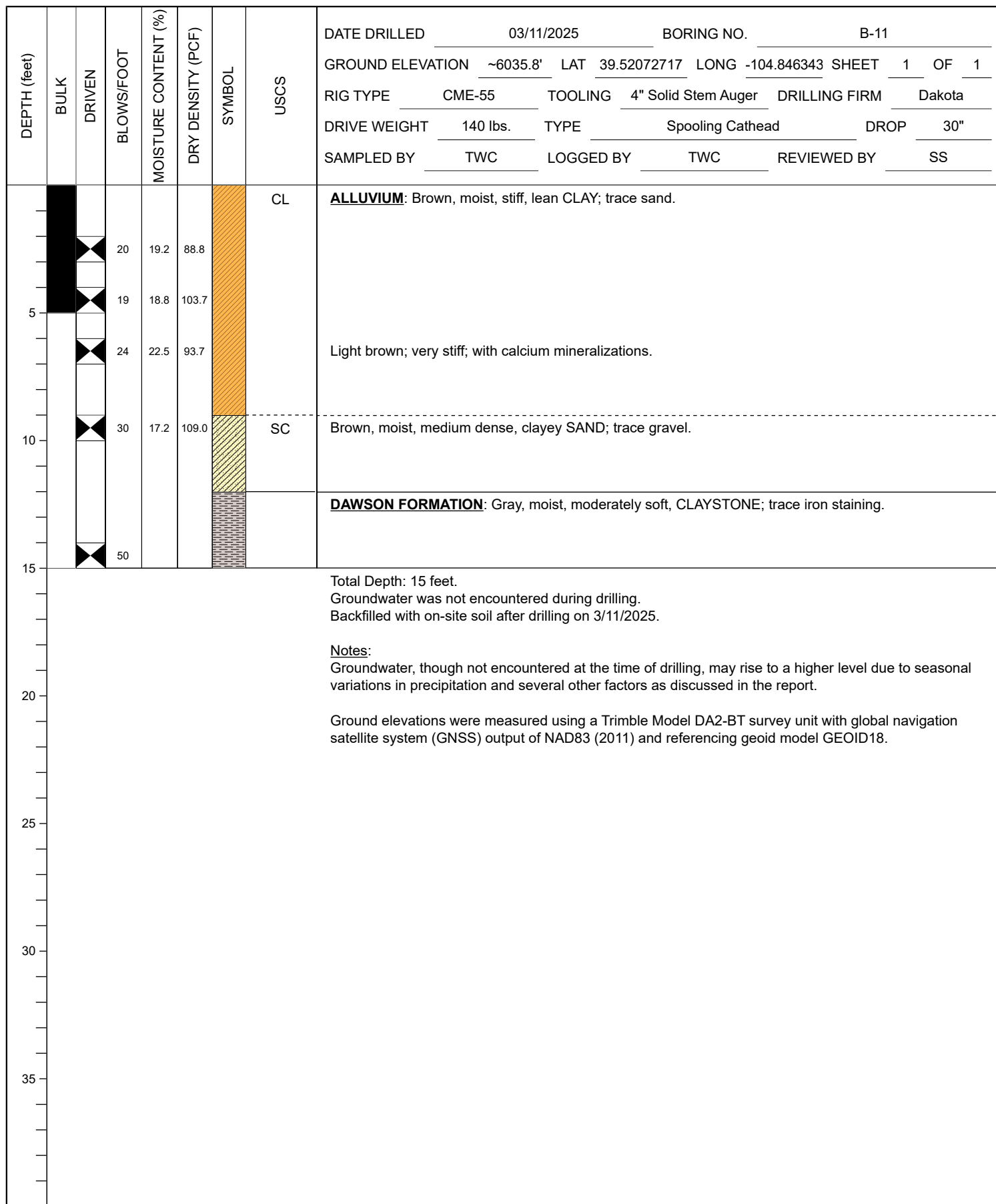


FIGURE A-11

DEPTH (feet)	BULK	DRIVEN	BLOWS/FOOT	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SYMBOL	USCS	DATE DRILLED 03/07/2025 BORING NO. B-12									
								GROUND ELEVATION ~6185.3'		LAT 39.47548613	LONG -104.800853	SHEET 1	OF 1				
								RIG TYPE CME-55		TOOLING 4" Solid Stem Auger	DRILLING FIRM Dakota						
								DRIVE WEIGHT 140 lbs.		TYPE Spooling Cathead		DROP 30"					
								SAMPLED BY TWC		LOGGED BY TWC		REVIEWED BY SS					
								FILL: Brown, moist, sandy lean CLAY.									
			50/10"	18.9	87.4		CL	ALLUVIUM: Brown, moist, lean CLAY with sand.									
			50/10"	8.2	102.9			DAWSON FORMATION: Yellowish brown, moist, moderately hard, sandy CLAYSTONE.									
5			50/5"	9.7	90.6			Light gray, moist, weakly cemented, SANDSTONE.									
								Strongly cemented.									
10			50/8"	24.3	100.5			Light brown, moist, moderately hard, CLAYSTONE.									
15			50/6"					Grayish brown; hard.									
								Total Depth: 14.5 feet. Groundwater was not encountered during drilling. Backfilled with on-site soil after drilling on 3/7/2025.									
								<u>Notes:</u> Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.									
								Ground elevations were measured using a Trimble Model DA2-BT survey unit with global navigation satellite system (GNSS) output of NAD83 (2011) and referencing geoid model GEOID18.									
20																	
25																	
30																	
35																	

FIGURE A-12

DEPTH (feet)	BULK	DRIVEN	BLOWS/FOOT	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SYMBOL	USCS	DATE DRILLED 03/07/2025 BORING NO. B-13							
								GROUND ELEVATION ~6177.1'		LAT 39.47428727	LONG -104.800650	SHEET 1	OF 1		
								RIG TYPE CME-55		TOOLING 4" Solid Stem Auger	DRILLING FIRM Dakota				
								DRIVE WEIGHT 140 lbs.		TYPE Spooling Cathead		DROP 30"			
								SAMPLED BY TWC		LOGGED BY TWC		REVIEWED BY SS			
								FILL: Light brown, moist, medium dense, clayey SAND; trace gravel.							
5			24	9.6	116.4		CL	ALLUVIUM: Yellowish brown, moist, very stiff, sandy lean CLAY; trace gravel.							
			25	17.1	112.3			Stiff.							
			19	16.8	101.9			Very stiff.							
10			31	12.8	120.3										
15			20	18.6	100.3			Brown to yellowish brown; stiff.							
								Total Depth: 15 feet. Groundwater was not encountered during drilling. Backfilled with on-site soil after drilling on 3/7/2025.							
								<u>Notes:</u> Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.							
								Ground elevations were measured using a Trimble Model DA2-BT survey unit with global navigation satellite system (GNSS) output of NAD83 (2011) and referencing geoid model GEOID18.							
20															
25															
30															
35															

FIGURE A-13



APPENDIX B

Laboratory Testing

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classifications System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the logs of the exploratory excavations in Appendix A.

In-Place Moisture and Density Tests

The moisture content and dry density of ring-lined samples obtained from the exploratory borings were evaluated in general accordance with ASTM D 2937. These test results are presented on the logs of the exploratory borings in Appendix A.

Atterberg Limits

Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the Unified Soil Classification System. The test results and classifications are shown on Figure B-1.

200 Wash

An evaluation of the percentage of particles finer than the No. 200 sieve in selected soil samples was performed in general accordance with ASTM D 1140. The results of the tests are presented on Figure B-2.

Consolidation/Swell Tests

The consolidation and/or swell potential of selected materials were evaluated in general accordance with ASTM D 4546. Specimens were loaded with a specified surcharge before inundation with water. Readings of volumetric consolidation/swell were recorded until completion of primary consolidation/swell. After the completion of primary swell, surcharge loads were increased incrementally to evaluate swell pressure. The results of the consolidation/swell tests are presented on Figures B-3 through B-7.

Direct Shear Tests

Direct shear tests were performed on relatively undisturbed samples in general accordance with ASTM D 3080 to evaluate the shear strength characteristics of selected materials. The samples were inundated during shearing to represent adverse field conditions. The results are shown on Figure 8.

Unconfined Compression Tests

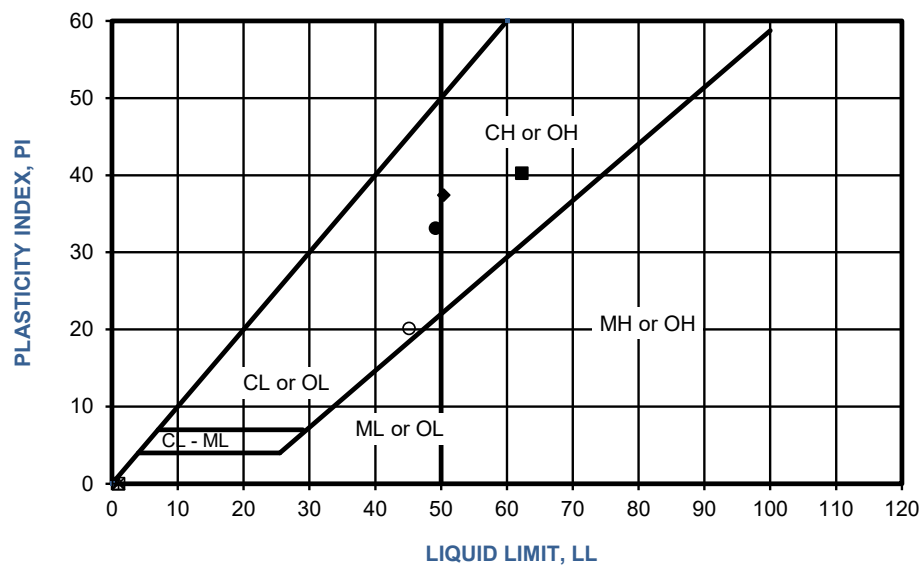
Unconfined compression tests were performed on relatively undisturbed samples in general accordance with ASTM D 2166. The test results are shown on Figure 9.

Soil Corrosivity Tests

A soil pH test was performed on a representative sample in general accordance with ASTM Test Method D 4972. A soil minimum resistivity test was performed on a representative sample in general accordance with AASHTO T288. The sulfate content of a selected sample was evaluated in general accordance with CDOT Test Method CP-L 2103. The chloride content of a selected sample was evaluated in general accordance with CDOT Test Method CP-L 2104. The test results are presented on Figure B-10.

SYMBOL	LOCATION	DEPTH (ft)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve)	EQUIVALENT USCS
●	B-1	4.0-5.0	49	16	33	CL	CL
■	B-5	4.0-5.0	62	22	40	CH	CH
◆	B-8	6.0-7.0	50	13	37	CH	CH
○	B-9	6.0-6.6	45	25	20	CL	CL

NP - INDICATES NON-PLASTIC



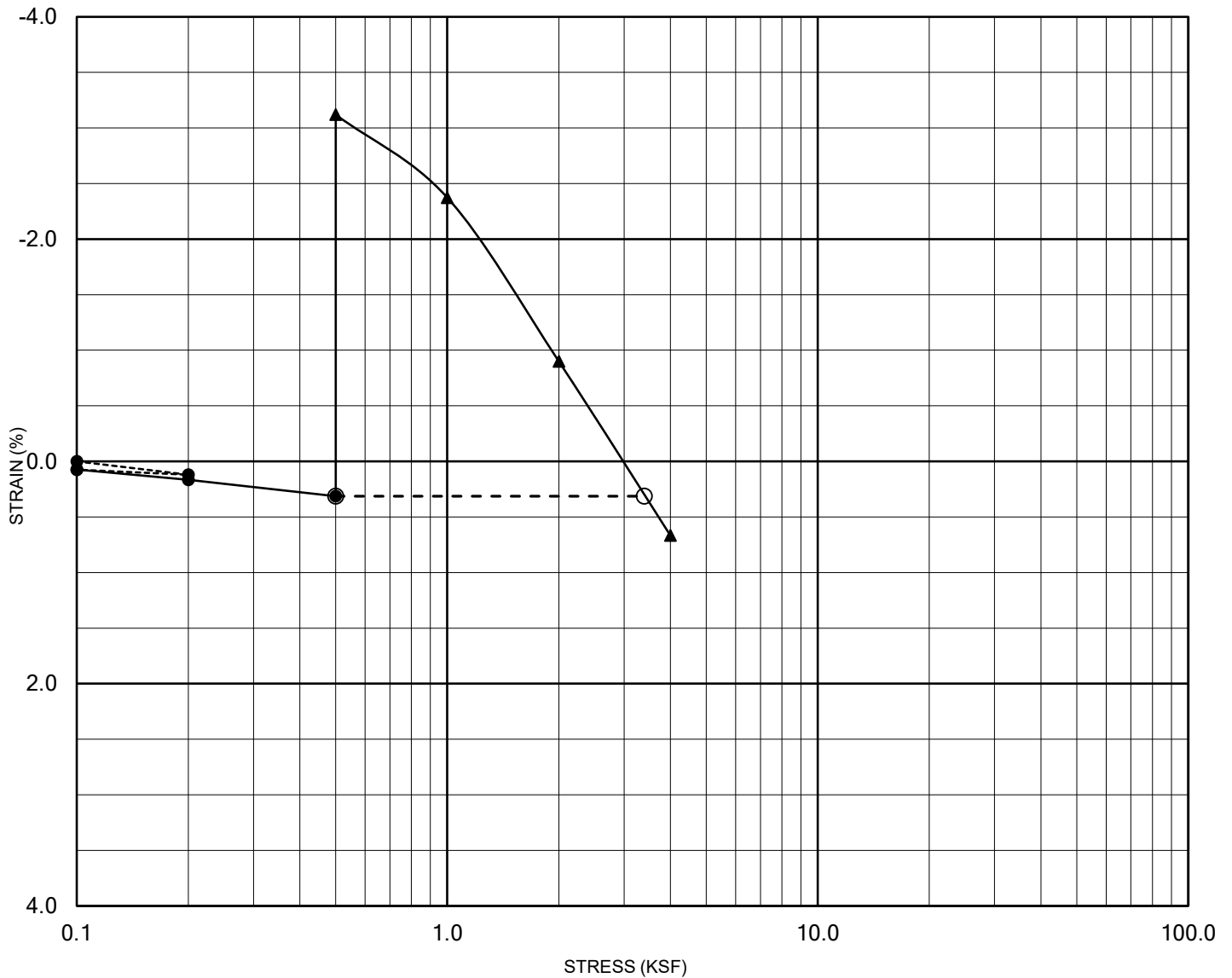
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-1

SAMPLE LOCATION	SAMPLE DEPTH (ft)	DESCRIPTION	PERCENT PASSING NO. 4	PERCENT PASSING NO. 200	EQUIVALENT USCS
B-1	4.0-5.0	Light Brown Lean CLAY with Sand; Trace Gravel	96	77	CL
B-3	4.0-5.0	Light Brown SAND with Clay and Gravel	65	7	SP-SC
B-5	4.0-5.0	Light Yellowish Brown CLAYSTONE; DAWSON FORMATION	100	88	CH
B-8	6.0-7.0	Dark Brown Fat CLAY with Sand; Trace Gravel	99	84	CH
B-9	6.0-6.6	Gray to Reddish Yellow Clayey SANDSTONE; DAWSON FORMATION	100	34	SC
B-11	4.0-5.0	Brown Lean CLAY; Trace Gravel	100	89	CL
B-11	9.0-10.0	Brown Clayey SAND; Trace Gravel	98	48	SC
B-12	4.0-4.5	Light Gray SANDSTONE; DAWSON FORMATION	100	11	SP-SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 1140

FIGURE B-2



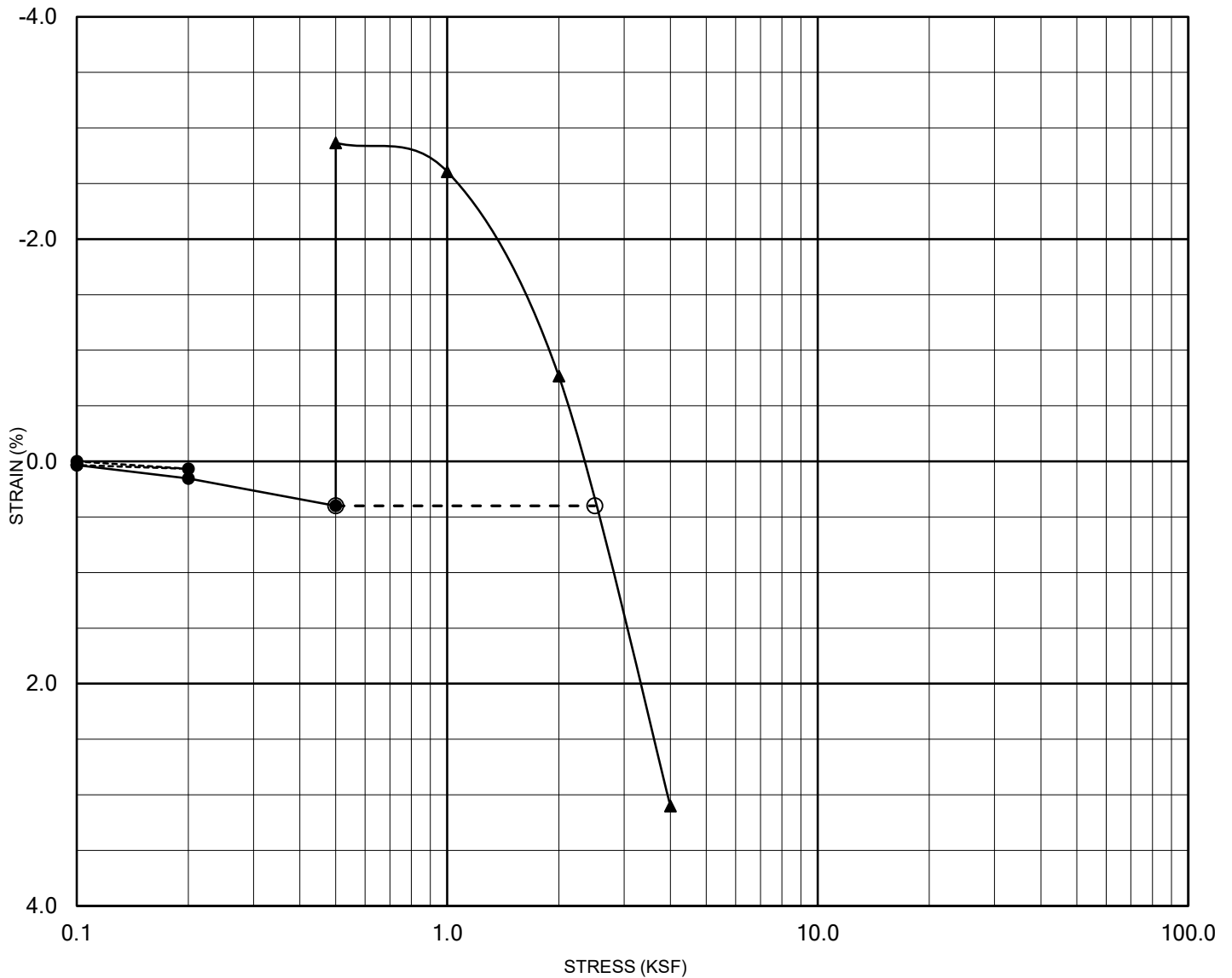
---●--- Seating Cycle
 —●— Load Prior to Inundation
 —▲— Load After Inundation
 - ⊖ - Swell Pressure

Moisture Increase (%): 16.9
 Swell Percentage (%): 3.4
 Swell Pressure (psf): 2,900

Sample Location: B-1
 Depth: 4.0-5.0
 Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-3



---●--- Seating Cycle

—●— Load Prior to Inundation

—▲— Load After Inundation

- ⊖ - Swell Pressure

Moisture Increase (%): 11.4

Swell Percentage (%): 3.3

Swell Pressure (psf): 2,000

Sample Location: B-5

Depth: 4.0-5.0

Soil Type: CLAYSTONE; DAWSON FORMATION

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-4

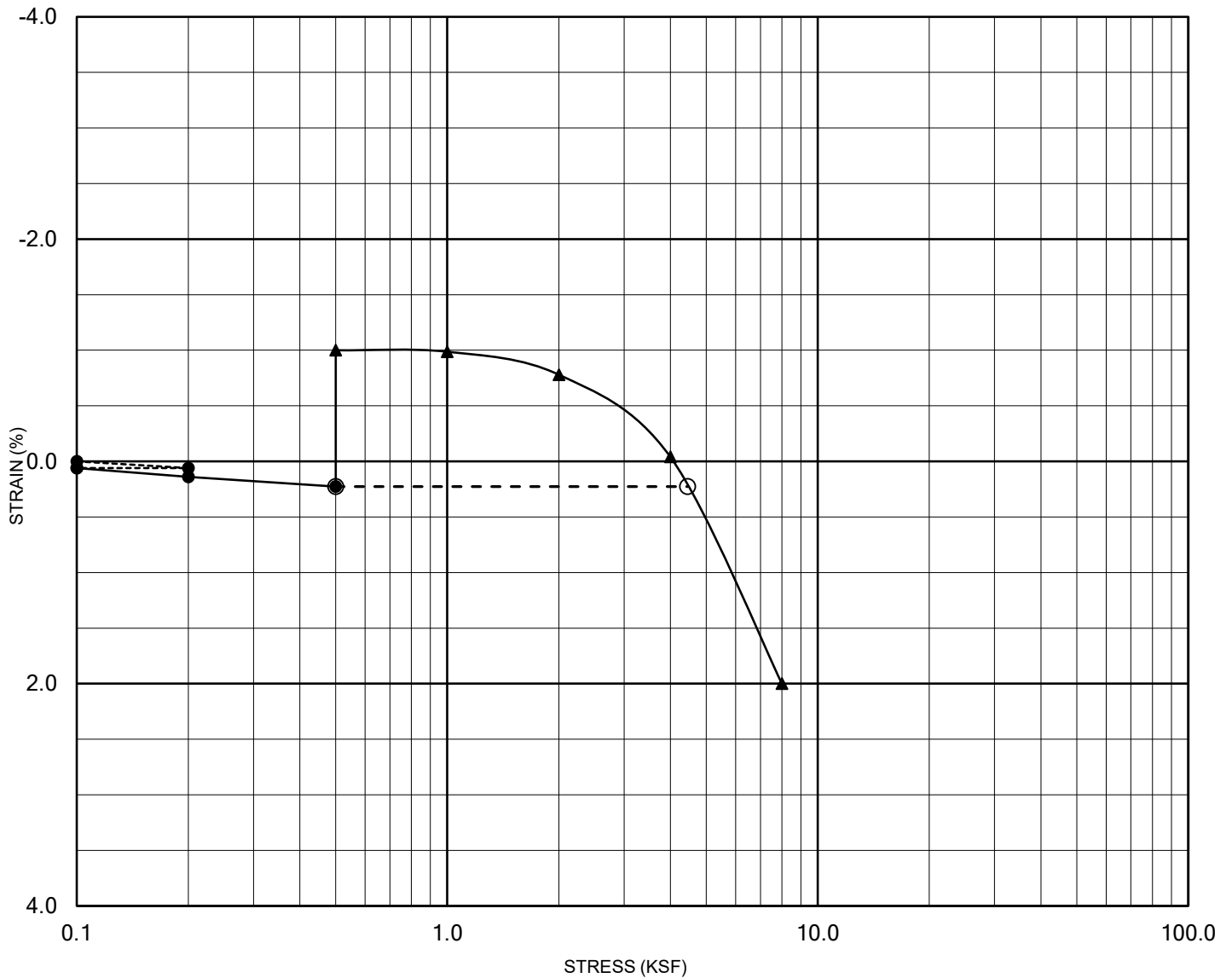
CONSOLIDATION TEST RESULTS

DENVER BASIN WELL SITES PHASE II & PIPELINE PROJECT

PARKER, COLORADO

503147001

4/25



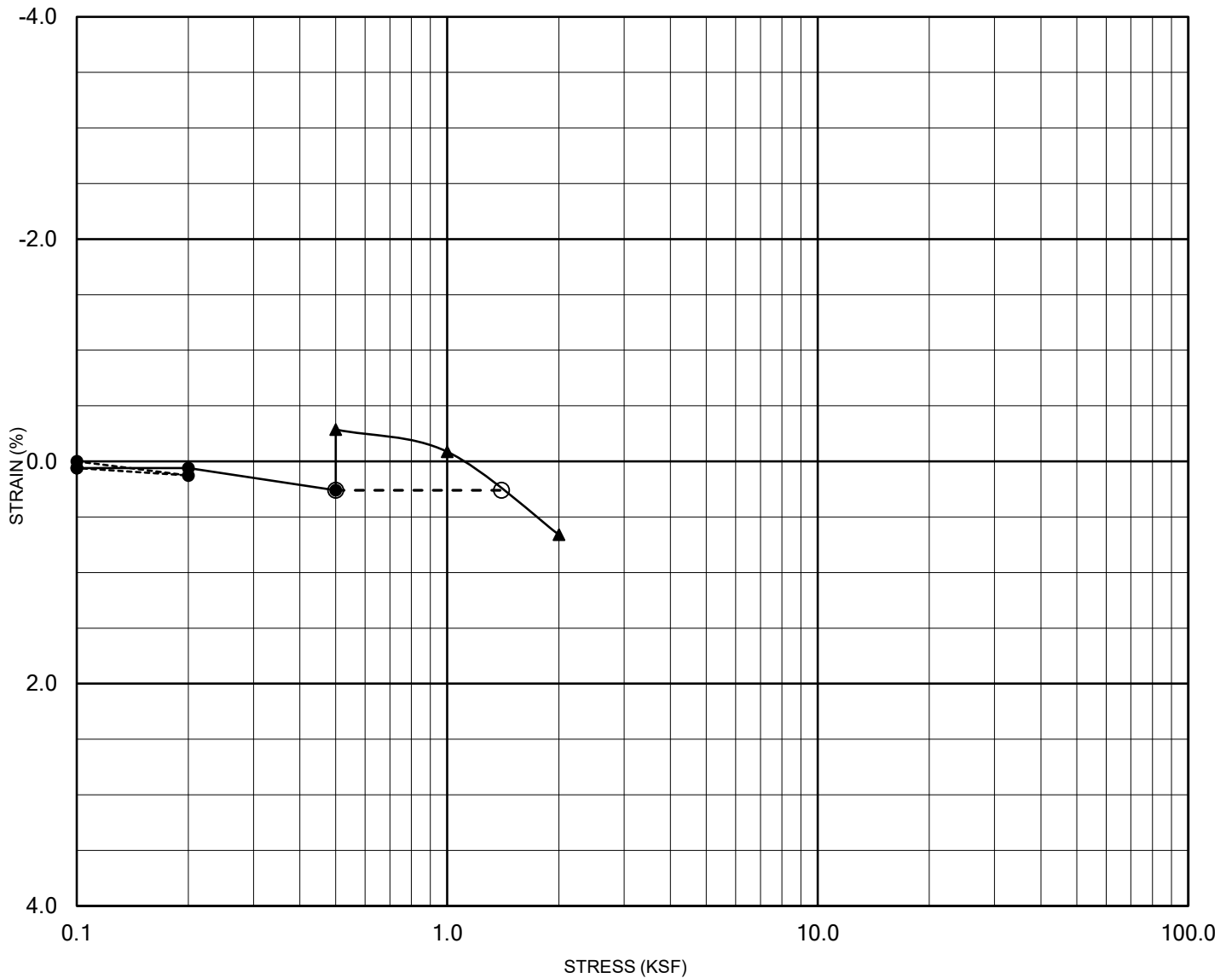
---●--- Seating Cycle
 —●— Load Prior to Inundation
 —▲— Load After Inundation
 - ⊖ - Swell Pressure

Moisture Increase (%): 1.0
 Swell Percentage (%): 1.2
 Swell Pressure (psf): 3,950

Sample Location: B-10
 Depth: 4.0-5.0
 Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-5



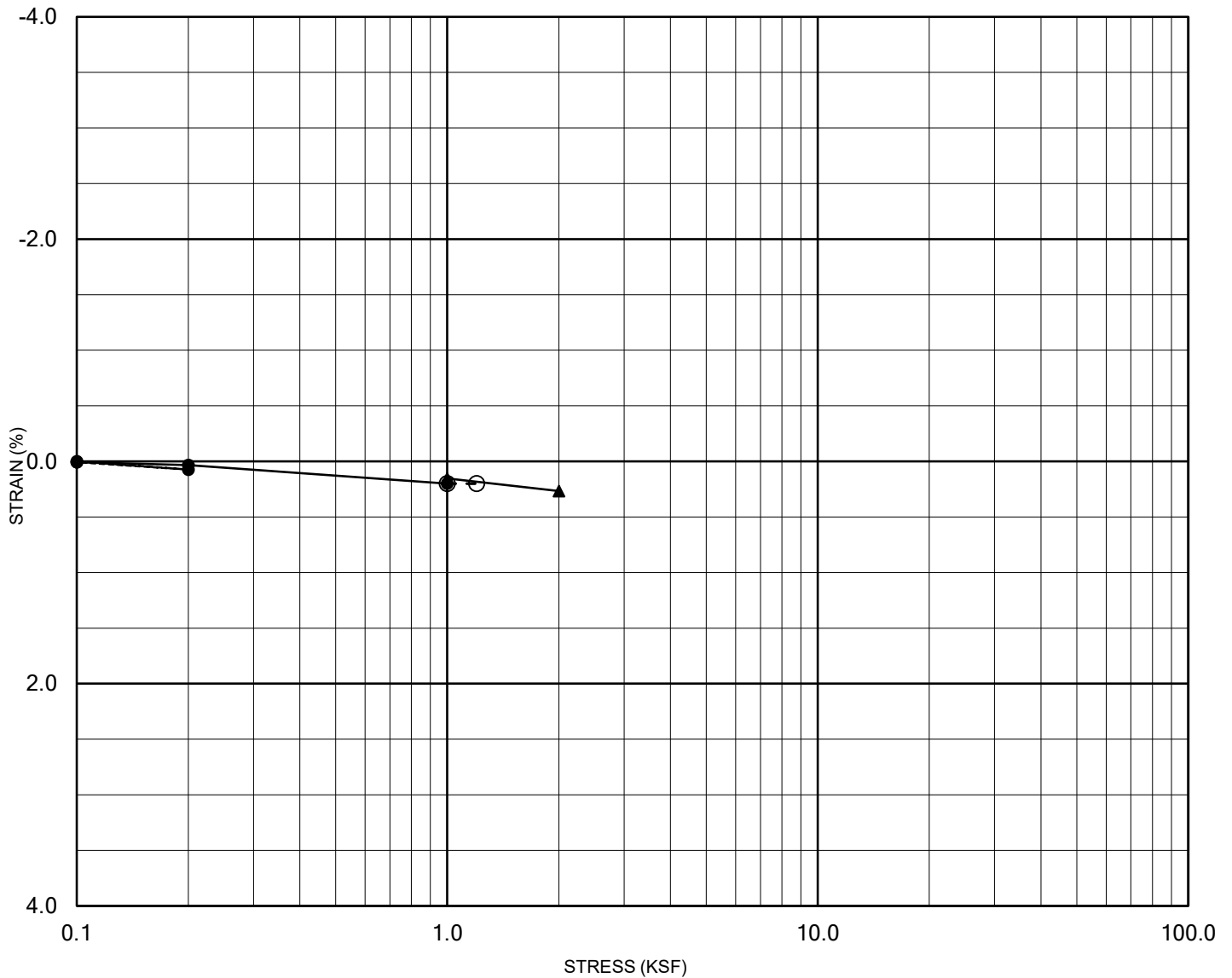
- Seating Cycle
- Load Prior to Inundation
- ▲— Load After Inundation
- ⊖ - Swell Pressure

Moisture Increase (%): 3.5
 Swell Percentage (%): 0.5
 Swell Pressure (psf): 900

Sample Location: B-13
 Depth: 4.0-5.0
 Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

FIGURE B-6



---●--- Seating Cycle
 —●— Load Prior to Inundation
 —▲— Load After Inundation
 - ⊖ - Swell Pressure

Moisture Increase (%): 1.8
 Swell Percentage (%): 0.1
 Swell Pressure (psf): 200

Sample Location: B-13
 Depth: 9.0-10.0
 Soil Type: CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4546

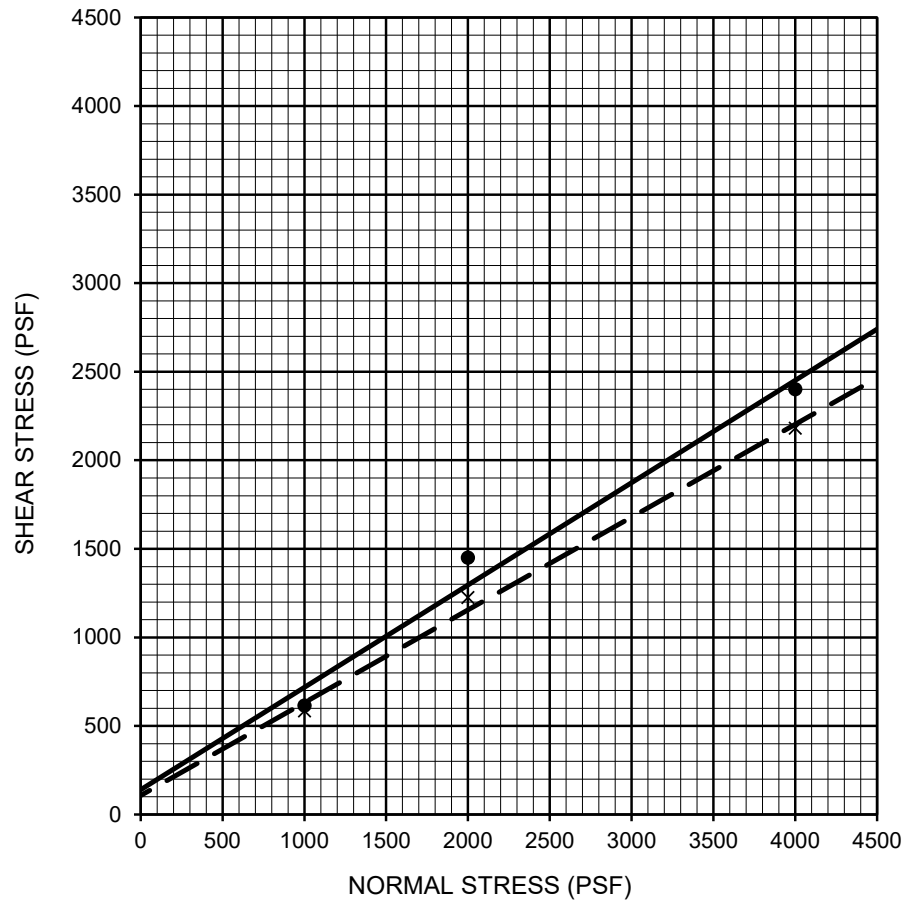
FIGURE B-7

Ninyo & Moore
 Geotechnical & Environmental Sciences Consultants

CONSOLIDATION TEST RESULTS
 DENVER BASIN WELL SITES PHASE II & PIPELINE PROJECT
 PARKER, COLORADO

503147001

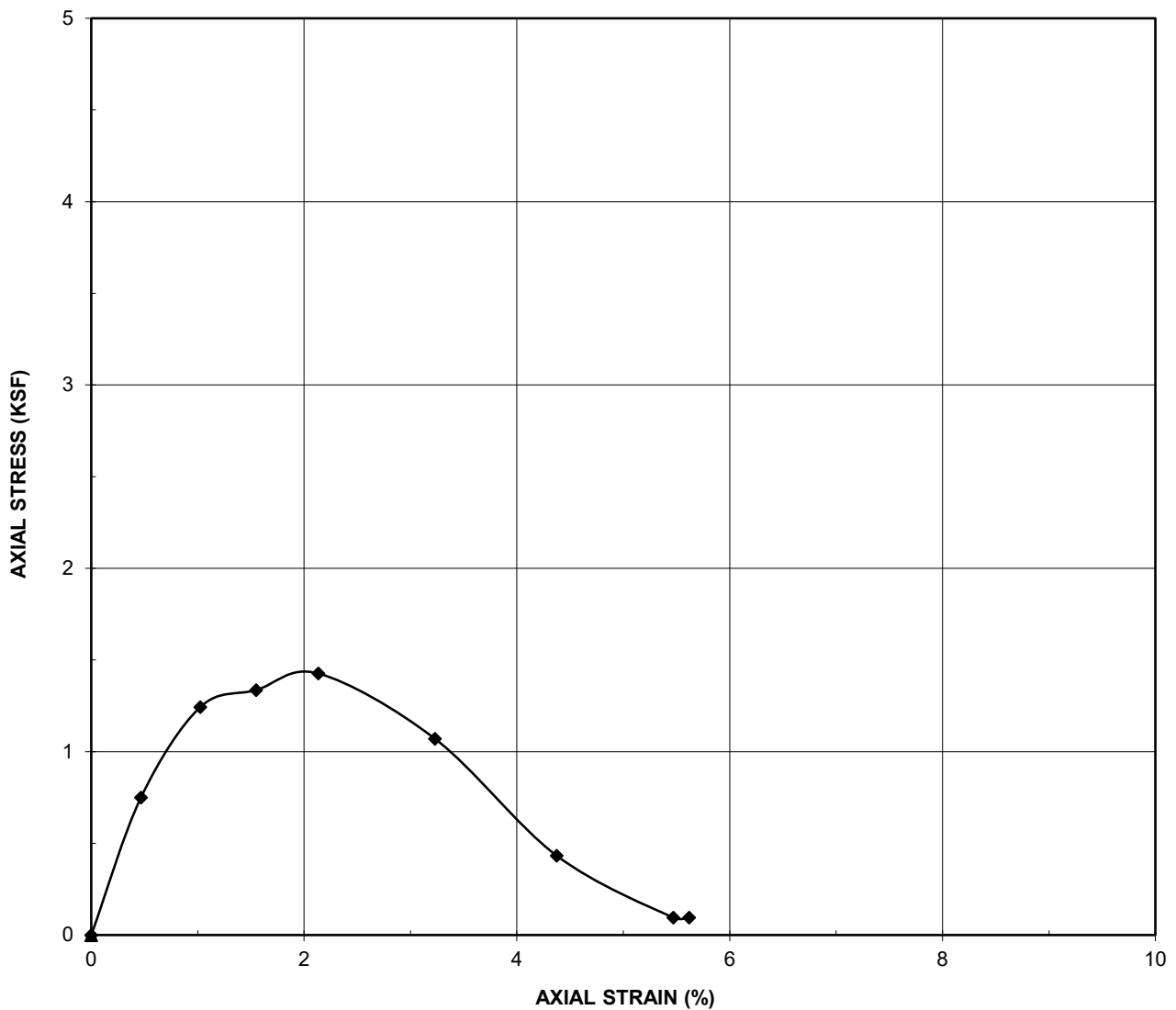
4/25



Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion (psf)	Friction Angle (degrees)	Equivalent USCS
Brown Clayey SAND; Trace Gravel		B-1	2.0-3.0	Peak	140	30	SC
Brown Clayey SAND; Trace Gravel		B-1	2.0-3.0	Ultimate	108	28	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 3080

FIGURE B-8



Symbol	Description	Soil Type	Sample Number	Sample Depth (feet)	Moisture Content w (%)	Dry Density γ_d (pcf)	Strain Rate (%/min)	Shear Strength S_u (ksf)
◆	Yellowish Brown Sandy Lean CLAY	CL	B-13	6.0-7.0	16.8	103.6	2.8	0.7

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2166

FIGURE B-9

SAMPLE LOCATION	SAMPLE DEPTH (ft)	pH ¹	RESISTIVITY ² (ohm-cm)	SULFATE CONTENT IN SOIL ³ (ppm) (%)		CHLORIDE CONTENT ⁴ (ppm)
B-1	0.0-5.0	6.9	1,490	10	0.001	35
B-5	0.0-5.0	7.1	130	10	0.001	40
B-9	0.0-5.0	7.0	636	31	0.003	50
B-11	0.0-5.0	6.3	614	4	0.000	40
B-12, B-13	0.0-5.0	7.2	259	11	0.001	35

¹ PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4972

² PERFORMED IN GENERAL ACCORDANCE WITH AASHTO T288

³ PERFORMED IN GENERAL ACCORDANCE WITH CDOT TEST METHOD CP-L 2103 METHOD B

⁴ PERFORMED IN GENERAL ACCORDANCE WITH CDOT TEST METHOD CP-L 2104

FIGURE B-10

CORROSIVITY TEST RESULTS

DENVER BASIN WELL SITES PHASE II & PIPELINE PROJECT

PARKER, COLORADO

503147001 | 4/25



APPENDIX C

Site Photographs and Descriptions

Project Name: Denver Basin Well Sites Phase II and Pipeline Project

Project No. 503147001

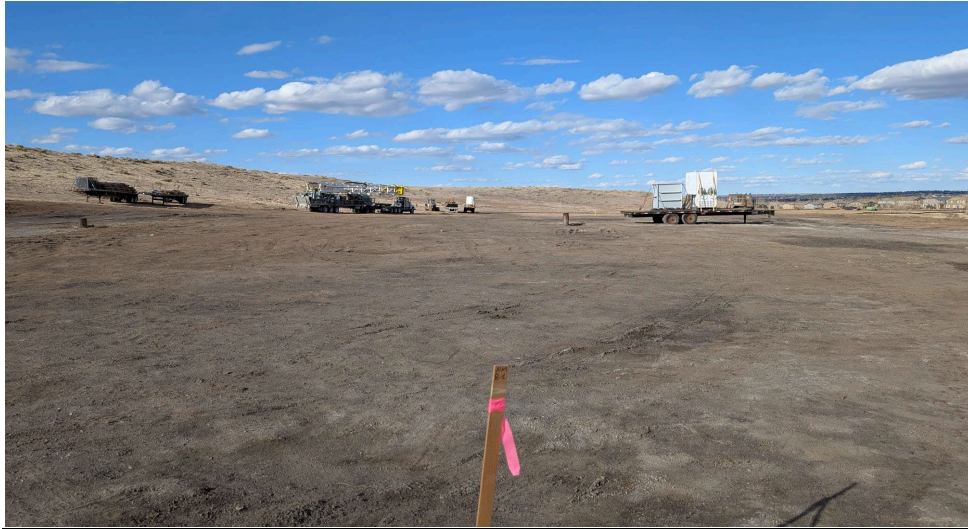


Photo No. 1 **Location:** Boring B-1 **Date:** Various
Overview of Boring B-1 and the Badger Gulch well site. Equipment was on-site to install the well.



Photo No. 2 **Location:** Boring B-2 **Date:** Various
View of Boring B-2, looking south.

Project Name: Denver Basin Well Sites Phase II and Pipeline Project

Project No. 503147001



Photo No. 3 **Location:** Boring B-3
Overview of Boring B-3.

Date: Various



Photo No. 4 **Location:** Boring B-7
View of Boring B-7 and North Ridgeway Parkway.

Date: Various

Project Name: Denver Basin Well Sites Phase II and Pipeline Project

Project No. 503147001



Photo No. 5 **Location:** Boring B-11
Existing Ridgeway Well House.

Date: Various



Photo No. 6 **Location:** Boring B-13
Site development is ongoing at the Rueter-Hess site and along Stroh Road.

Project Name: Denver Basin Well Sites Phase II and Pipeline Project

Project No. 503147001



Photo No. 7

Location: Boring B-5

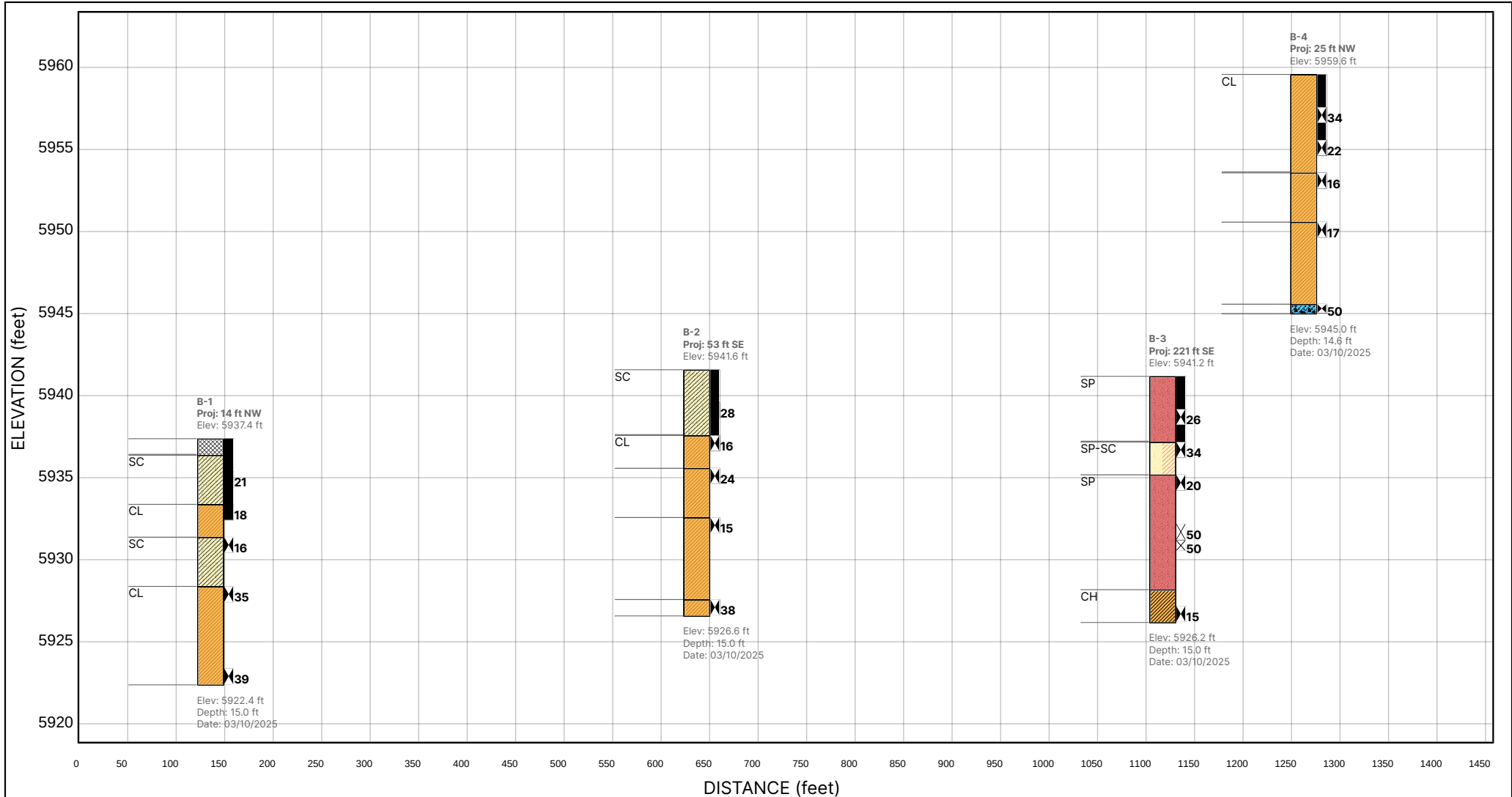
Date: Various

Drilling was completed with a truck rig equipped with 4-inch solid stem augers.



APPENDIX D

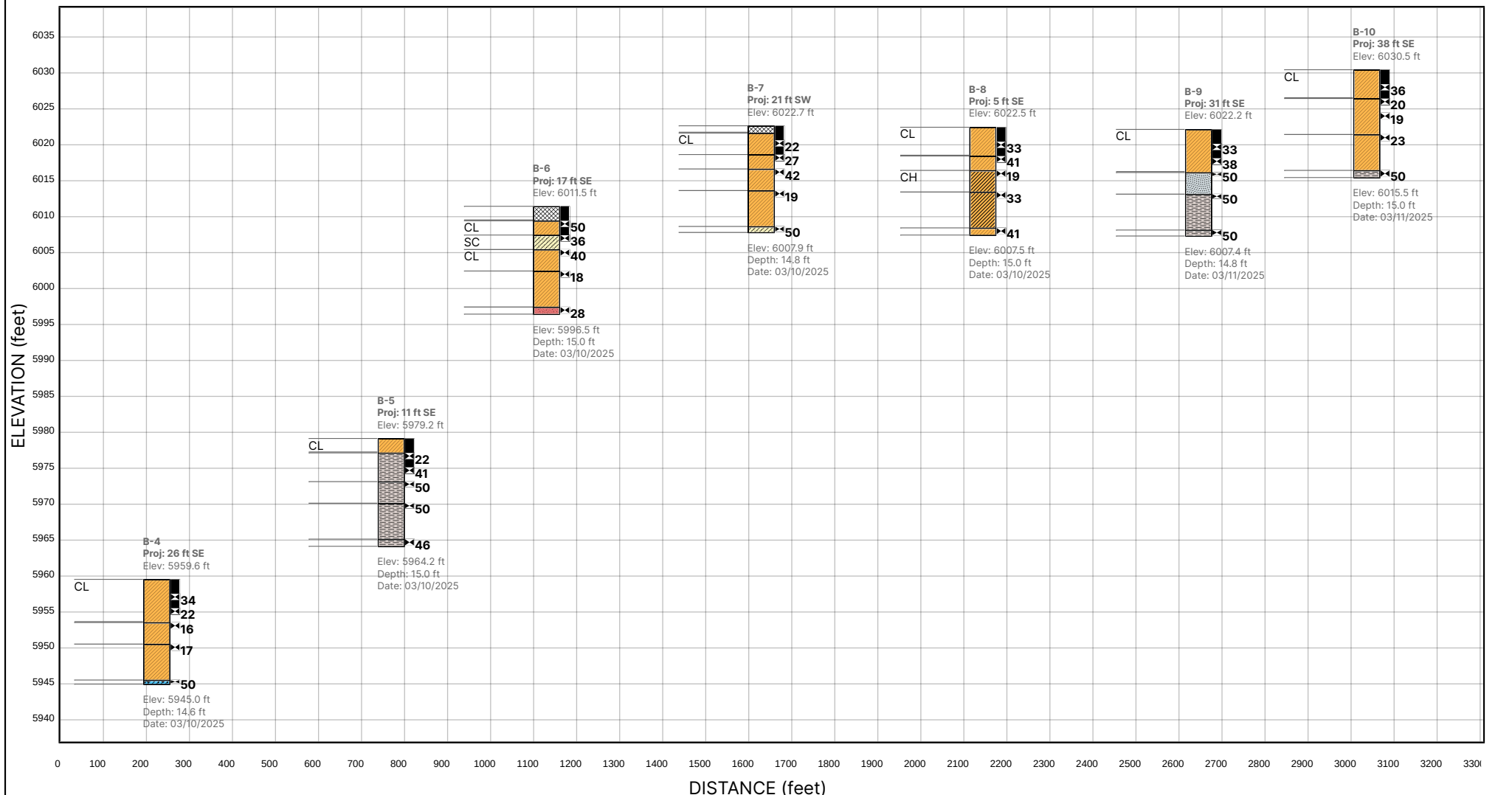
Cross Sections



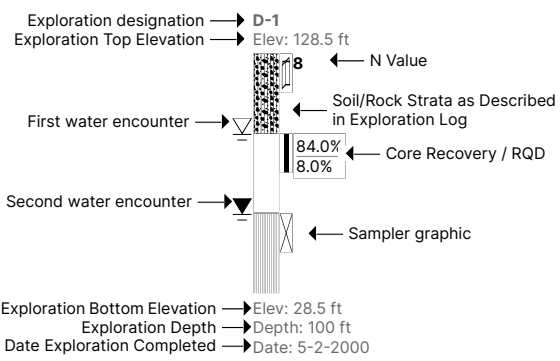
DENVER BASIN WELL SITES PHASE II
& PIPELINE PROJECT
PARKER, COLORADO

CROSS SECTION A-A'

Ninyo & Moore



EXPLORATION LOG LEGEND



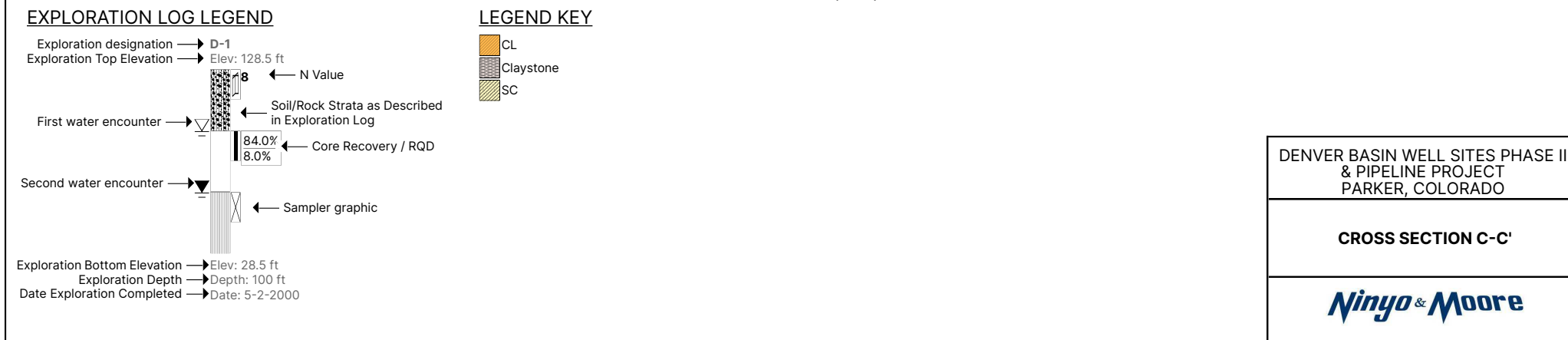
LEGEND KEY

- CL
- GC
- Claystone
- SP
- SC
- Fill
- CH
- Sandstone

DENVER BASIN WELL SITES PHASE II
& PIPELINE PROJECT
PARKER, COLORADO

CROSS SECTION B-B'







APPENDIX E

ESAL Estimate

AASHTO 1993 ESAL Calculator for Flexible Pavements

Vehicle Description	Traffic Volume			Analysis Period (years)	Axle Load and Type						Gross Weight (pounds)	Equivalency Factors			ESAL's
	Quantity in the Design Lane	Days per Week	Weeks per Year		Axle 1 (kips)	Axle 2 (kips)	Axle 3 (kips)		Axle 1	Axle 2		Axle 3			
Car/SUV/Pickup Truck	100	7	52	20	3	S	3	S			6,000	0.0011	0.0011	0	1,602
Pick-up truck or van					3	S	3	S			6,000	0.0011	0.0011	0	0
Recreational vehicle					4	S	4	S			8,000	0.002	0.002	0	0
School bus					12	S	22	S			20,000	0.189	2.35	0	0
TARC bus					8	S	14	S			22,000	0.036	0.354	0	0
Commercial Carrier Bus					17	S	19	S			36,000	0.8065	1.28	0	0
Package delivery truck					4	S	16	S			20,000	0.002	0.613	0	0
Beverage delivery truck					6	S	12	S	12	S	30,000	0.011	0.189	0.189	0
Garbage/dumpster truck					16	S	17	T			33,000	0.613	0.0655	0	0
Concrete truck (full)					20	S	48	R			68,000	1.56	1.015	0	0
Dump truck (full)	1	2	52	20	20	S	48	R			68,000	1.56	1.015	0	5,356
Semi-tractor (no trailer)					8	S	2	T			10,000	0.036	0	0	0
Semi-tractor trailer (empty)					8	S	8	T	6	T	22,000	0.036	0.003	0.001	0
Semi-tractor trailer					12	S	34	T	34	T	80,000	0.189	1.08	1.08	0
Fire Truck	1	2	52	20	12	S	30	T	30	T	72,000	0.189	0.646	0.646	3,080
RTD Bus					14	S	24	T		T	38,000	0.354	0.26	0	0
Vehicle type H10					4	S	16	S			20,000	0.002	0.613	0	0
Vehicle type H15					6	S	24	S			30,000	0.011	3.43	0	0
Vehicle type H20					8	S	32	S			40,000	0.036	12.4	0	0
Vehicle type 3					16	S	34	T			50,000	0.613	1.08	0	0
Vehicle type HS15					6	S	24	S	24	S	54,000	0.011	3.43	3.43	0
Vehicle type HS20					8	S	32	S	32	S	72,000	0.036	12.4	12.4	0
Vehicle type 3S2					10	S	31	T	31	T	72,000	0.09	0.7445	0.7445	0

Terminal Serviceability, r_t	2.0
Assumed Structural Number, SN	3
Traffic Growth Rate, %/yr	0

Summary:	Total AASHTO ESAL's	10,038
	Superpave	ESAL Class 1
	Traffic Category	Light Duty Pavement

Project: PWSD Waterline

Location:

Lone Tree

Job No.: 503147001

Date:

4/25/2025

Ninyo & Moore



9707 East Easter Lane | Centennial, Colorado 80112 | p. 303.629.6000

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Geotechnical & Environmental Sciences Consultants

Appendix C: Erosion Control Plans

PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO



DENVER BASIN WELL SITES PHASE II AND PIPELINE
BADGER GULCH WELLS AND IMPROVEMENTS

HAZEN CONTRACT NO.: 70069-008
DATE: SEPTEMBER 2025

SHEET LIST

GENERAL

DRAWING NO	SHEET NAME
G000	COVER SHEET
G001	LEGEND, SYMBOLS, ABBREVIATIONS, AND INDEX OF DRAWINGS

CIVIL

DRAWING NO	SHEET NAME
C001	CIVIL LEGENDS AND GENERAL NOTES
C002	OVERALL MAP, KEY MAP, AND SURVEY CONTROL
C003	OVERALL GESC MAP
C004	EROSION AND SEDIMENT CONTROL PLAN NOTES AND DETAILS I
C005	EROSION AND SEDIMENT CONTROL PLAN NOTES AND DETAILS II
C006	EROSION AND SEDIMENT CONTROL PLAN NOTES AND DETAILS III
C007	BADGER GULCH WELL SITE EROSION CONTROL PLAN
C008	ACCESS ROAD EROSION CONTROL PLAN
C009	PIPELINE GESC PLAN I
C010	PIPELINE GESC PLAN II
C011	PIPELINE GESC PLAN III
C012	PIPELINE GESC PLAN IV
C200	OVERALL SITE PLAN I
C201	OVERALL SITE PLAN II
C202	FACILITY PLAN
C203	GRADING PLAN
C300	BADGER GULCH PIPELINE PLAN AND PROFILE STA 10+00 TO STA 15+50
C301	BADGER GULCH PIPELINE PLAN AND PROFILE STA 15+50 TO STA 21+00
C302	BADGER GULCH PIPELINE PLAN AND PROFILE STA 21+00 TO STA 28+50
C303	BADGER GULCH PIPELINE PLAN AND PROFILE STA 28+50 TO STA 35+50
C304	BADGER GULCH PIPELINE PLAN AND PROFILE STA 35+50 TO STA 43+00
C305	BADGER GULCH PIPELINE PLAN AND PROFILE STA 43+00 TO STA 51+00
C306	BADGER GULCH PIPELINE PLAN AND PROFILE STA 51+00 TO STA 58+50
C307	BADGER GULCH PIPELINE PLAN AND PROFILE STA 58+50 TO STA 64+86
C308	RIDGEGATE WELL HOUSE FIBER SITE PLAN
CD01	CIVIL STANDARD DETAILS
CD02	PROJECT DETAILS
CD03	PWSD DETAILS I
CD04	PWSD DETAILS II

MECHANICAL

DRAWING NO	SHEET NAME
M100	OVERALL PLAN
M101	ENLARGED PLAN, SECTION, AND DETAIL
M102	ENLARGED PLAN AND ISOMETRIC
M103	SECTIONS
VAULT	
M200	PLANS
M201	SECTIONS
M202	SECTIONS AND ISOMETRIC
M203	STRUCTURAL STANDARD DETAILS

HVAC

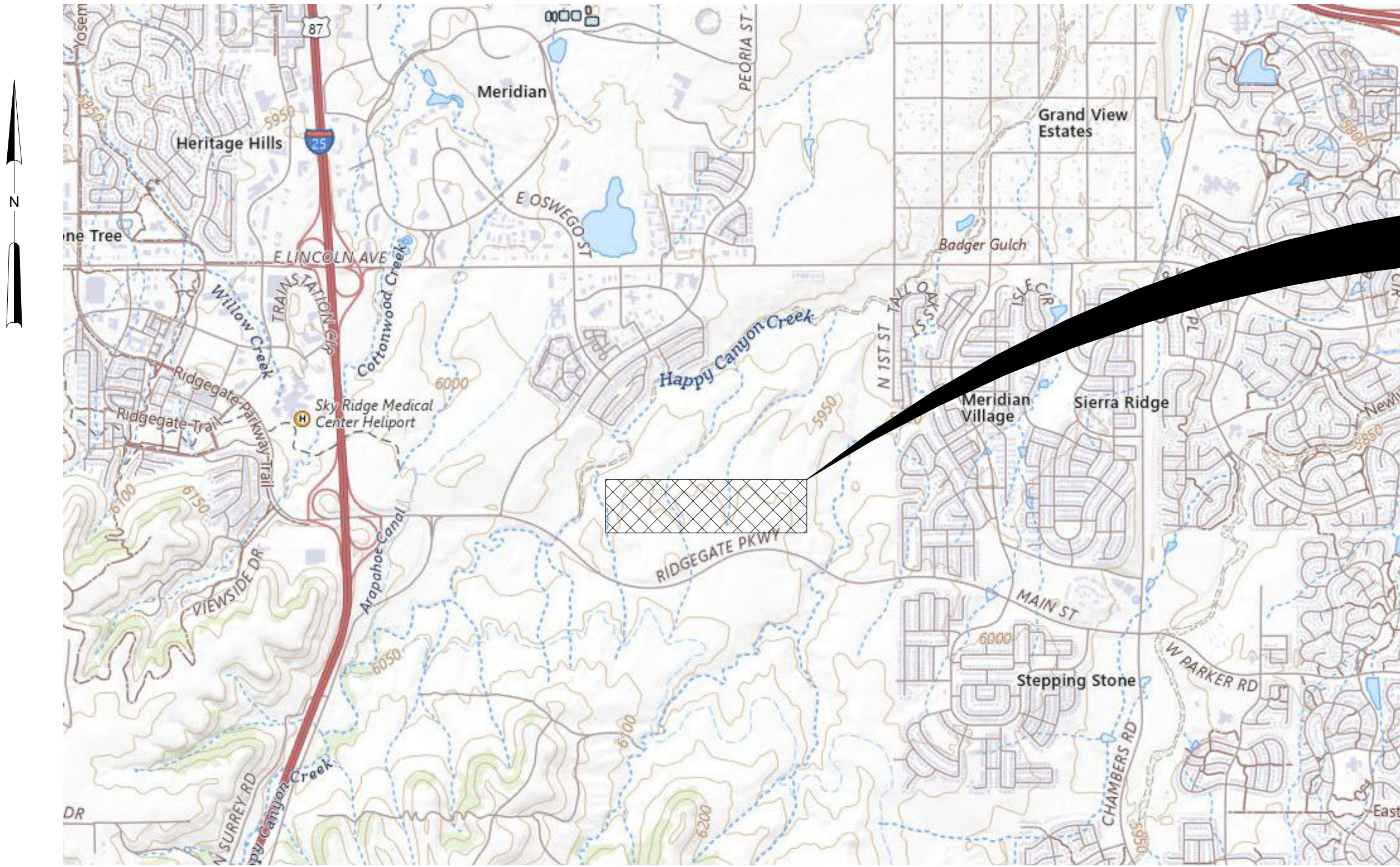
DRAWING NO	SHEET NAME
VAULT	
H001	GENERAL NOTES
H002	SCHEDULES, AIRFLOW DIAGRAM, AND SEQUENCE OF OPERATIONS
H200	PLANS
H201	SECTIONS

ELECTRICAL

DRAWING NO	SHEET NAME
GENERAL	
E001	LEGEND AND SYMBOLS
E002	NOTES AND ABBREVIATIONS
RIDGEGATE WELL HOUSE	
E101	POWER PLAN
E102	SINGLE LINE DIAGRAM, ELEVATION, AND RISER DIAGRAM
VAULT	
E201	SITE PLAN
E202	ENLARGED WELL SITE PLAN
E203	VAULT POWER PLAN
E204	SINGLE LINE DIAGRAM AND ELEVATION
E205	PANEL SCHEDULE AND RISER DIAGRAMS
E500	BLOCK DIAGRAMS
E501	CONDUIT AND DUCT BANK SCHEDULES
E502	ELEMENTARY CONTROL SCHEMATICS
ED01	ELECTRICAL DETAILS - I
ED02	ELECTRICAL DETAILS - II

INSTRUMENTATION
AND CONTROL

DRAWING NO	SHEET NAME
GENERAL	
I001	SYMBOLS AND LEGEND I
I002	SYMBOLS AND LEGEND II
I003	NETWORK DIAGRAM
I004	CE-7005 PANEL SCHEMATIC
I005	CE-7005 PANEL LAYOUT
RIDGEGATE WELL HOUSE	
I100	RIDGEGATE WELL HOUSE - P&ID
VAULT	
I200	BADGER GULTCH WELL SITE - P&ID
ID01	STANDARD DETAILS



LOCATION PLAN
NOT TO SCALE

Hazen

HAZEN AND SAWYER
6251 GREENWOOD PLAZA BLVD, SUITE
275 GREENWOOD VILLAGE, CO. 80111

BID PACKAGE

PROJECT AREA



CITY OF LONE TREE

DATE

THESE CONSTRUCTION PLANS HAVE BEEN REVIEWED BY THE CITY OF LONE TREE FOR DRAINAGE AND GRADING AND EROSION CONTROL IMPROVEMENTS ONLY.

ENGINEERING DIVISION ACCEPTANCE BLOCK

THE GRADING, EROSION, AND SEDIMENT CONTROL PLAN INCLUDED HEREIN HAS BEEN PLACED IN THE CITY OF LONE TREE FILE FOR THIS PROJECT AND APPEARS TO FULFILL APPLICABLE LONE TREE GRADING, EROSION, AND SEDIMENT CONTROL CRITERIA, AS AMENDED. ADDITIONAL GRADING, EROSION AND SEDIMENT CONTROL MEASURES MAY BE REQUIRED OF THE PERMITTEES DUE TO UNFORESEEN EROSION PROBLEMS OR IF THE SUBMITTED PLAN DOES NOT FUNCTION AS INTENDED. THE REQUIREMENTS OF THIS PLAN SHALL RUN WITH THE LAND AND BE THE OBLIGATION OF THE PERMITTEES, UNTIL SUCH TIME AS THE PLAN IS PROPERLY COMPLETED, MODIFIED, OR VOIDED.

THE GRADING, EROSION, AND SEDIMENT CONTROL PLAN INCLUDED HEREIN HAS BEEN PREPARED UNDER MY DIRECT SUPERVISION IN ACCORDANCE WITH THE REQUIREMENTS OF THE GRADING, EROSION, AND SEDIMENT CONTROL (GESC) CRITERIA MANUAL OF DOUGLAS COUNTY, AS AMENDED.

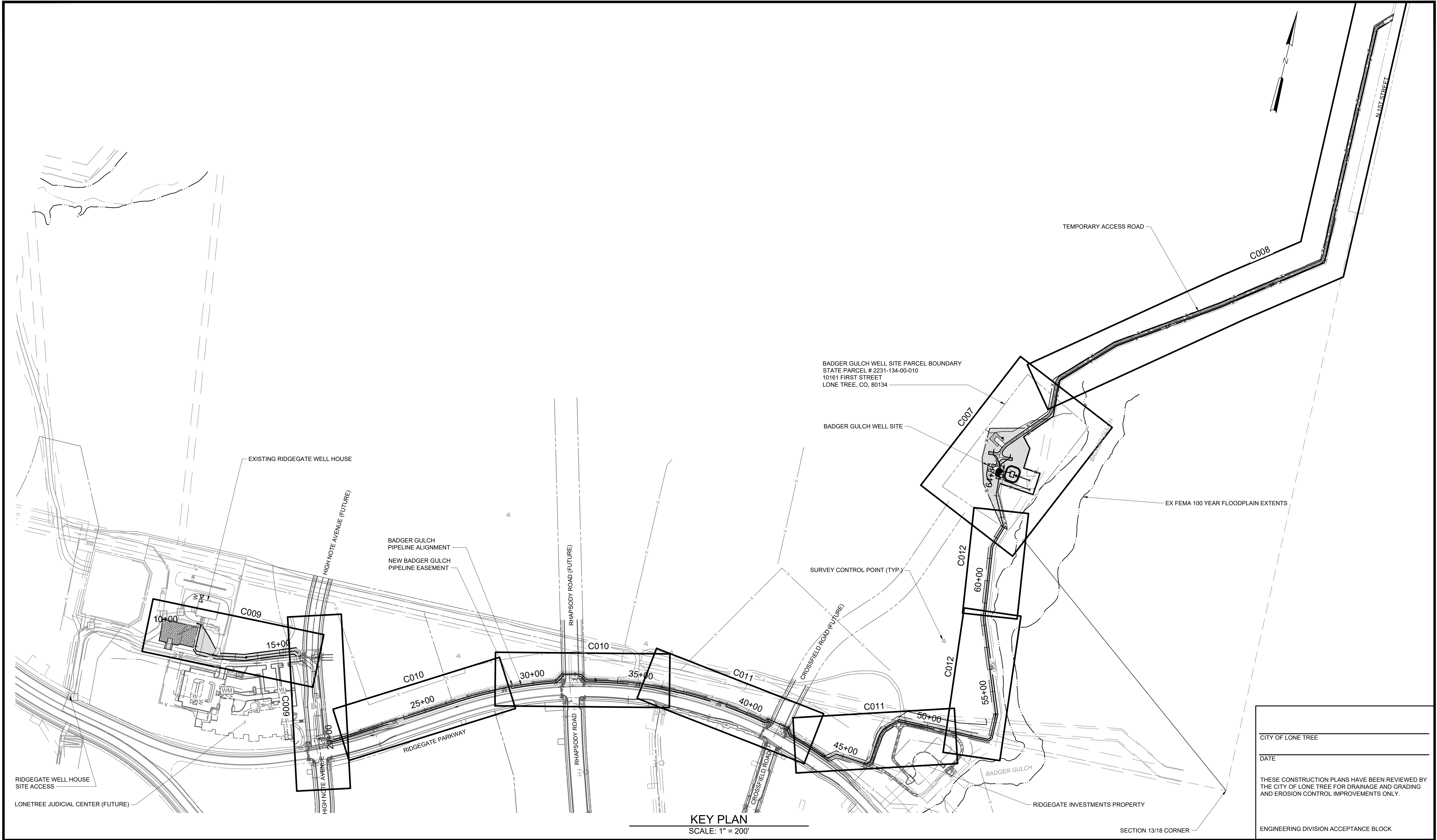
GESC PLAN PREPARED BY:

Bethany Lamy, P.E.
COLORADO REGISTRATION NO. 0060771

09/05/2025

DATE

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DESIGNED BY:	B. LAMY
DRAWN BY:	L. DESKINS
CHECKED BY:	E. FORD
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE	0 1/2" 1"

BID PACKAGE

Hazen

HAZEN AND SAWYER
6251 GREENWOOD PLAZA BLVD, SUITE 275
GREENWOOD VILLAGE, CO. 80111

PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

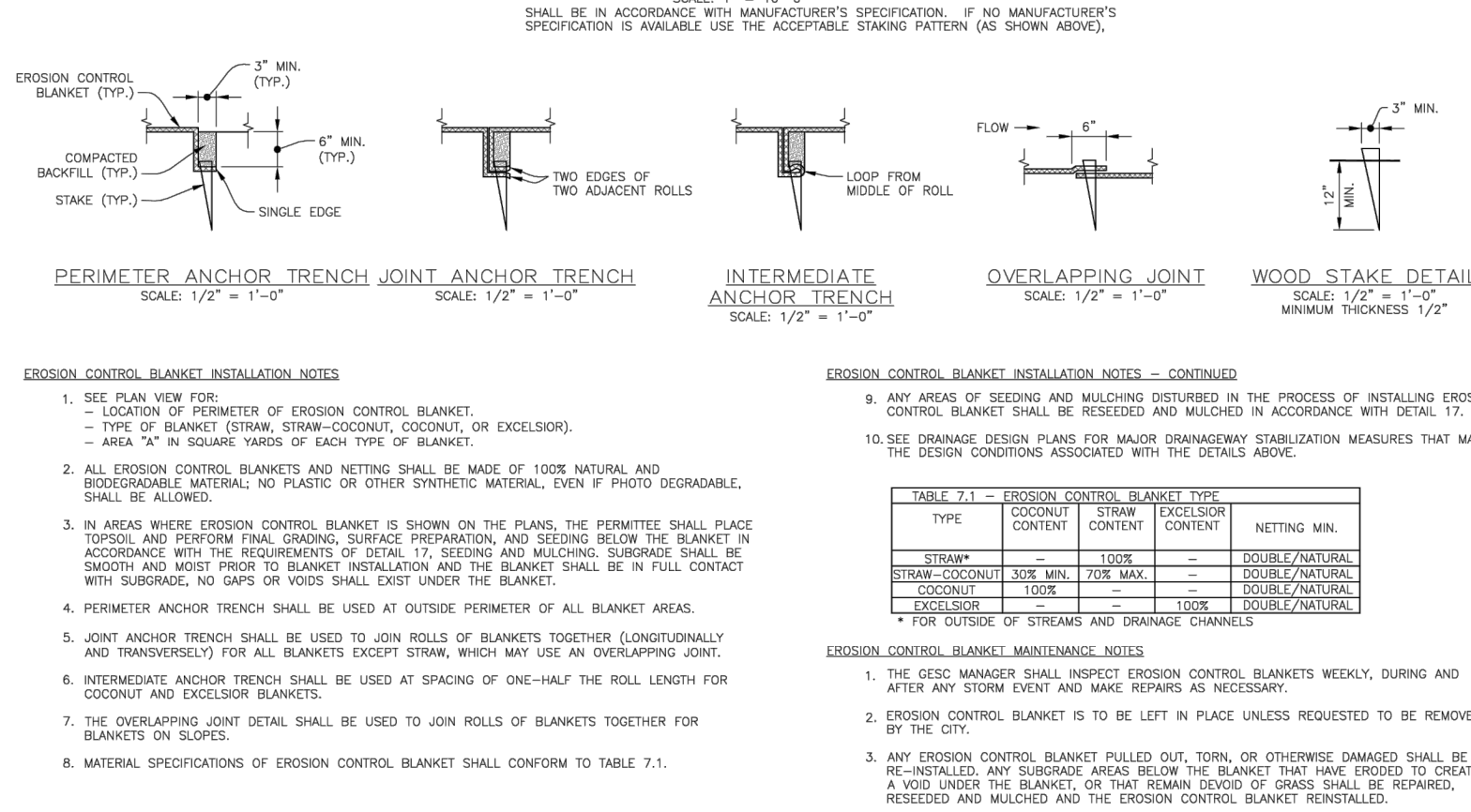
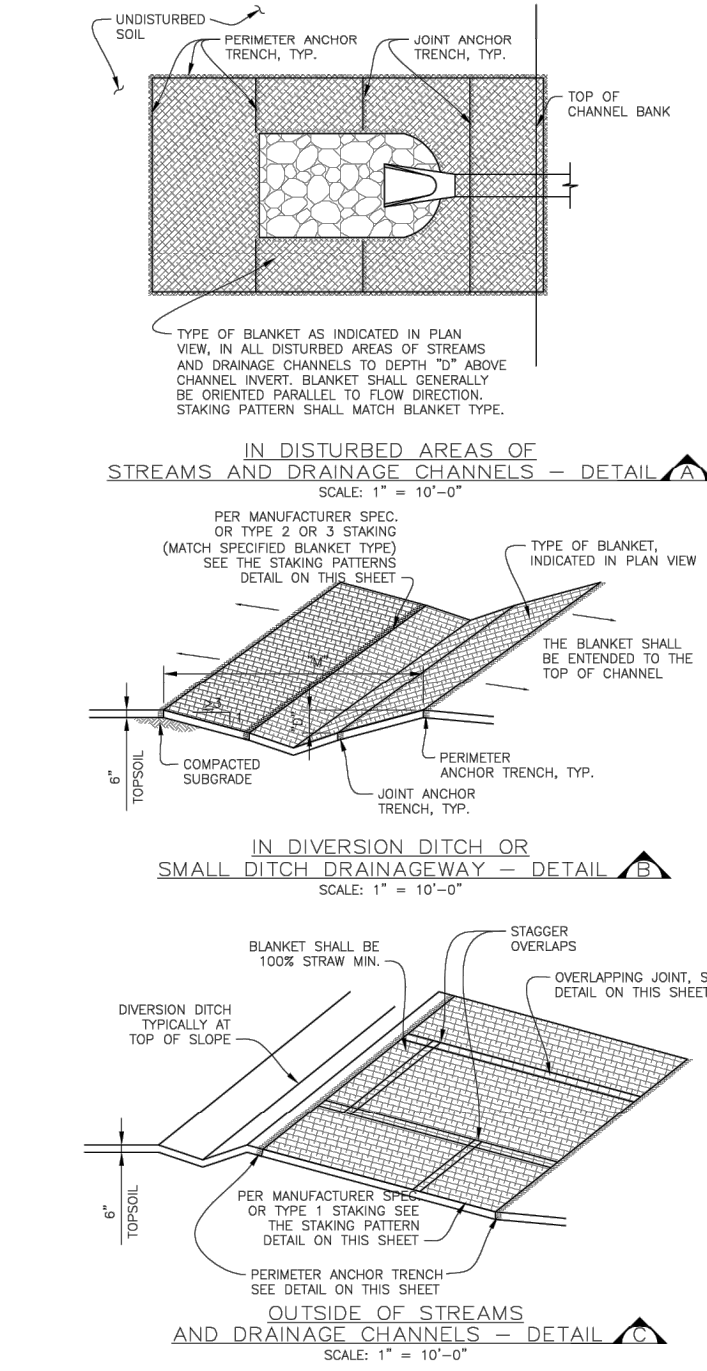
BADGER GULCH WELLS
AND IMPROVEMENTS

CIVIL
BADGER GULCH PIPELINE AND WELL SITE
OVERALL GESC MAP

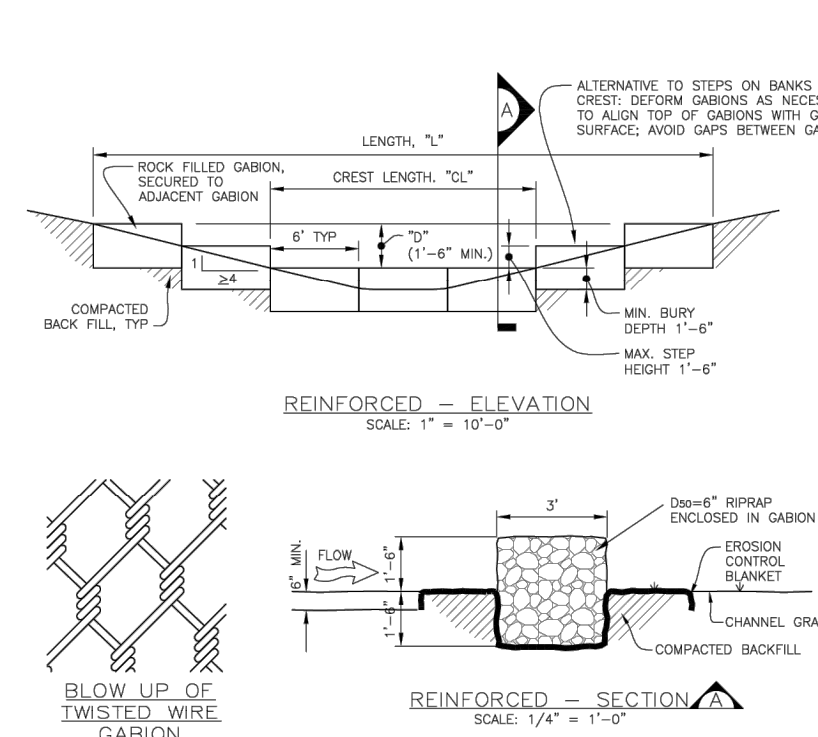
CITY OF LONE TREE
DATE
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ENGINEERING DIVISION ACCEPTANCE BLOCK

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	C003

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ECB EROSION CONTROL BLANKET 9

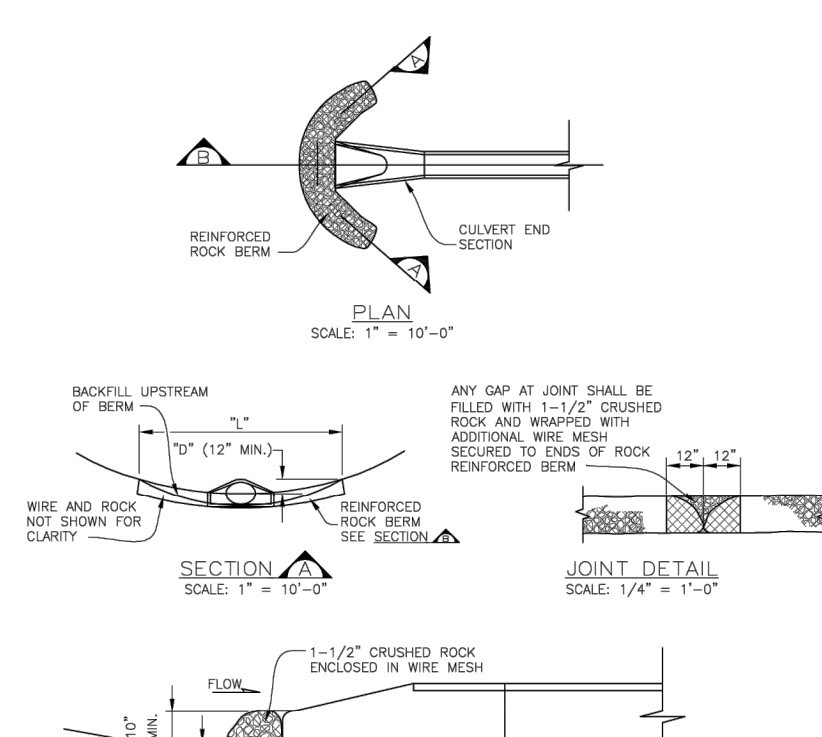


- REINFORCED CHECK DAM INSTALLATION NOTES**
- SEE PLAN VIEW FOR:
 - LOCATIONS OF CHECK DAMS
 - LENGTH, "L", AND DEPTH, "D", DIMENSIONS
 - CHECK DAMS INDICATED ON INITIAL GESC PLAN SHALL BE INSTALLED AFTER CONSTRUCTION FENCE, BUT PRIOR TO ANY UPSTREAM LAND-RESTORATION ACTIVITIES.
 - REINFORCED CHECK DAMS, GABIONS SHALL HAVE GALVANIZED TWISTED WIRE NETTING WITH A MAXIMUM OPENING DIMENSION OF 3-1/2" AND A MINIMUM WIRE THICKNESS OF 0.10" WIRE. "HOG RINGS" AT 4" SPACING OR GREATER APPROVED EROSION CONTROL MEANS SHALL BE USED AT ALL GABION SEAMS AND TO SECURE THE GABION TO THE ADJACENT GABION.
 - RIPRAP UTILIZED FOR CHECK DAMS SHALL HAVE A D_{50} MEDIAN STONE SIZE OF 6".
 - THE CHECK DAM SHALL BE TRENCHED INTO THE GROUND A MINIMUM OF 1'-4".
 - EROSION BLANKET SHALL BE PLACED IN THE REINFORCED CHECK DAM TRENCH EXTENDING A MINIMUM OF 1'-6" ON BOTH THE UPSTREAM AND DOWNSTREAM SIDES OF THE REINFORCED CHECK DAM.
- REINFORCED CHECK DAM MAINTENANCE NOTES**
- THE GESC MANAGER SHALL INSPECT CHECK DAMS WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.
 - SEDIMENT ACCUMULATED UPSTREAM OF CHECK DAMS SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF CHECK DAM IS WITHIN 2.0 FEET OF THE CREST.
 - CHECK DAMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED BY THE CITY.
 - WHEN CHECK DAMS ARE REMOVED, DISTURBED AREAS SHALL BE FILLED WITH SUITABLE COMPACTED BACKFILL. ANY DISTURBED AREA SHALL BE DRILL SEEDING AND CRIMP MULCHED AND COVERED WITH EROSION CONTROL BLANKET OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE CITY.

RCD REINFORCED CHECK DAM 11

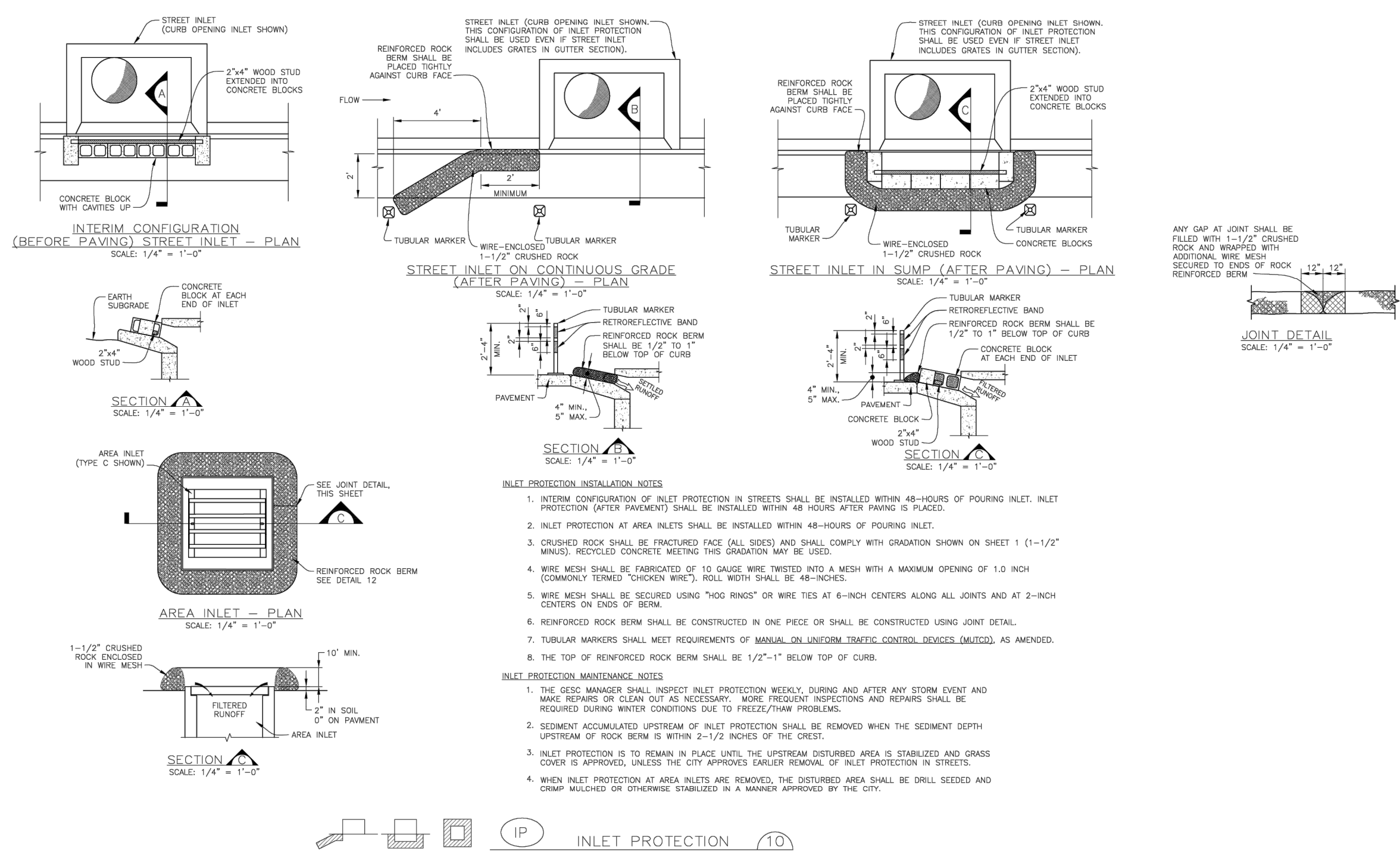
- REINFORCED ROCK BERM INSTALLATION NOTES**
- SEE PLAN VIEW FOR:
 - LOCATIONS OF REINFORCED ROCK BERMS
 - LENGTH, "L", AND DEPTH, "D", DIMENSIONS
 - REINFORCED ROCK BERM SECTION APPLIES TO CULVERT INLET FILTER AND INLET PROTECTION.
 - CRUSHED ROCK SHALL BE FRACTURED FACE (ALL SIDES) AND SHALL COMPLY WITH GRADATION SHOWN ON SHEET 1 (1-1/2" MINUS). RECYCLED CONCRETE MEETING THIS GRADATION MAY BE USED.
 - WIRE MESH SHALL BE FABRICATED OF 10 GAUGE WIRE TWISTED INTO A MESH WITH A MAXIMUM OPENING OF 1.0 INCH (COMMONLY TERMED "CHICKEN WIRE"). ROLL WIDTH SHALL BE 48-INCHES.
 - WIRE MESH SHALL BE SECURED USING "HOG RINGS" OR WIRE TIES AT 6-INCH CENTERS ALONG ALL JOINTS AND AT 2-INCH CENTERS ON ENDS OF BERM.
 - FOR CONCENTRIC FLOW AREAS THE ENDS OF THE REINFORCED ROCK BERM SHALL BE 12" HIGHER THAN THE CENTER OF THE BERM.
- REINFORCED ROCK BERM MAINTENANCE NOTES**
- THE GESC MANAGER SHALL INSPECT REINFORCED ROCK BERM WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.
 - SEDIMENT ACCUMULATED UPSTREAM OF REINFORCED ROCK BERM SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF FILTER IS WITHIN 5 INCHES OF THE CREST.
 - REINFORCED ROCK BERMS ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED.
 - WHEN REINFORCED ROCK BERMS ARE REMOVED, ANY DISTURBED AREA SHALL BE DRILL SEEDING AND CRIMP MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE CITY.

RRB REINFORCED ROCK BERM 12

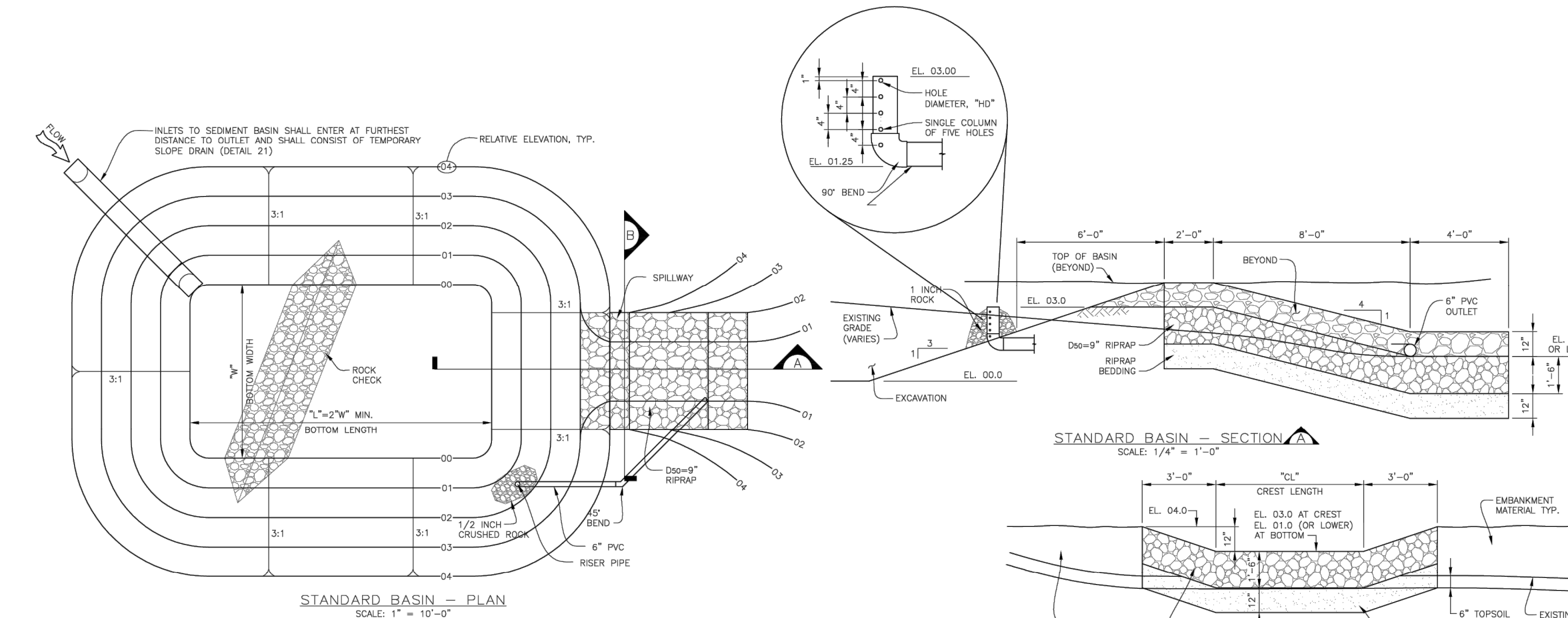


- INSTALLATION NOTES**
- SEE PLAN VIEW FOR:
 - LOCATIONS OF CULVERT INLET FILTERS
 - LENGTH, "L", AND DEPTH, "D",
 - CRUSHED ROCK SHALL BE FRACTURED FACE (ALL SIDES) AND SHALL COMPLY WITH GRADATION SHOWN ON SHEET 1 (1-1/2" MINUS). RECYCLED CONCRETE MEETING THIS GRADATION MAY BE USED.
 - WIRE MESH SHALL BE FABRICATED OF 10 GAUGE WIRE TWISTED INTO A MESH WITH A MAXIMUM OPENING OF 1.0 INCH (COMMONLY TERMED "CHICKEN WIRE"). ROLL WIDTH SHALL BE 48-INCHES.
 - WIRE MESH SHALL BE SECURED USING "HOG RINGS" OR WIRE TIES AT 6-INCH CENTERS ALONG ALL JOINTS AND AT 2-INCH CENTERS ON ENDS OF BERM.
 - THE ENDS OF THE REINFORCED ROCK BERM SHALL BE 12" HIGHER THAN THE CENTER OF THE BERM.
- MAINTENANCE NOTES**
- THE GESC MANAGER SHALL INSPECT CULVERT INLET FILTER WEEKLY, DURING AND AFTER ANY STORM EVENT AND MAKE REPAIRS OR CLEAN OUT AS NECESSARY.
 - SEDIMENT ACCUMULATED UPSTREAM OF CULVERT INLET FILTER SHALL BE REMOVED WHEN THE SEDIMENT DEPTH UPSTREAM OF FILTER IS 3 FEET OF THE HEIGHT OF THE REINFORCED ROCK BERM.
 - RIPRAP FOR CULVERT PROTECTION ARE TO REMAIN IN PLACE UNTIL THE UPSTREAM DISTURBED AREA IS STABILIZED AND GRASS COVER IS APPROVED BY THE CITY.
 - WHEN CULVERT INLET FILTERS ARE REMOVED, ANY DISTURBED AREA SHALL BE DRILL SEEDING AND CRIMP MULCHED OR OTHERWISE STABILIZED IN A MANNER APPROVED BY THE CITY.

RRC RRB FOR CULVERT PROTECTION 13



IP INLET PROTECTION 10



SB SEDIMENT BASIN 14

Sheet Revisions

6/30/05	ADOPTED FROM DOUGLAS COUNTY GESC PLANS	MLP
5/ /08	EDIT UPDATES	GAW
11/ /08	ADD CURB SOCK DETAIL (REF UDFCD, V3 FIGURE C5-23), MISC. NOTE EDITS	GAW

SCALES SHOWN ARE FOR 24"x36" SHEETS; ADJUST ACCORDINGLY FOR 11"x17" SHEETS.



CITY OF LONE TREE
DEPARTMENT OF PUBLIC WORKS
Engineering Division

GESC GRADING, EROSION, AND SEDIMENT CONTROL

GESC PLAN STANDARD NOTES AND DETAILS

SHEET 2 OF 3

CITY OF LONE TREE

DATE

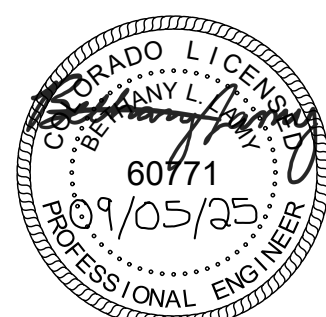
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ENGINEERING DIVISION ACCEPTANCE BLOCK

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DESIGNED BY:	S. TROUT
DRAWN BY:	L. DESKINS
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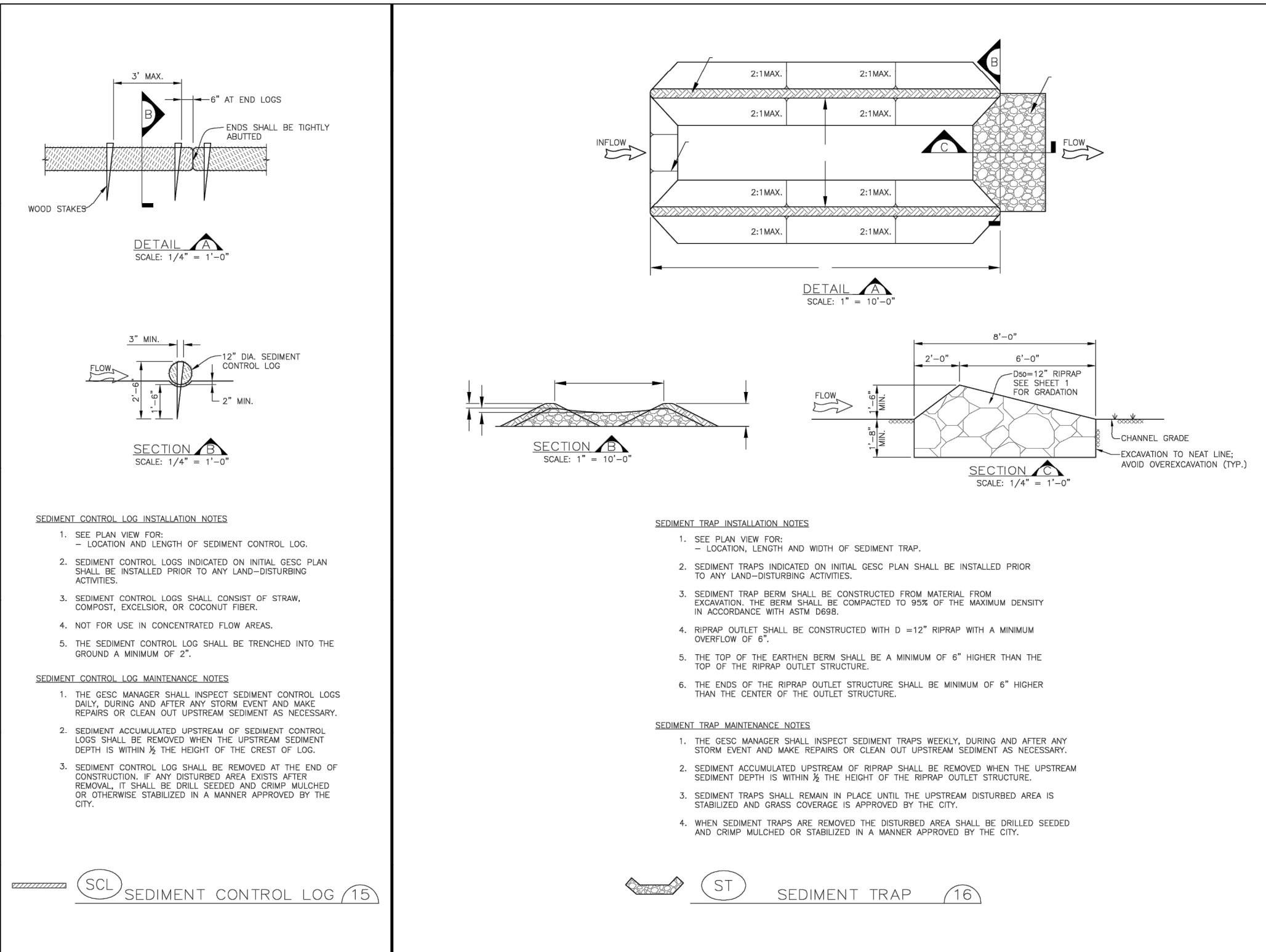
PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

BADGER GULCH WELLS AND IMPROVEMENTS

CIVIL
BADGER GULCH PIPELINE AND WELL SITE
EROSION AND SEDIMENT CONTROL PLAN NOTES AND DETAILS II

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	C005

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SEEDING AND MULCHING INSTALLATION NOTES

- SEE PLAN VIEW FOR:
 - AREA OF SEEDING AND MULCHING.
 - TYPE OF SEED MIX (PERMANENT, TEMPORARY, OR LOW-GROWTH).
- ALL BRANDS FURNISHED SHALL BE FREE FROM SUCH NOXIOUS SEEDS AS RUSSIAN OR CANADIAN THISTLE, COARSE FESCUE, EUROPEAN BROWNED, JOHNSON GRASS, KNAW WEED AND LIPSY GRASS.
- THE SEEDER SHALL FURNISH TO THE CONTRACTOR A SIGNED STATEMENT CERTIFYING THAT THE SEED FURNISHED IS FROM A LOT THAT HAS BEEN TESTED BY A RECOGNIZED LABORATORY, SEED WHICH HAS BECOME WET, MOLTY, OR OTHERWISE DAMAGED IN TRANSIT OR IN STORAGE, WILL NOT BE ACCEPTABLE. SEED TESTS SHALL BE PROVIDED TO CITY OF LONE TREE UPON REQUEST.
- GRILL SEEDING MIX SHALL CONFORM TO THE TABLE ON THE RIGHT.
- IF THE SEED AVAILABLE ON THE MARKET DOES NOT MEET THE MINIMUM PURITY AND GERMINATION PERCENTAGE SPECIFIED, THE SUBCONTRACTOR MUST COMPENSATE FOR A LESSER PERCENTAGE OF PURITY OR GERMINATION BY FURNISHING SUFFICIENT ADDITIONAL SEED TO EQUAL THE SPECIFIED PRODUCT. THE TASS FROM THE SEED MIXES MUST BE SUPPLIED TO CONTRACTOR AND FORWARDED TO THE CITY OF LONE TREE GESC INSPECTOR.
- THE FORMULA USED FOR DETERMINING THE QUANTITY OF PURE LIVE SEED (PLS) SHALL BE: (POUNDS OF SEED) X (PURITY) X (GERMINATION) = POUNDS OF PURE LIVE SEED (PLS).
- PERMANENT SEED MIX SHALL BE USED UNLESS OTHERWISE APPROVED BY THE CITY.
- SOIL TO BE SEEDING AND MULCHED SHALL HAVE NATIVE TOPSOIL OR APPROVED SOIL AMENDMENTS SPREAD TO A DEPTH OF AT LEAST 6 INCHES (LOOSE DEPTH). HAIL, ROCKS AND OTHER COMPACTED AREAS SHALL BE LOOSENED TO A DEPTH OF 6 INCHES PRIOR TO SPREADING TOPSOIL.
- SOIL TO BE PARADIGMALLY LOOSENED (TILLED) TO A DEPTH OF AT LEAST 6 INCHES PRIOR TO SEEDING. THE TOP 6 INCHES OF THE SEED BED SHALL BE FREE OF ROCKS GREATER THAN 4 INCHES AND SOIL CLOSER GREATER THAN 1 INCHES. SEEDING OVER ANY COMPACTED AREAS THAT HAVE NOT BEEN THOROUGHLY LOOSENED SHALL BE REJECTED.
- SEED IS TO BE APPLIED USING A MECHANICAL DRILL TO A DEPTH OF 1/4 INCH. ROW SPACING SHALL BE NO MORE THAN 6 INCHES. MATERIAL USED FOR MULCH SHALL CONSIST OF LONG-STEMMED STRAW, AT LEAST 50 PERCENT OF THE MULCH, BY WEIGHT, SHALL BE 10 INCHES OR MORE IN LENGTH. MULCH SHALL BE APPLIED AND MECHANICALLY ANCHORED TO A DEPTH OF AT LEAST 2 INCHES. MULCH SHALL BE APPLIED AT A RATE OF 4000 LB. OF STRAW PER ACRE.
- IF THE PERMITTEE DEMONSTRATES TO THE CITY THAT IT IS NOT POSSIBLE TO DRILL SEED, SEED IS TO BE UNIFORM BROADCAST AT TWO TIMES THE DRILLED RATE, THEN LIGHTLY HARROWED TO PROVIDE A SEED DEPTH OF APPROXIMATELY 1/4 INCH, THEN ROLLED TO COMPACT, THEN MULCHED AS SPECIFIED ABOVE.
- SEEDING AND MULCHING SHALL BE COMPLETED WITHIN 30 DAYS OF INITIAL EXPOSURE OR 7 DAYS AFTER GRADING IS SUBSEQUENTIALLY COMPLETED OR GIVEN AREA AS DEFINED BY THE CITY. THIS MAY REQUIRE MULTIPLE MOBILIZATIONS FOR SEEDING AND MULCHING.
- MULCH SHALL BE APPLIED WITHIN 24-HOURS OF SEEDING.
- TACKIFIER SHOULD BE UTILIZED TO HELP WITH STRAW DISPLACEMENT.

CITY OF LONE TREE PERMANENT DRILL SEEDING MIX

SEEDS	VARIETY	NOTES	# IN MIX	POUNDS OF PLS PER ACRE
BIG BLUESTEM	KAW	PWMS	10	1.1
YELLOW INDIANGRASS	CHEYENNE	PWMS	10	1
SWITCHGRASS	BLACKWELL	PWMS	10	0.4
SIDEGRASS GRAMA	VAUGHN	PWMB	10	0.8
WESTERN WHEATGRASS	ARRIBA	PWMS	10	1.6
BLUE GRAMA	HACHITA	PWMB	10	0.3
THICKSPICE WHEATGRASS	ORTIMA	PWMS	10	1
FRANKIE SANDREED	GOSHEN	PWMS	10	0.7
GREEN NEEDLEGRASS	LOOMER	PWMS	10	1
NEEDLEGRASS	PRYOR	PWMS	5	0.6
STREAMBARK WHEATGRASS	SODAR	PWMS	5	0.6
TOTAL				9.2

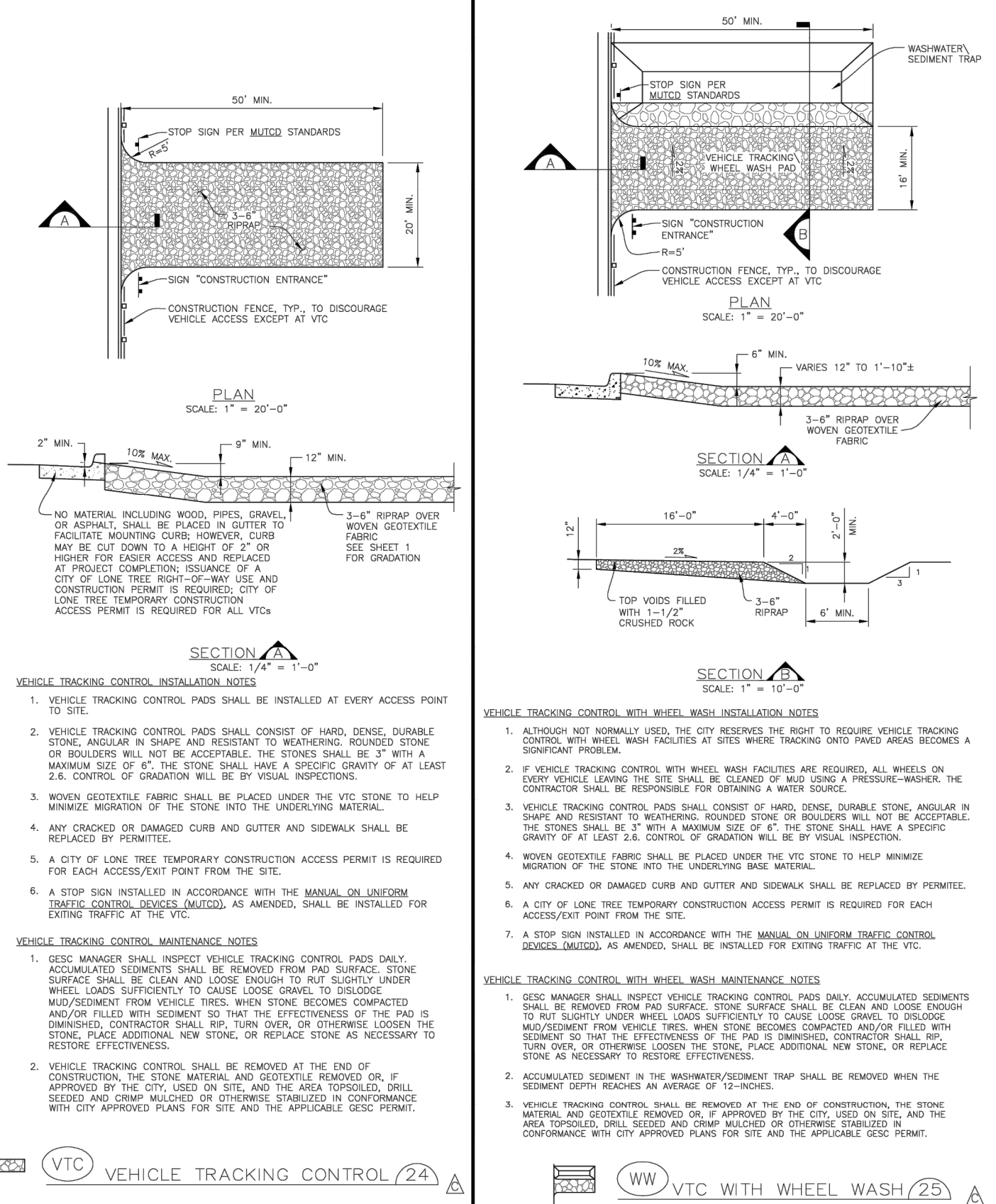
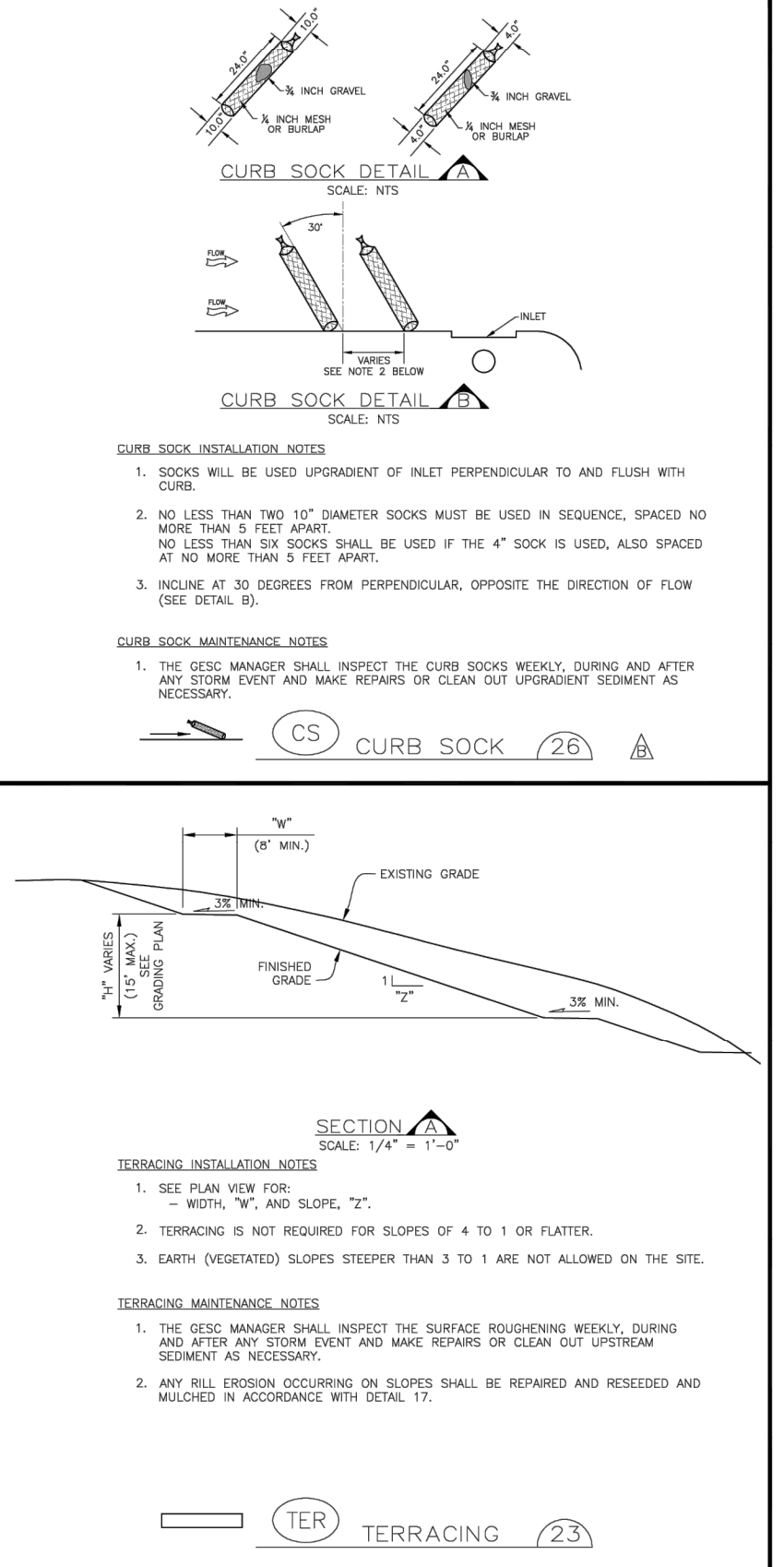
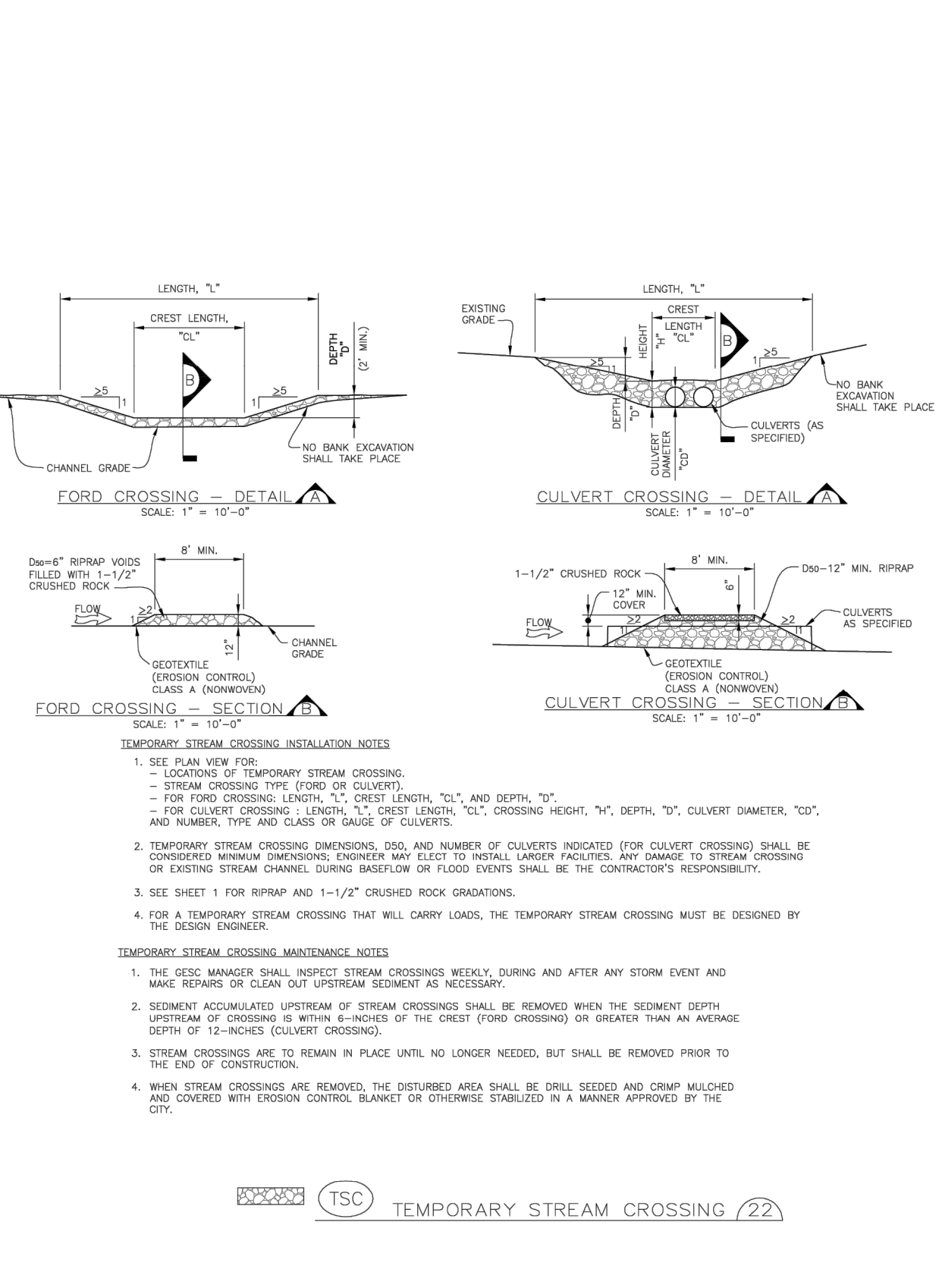
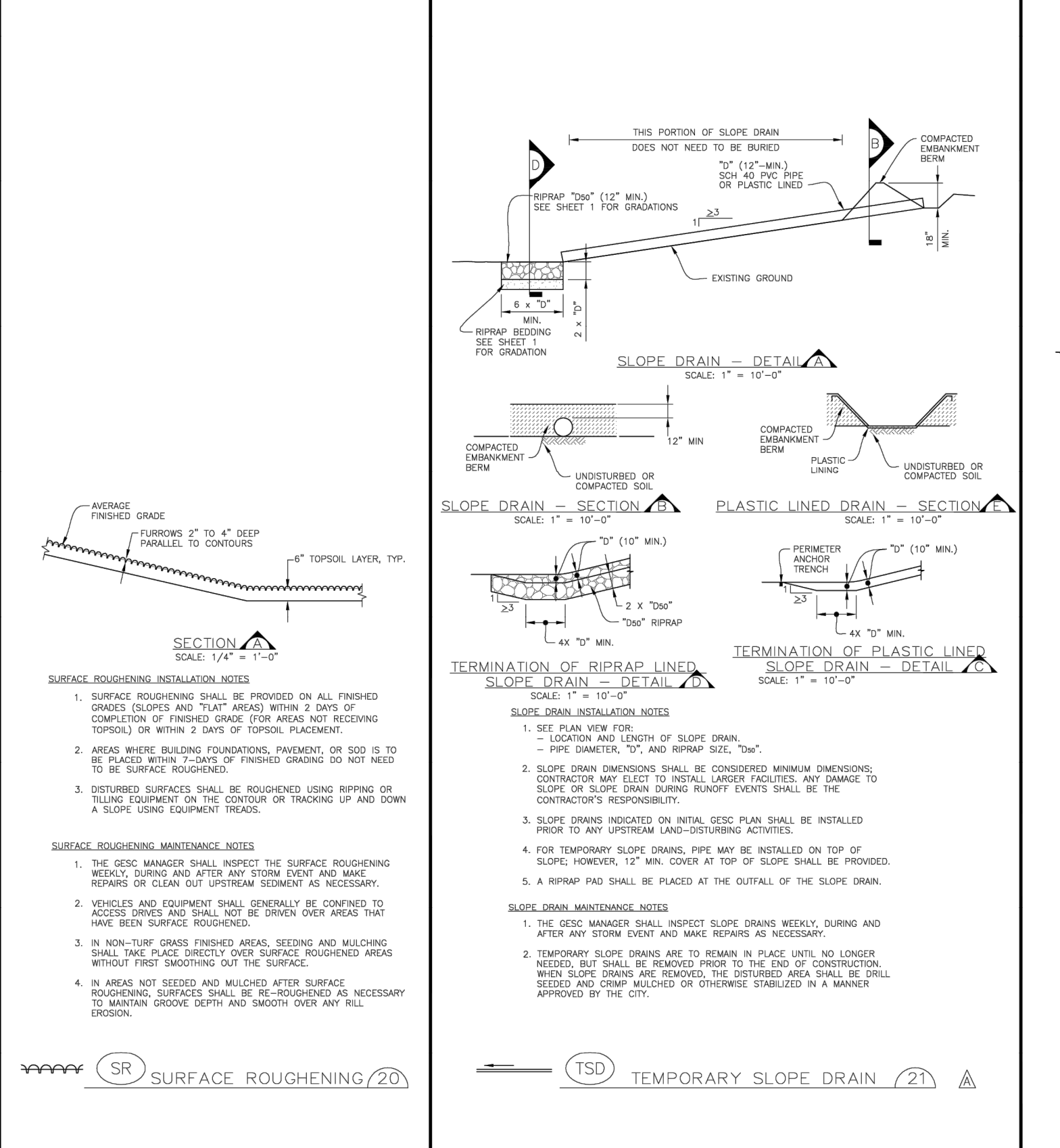
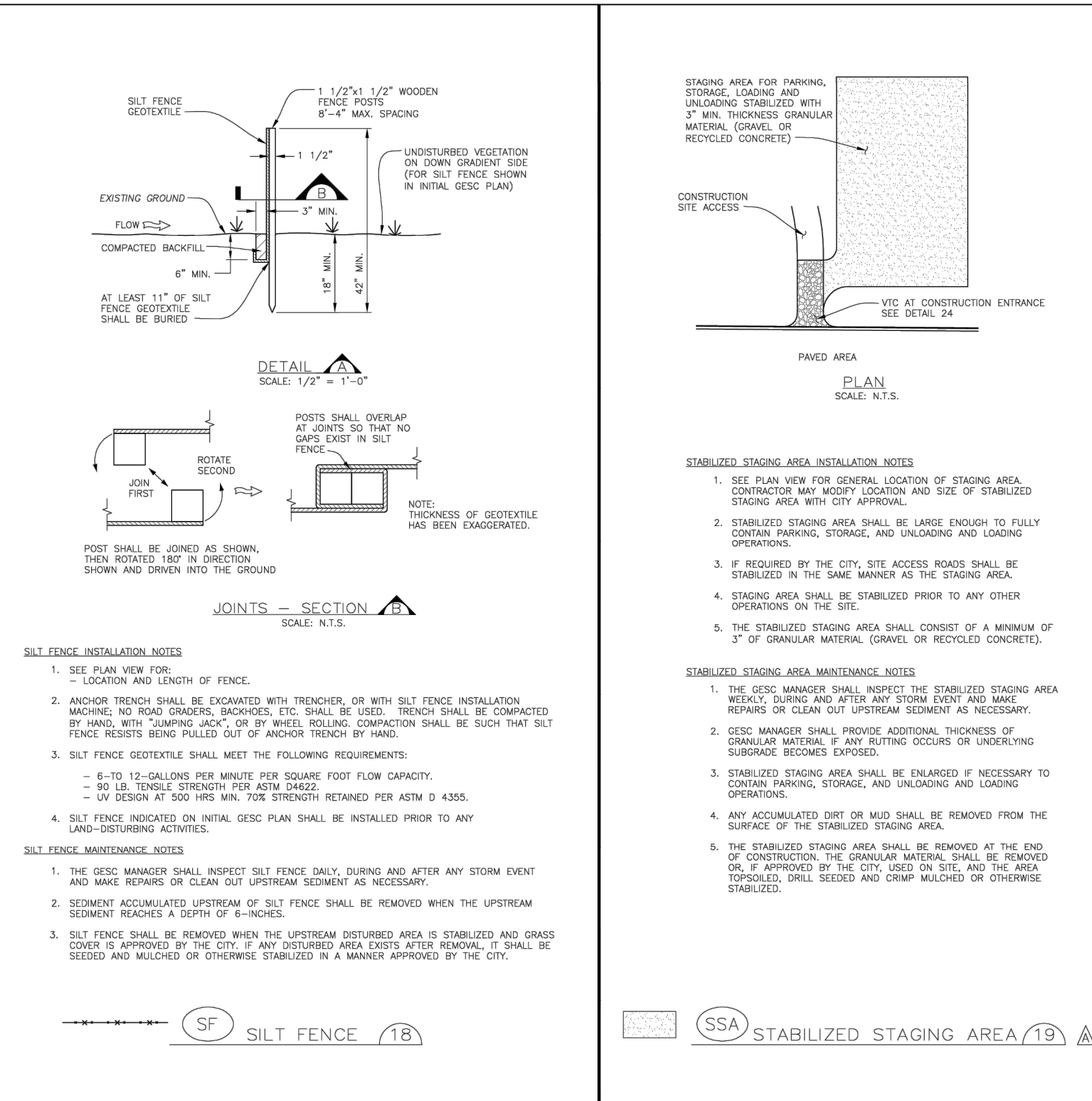
CITY OF LONE TREE TEMPORARY DRILL SEEDING MIX

SEEDS	VARIETY	NOTES	# IN MIX	POUNDS OF PLS PER ACRE
SMOOTH BROMGRASS	LINCOLN	PCS	30	3.9
INTERMEDIATE WHEATGRASS	DAHE	PCS	30	4.3
PURSHOTT WHEATGRASS	LUNA	PCS	30	4.2
ANNUAL RYEGRASS	N/A	ACB	10	0.8
TOTAL				13.4

CITY OF LONE TREE LOW-GROWTH DRILL SEEDING MIX

SEEDS	VARIETY	NOTES	# IN MIX	POUNDS OF PLS PER ACRE
BUFFALOGRASS	TEOKA	PWMS	20	3.2
BLUE GRAMA	HACHITA	PWMB	20	0.6
WESTERN WHEATGRASS	ARRIBA	PWMS	20	3.2
SIDEGRASS GRAMA	VAUGHN	PWMB	20	1.8
THICKSPICE WHEATGRASS	ORTIMA	PWMS	10	1
STREAMBARK WHEATGRASS	SODAR	PWMS	10	1.2
TOTAL				11.0

SEEDING AND MULCHING (17)



Sheet Revisions

REV	ISSUED FOR	DATE	BY
6/30/05	ADOPTED FROM DOUGLAS COUNTY GESC PLANS		MLP
5/ /08	EDIT UPDATES		GAW
11/ /08	ADD CURB SOCK DETAIL (REF UDFCD, V3 FIGURE C9-23), MISC. NOTE EDITS		GAW
12/ /09	UPDATE VTC & WW		GAW

NOTES: SCALES SHOWN ARE FOR 24"x36" SHEETS; ADJUST ACCORDINGLY FOR 11"x17" SHEETS.

CITY OF LONE TREE
DEPARTMENT OF PUBLIC WORKS
Engineering Division

GESC GRADING, EROSION, AND SEDIMENT CONTROL STANDARD PLAN AND DETAILS

SHEET 3 OF 3

CITY OF LONE TREE

DATE

THESE CONSTRUCTION PLANS HAVE BEEN REVIEWED BY THE CITY OF LONE TREE FOR DRAINAGE AND GRADING AND EROSION CONTROL IMPROVEMENTS ONLY.

ENGINEERING DIVISION ACCEPTANCE BLOCK

PROJECT ENGINEER:	R. VEYANG
DESIGNED BY:	S. TROUT
DRAWN BY:	L. DESKINS
CHECKED BY:	E. FORD
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE	0 1/2" 1"

BID PACKAGE

HAZEN AND SAWYER
60771
PROFESSIONAL ENGINEER
09/10/05/05

Hazen
HAZEN AND SAWYER
6251 GREENWOOD PLAZA BLVD, SUITE 275
GREENWOOD VILLAGE, CO. 80111

PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

BADGER GULCH WELLS AND IMPROVEMENTS

CIVIL

BADGER GULCH PIPELINE AND WELL SITE EROSION AND SEDIMENT CONTROL PLAN NOTES AND DETAILS III

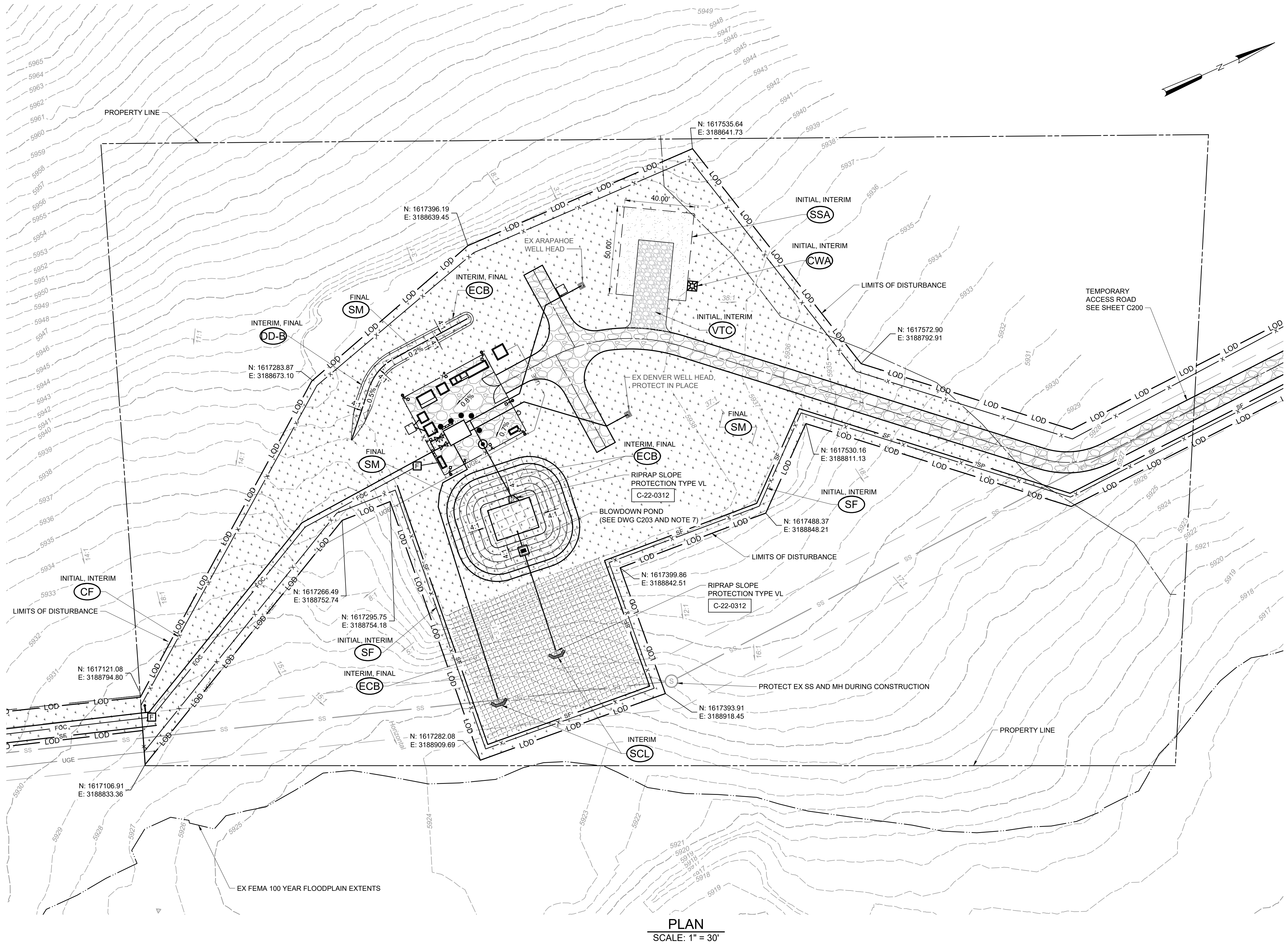
DATE: SEPTEMBER 2025

HAZEN NO.: 70069-008

CONTRACT NO.:

DRAWING NUMBER: C006

- NOTES:
- RESTORE ALL AREAS DISTURBED DURING CONSTRUCTION AT THE BADGER GULCH WELL SITE TO MATCH EXISTING PRE-CONSTRUCTION CONDITIONS. SEE SPECIFICATION 32 90 00.
 - INSTALL VEHICLE TRACKING CONTROL AT THE ENTRANCE OF THE STABILIZED STORAGE AREA AND THE TRANSITION FROM N 1ST STREET TO THE ACCESS ROAD FOR THE WELL SITE.
 - SEE COVER SHEET OF LONE TREE STANDARD NOTES AND DETAILS (SHEET 1 OF 3) FOR LEGEND OF BMP NAMES AND SYMBOLS.
 - SHADED BMPs INSTALLED IN THE INITIAL STAGE SHALL BE LEFT IN PLACE IN THE INTERIM STAGE.
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 - SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINS, AND INLET AND OUTLET PROTECTION.
 - SSA, IP, VTC, SF, AND CF TO BE REMOVED PRIOR TO END OF CONSTRUCTION.
 - CUT AND FILL VOLUMES FOR THE SITE DEVELOPMENT ARE AS FOLLOWS:
 - CUT: 259 CY
 - FILL: 44 CY
 - NET: 215 CY HAUL OFF
 - EXISTING TOPOGRAPHY CONTOURS ARE SHOWN IN GRAY, WITH CORRESPONDING GRAY SLOPE LABELS. PROPOSED GRADING CONTOURS ARE SHOWN IN BLACK, WITH CORRESPONDING BLACK SLOPE LABELS.
 - ALL PORTABLE TOILETS SHALL BE PLACED ON A PERVIOUS SURFACE AND STAKED DOWN ON ALL FOUR SIDES.
 - ALL ADJACENT AREAS SHALL BE CLEANED OF DIRT AND DEBRIS IMMEDIATELY USING DRY METHODS ONLY.
 - CONTROL MEASURE DEVIATIONS, FROM THE APPROVED CITY OF LONE TREE SPECIFICATIONS AND DETAILS, REQUIRE PRIOR CITY OF LONE TREE WRITTEN APPROVAL.



PLAN
SCALE: 1" = 30'

CITY OF LONE TREE

DATE

THESE CONSTRUCTION PLANS HAVE BEEN REVIEWED BY THE CITY OF LONE TREE FOR DRAINAGE AND GRADING AND EROSION CONTROL IMPROVEMENTS ONLY.

ENGINEERING DIVISION ACCEPTANCE BLOCK

PROJECT ENGINEER:	R. VEANG
DESIGNED BY:	B. LAMY
DRAWN BY:	L. DESKINS
CHECKED BY:	E. FORD
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE	0 1/2" 1"

BID PACKAGE



Hazen

HAZEN AND SAWYER
6251 GREENWOOD PLAZA BLVD, SUITE 275
GREENWOOD VILLAGE, CO. 80111

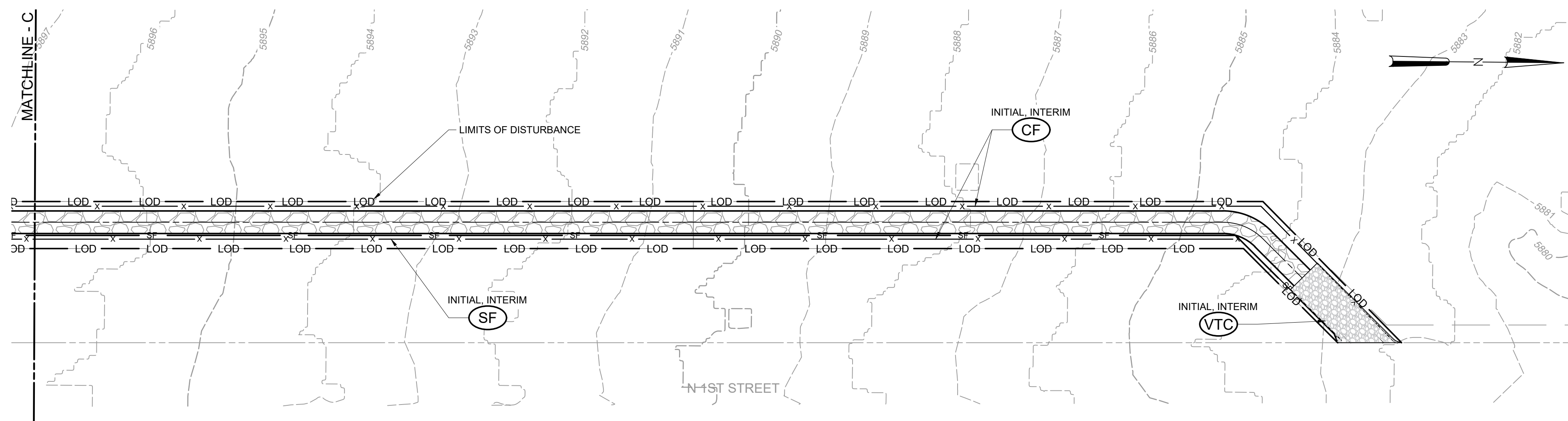
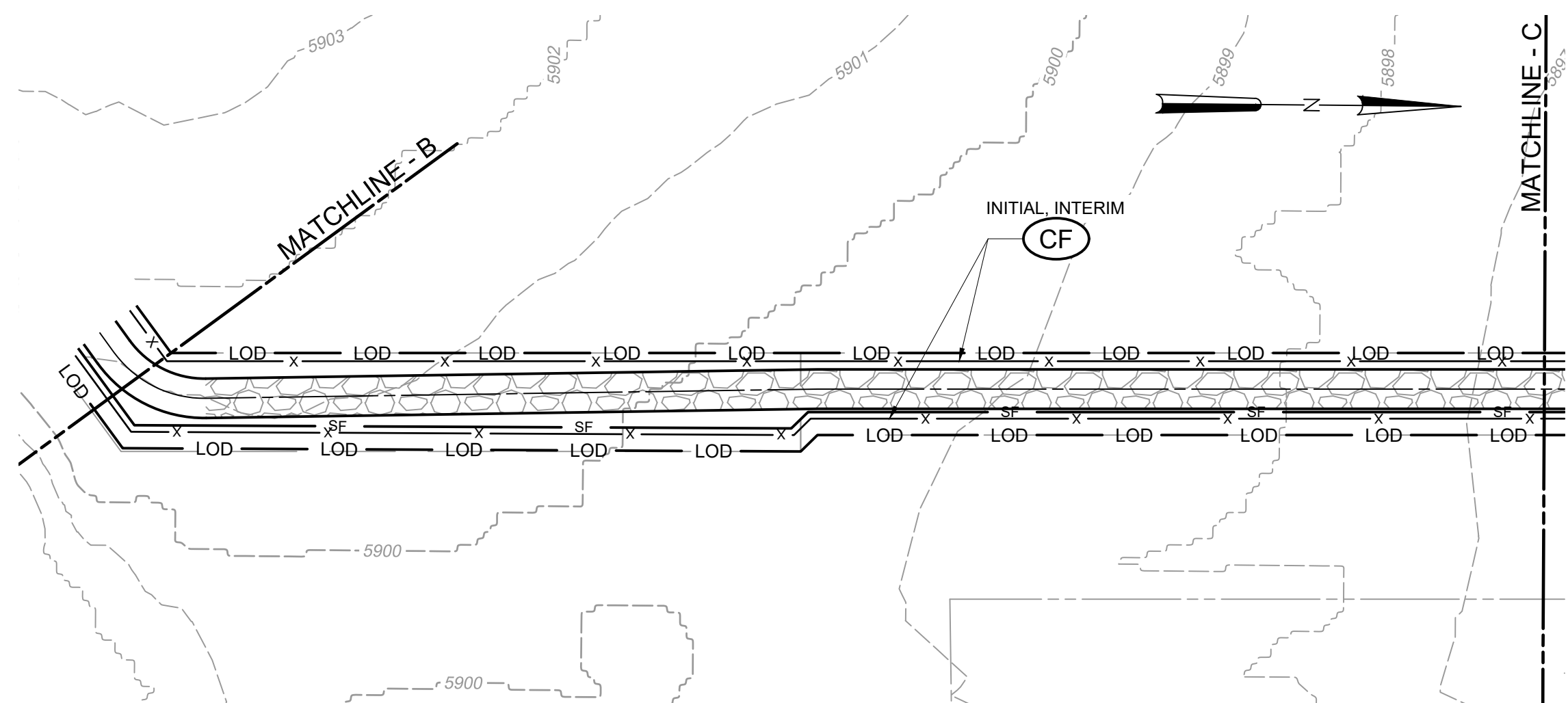
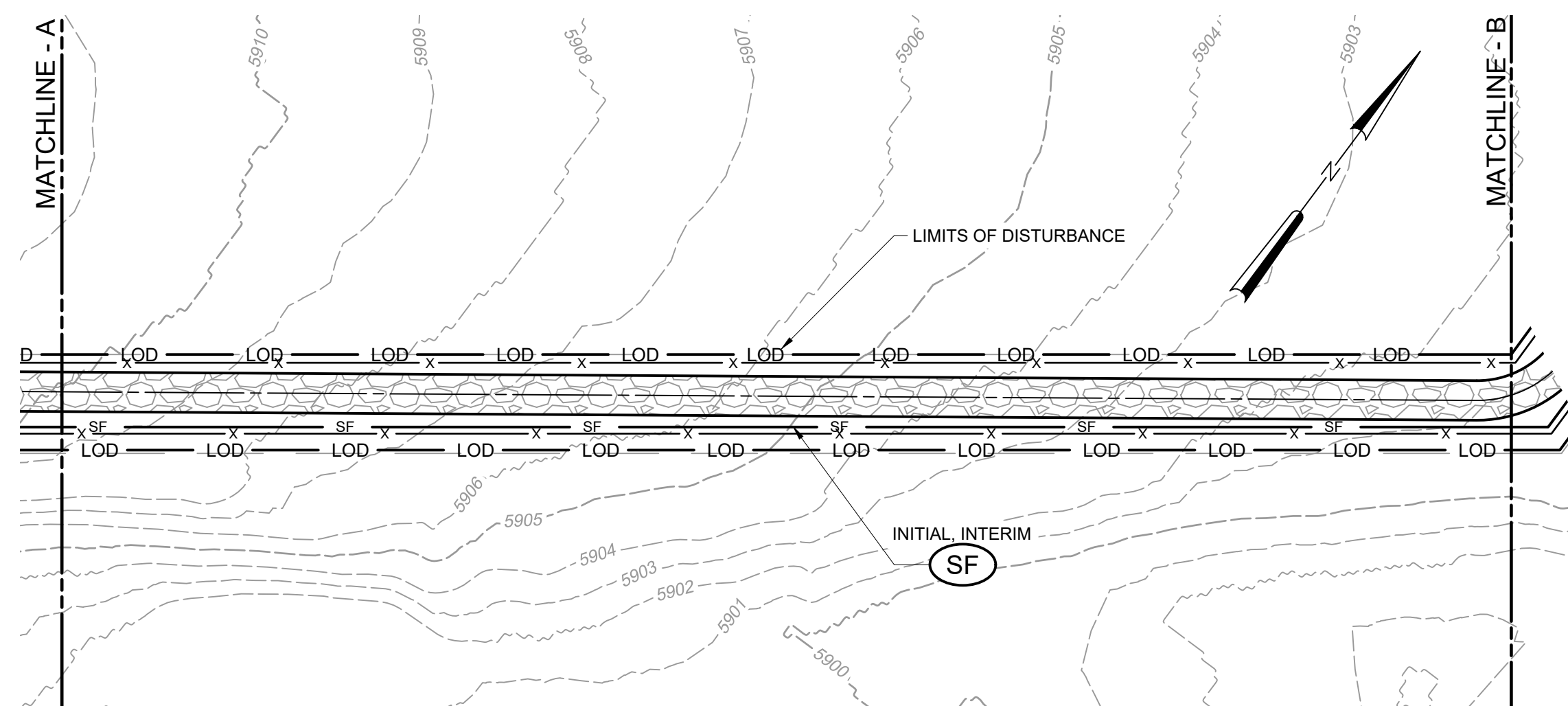
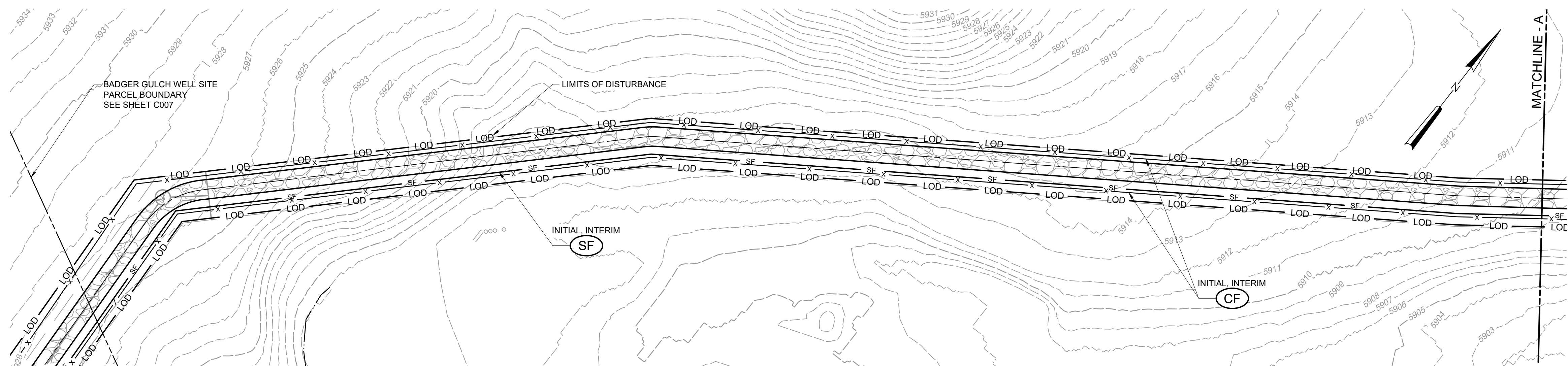
PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

BADGER GULCH WELLS
AND IMPROVEMENTS

CIVIL
BADGER GULCH PIPELINE AND WELL SITE
BADGER GULCH WELL SITE EROSION CONTROL PLAN

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	

C007



PLAN

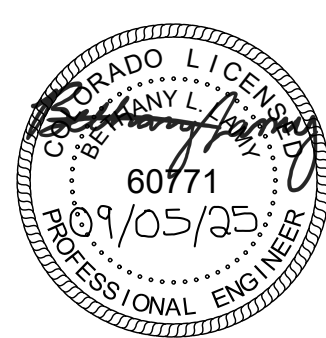
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- # NOTES:
1. RESTORE ALL AREAS DISTURBED DURING CONSTRUCTION AT THE BADGER GULCH WELL SITE TO MATCH EXISTING PRE-CONSTRUCTION CONDITIONS. SEE SPECIFICATION 32 90.00.
 2. INSTALL VEHICLE TRACKING CONTROL AT THE ENTRANCE OF THE STABILIZED STORAGE AREA AND THE TRANSITION FROM N 1ST STREET TO THE ACCESS ROAD FOR THE WELL SITE.
 3. SEE COVER SHEET OF LONE TREE STANDARD NOTES AND DETAILS (SHEET 1 OF 3) FOR LEGEND OF BMP NAMES AND SYMBOLS.
 4. SHADED BMPs INSTALLED IN THE INITIAL STAGE SHALL BE LEFT IN PLACE IN THE INTERIM STAGE.
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 6. SEE CONSTRUCTION PLANS FOR DETAILS OF PERMANENT DRAINAGE FACILITIES SUCH AS DETENTION FACILITIES, CULVERTS, STORM DRAINS, AND INLET AND OUTLET PROTECTION.
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 13. CONTROL MEASURE DEVIATIONS, FROM THE APPROVED CITY OF LONE TREE SPECIFICATIONS AND DETAILS, REQUIRE PRIOR CITY OF LONE TREE WRITTEN APPROVAL.

CITY OF LONE TREE
DATE
THESE CONSTRUCTION PLANS HAVE BEEN REVIEWED BY THE CITY OF LONE TREE FOR DRAINAGE AND GRADING AND EROSION CONTROL IMPROVEMENTS ONLY.
ENGINEERING DIVISION ACCEPTANCE BLOCK

				PROJECT ENGINEER:	R. VEVANG
				DESIGNED BY:	B. LAMY
				DRAWN BY:	L. DESKINS
				CHECKED BY:	E. FORD
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REV	ISSUED FOR	DATE	BY		

BID PACKAGE



Hazen

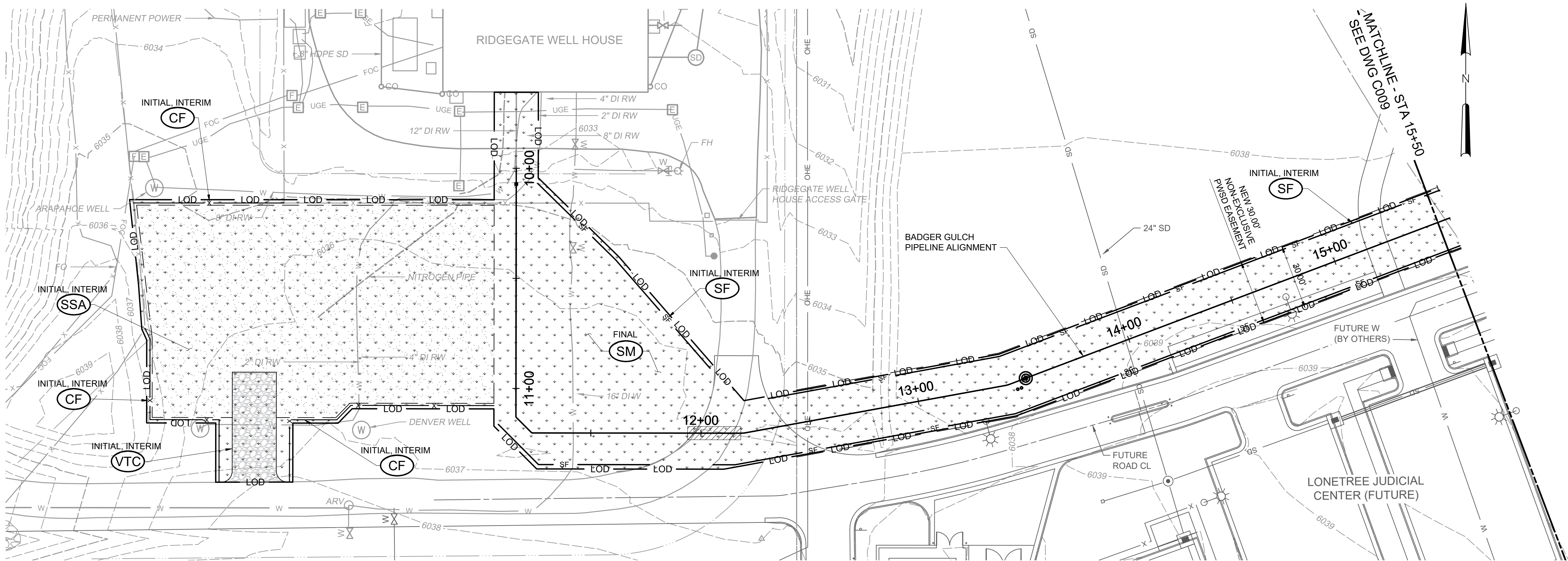
HAZEN AND SAWYER
6251 GREENWOOD PLAZA BLVD, SUITE 275
GREENWOOD VILLAGE, CO. 80111

PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

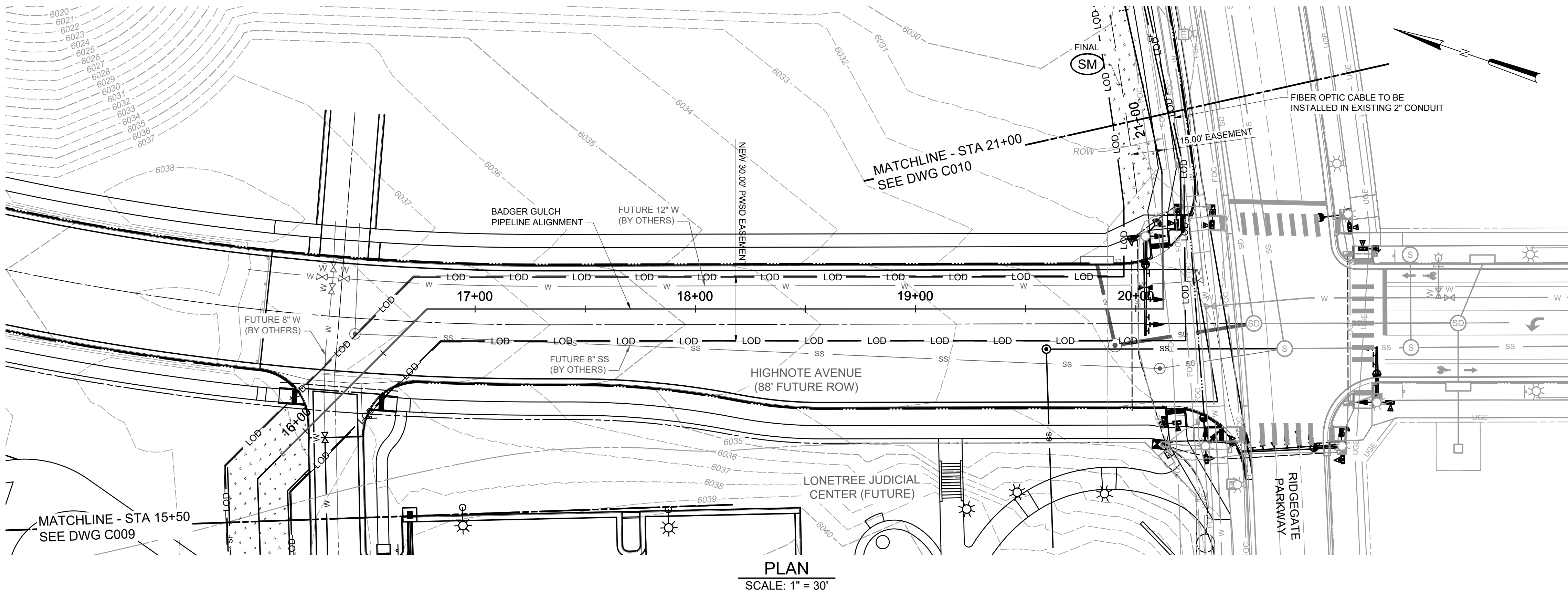
BADGER GULCH WELLS AND IMPROVEMENTS

CIVIL
BADGER GULCH PIPELINE AND WELL SITE
ACCESS ROAD EROSION CONTROL PLAN

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	C008



- NOTES:
- RESTORE ALL AREAS DISTURBED DURING CONSTRUCTION AT THE RIDGEGATE WELL HOUSE AND BADGER GULCH PIPELINE SITE TO MATCH EXISTING PRE-CONSTRUCTION CONDITIONS. SEE SPECIFICATION 32 90 00.
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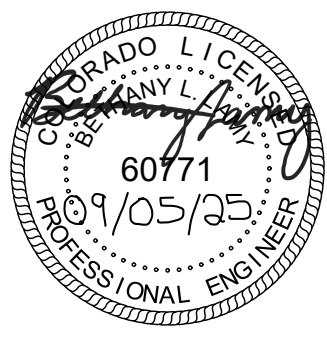
PLAN
SCALE: 1" = 30'

CITY OF LONE TREE
DATE
THESE CONSTRUCTION PLANS HAVE BEEN REVIEWED BY THE CITY OF LONE TREE FOR DRAINAGE AND GRADING AND EROSION CONTROL IMPROVEMENTS ONLY.
ENGINEERING DIVISION ACCEPTANCE BLOCK

REV	ISSUED FOR	DATE	BY

PROJECT ENGINEER:	R. VEANG
DESIGNED BY:	B. LAMY
DRAWN BY:	L. DESKINS
CHECKED BY:	E. FORD
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BID PACKAGE



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HAZEN AND SAWYER
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GREENWOOD VILLAGE, CO. 80111

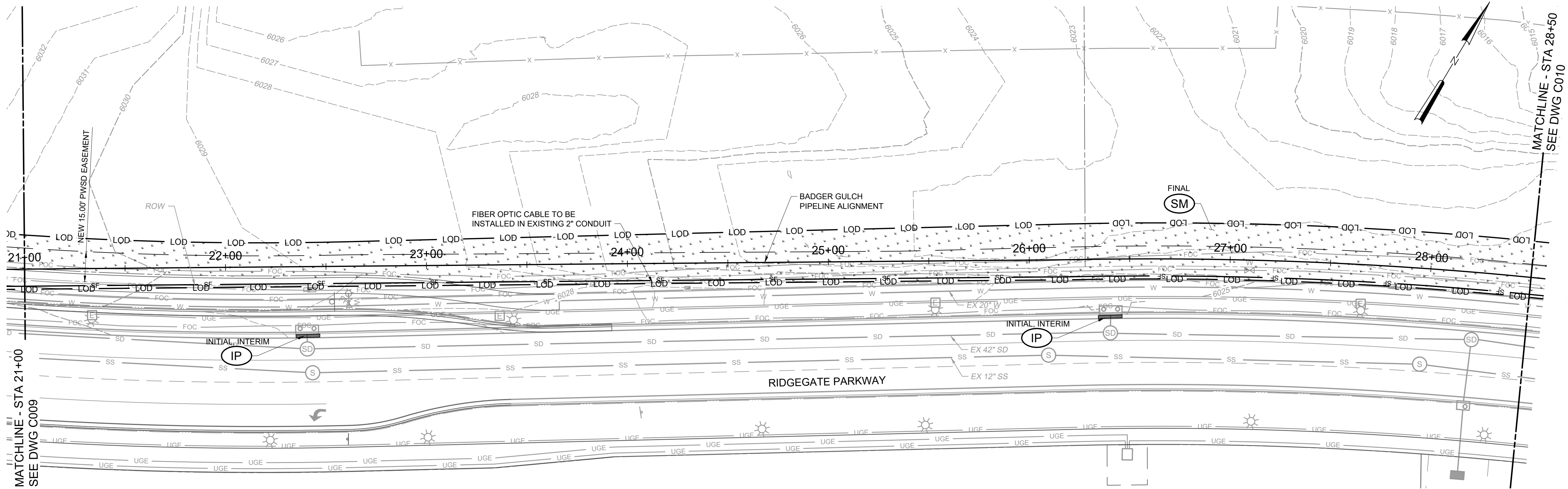
PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

BADGER GULCH WELLS
AND IMPROVEMENTS

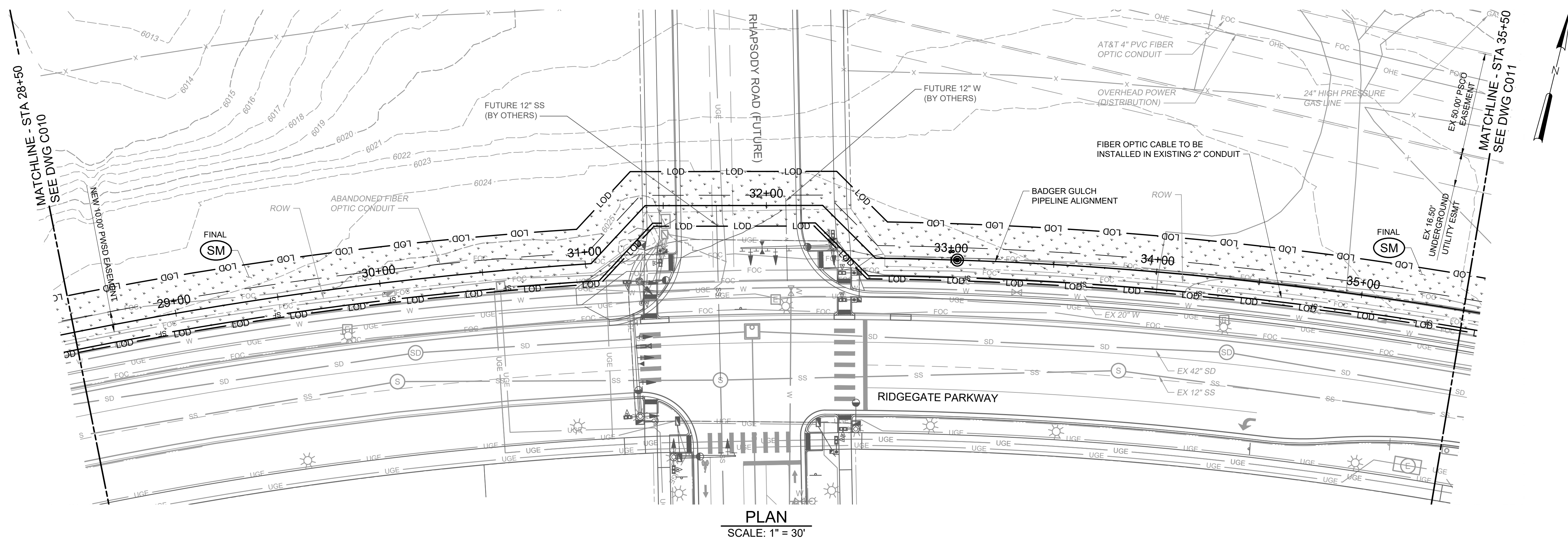
CIVIL
BADGER GULCH PIPELINE AND WELL SITE
PIPELINE GESC PLAN I

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	C009

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- NOTES:
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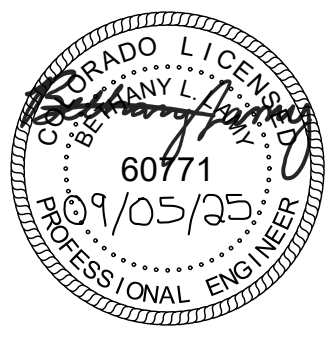
PLAN
SCALE: 1" = 30'

CITY OF LONE TREE
DATE
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ENGINEERING DIVISION ACCEPTANCE BLOCK

REV	ISSUED FOR	DATE	BY

PROJECT ENGINEER:	R. VEANG
DESIGNED BY:	B. LAMY
DRAWN BY:	L. DESKINS
CHECKED BY:	E. FORD
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BID PACKAGE



Hazen
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6251 GREENWOOD PLAZA BLVD, SUITE 275
GREENWOOD VILLAGE, CO. 80111

PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

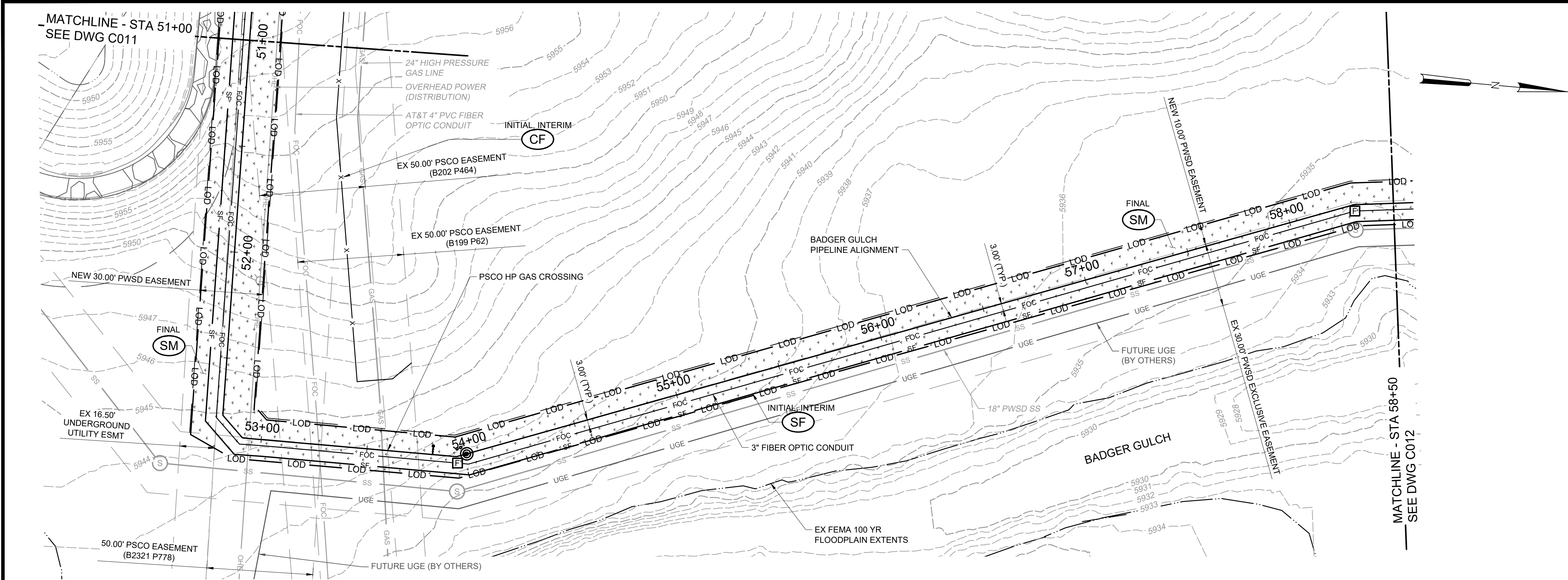
BADGER GULCH WELLS
AND IMPROVEMENTS

CIVIL
BADGER GULCH PIPELINE AND WELL SITE
PIPELINE GESC II

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	

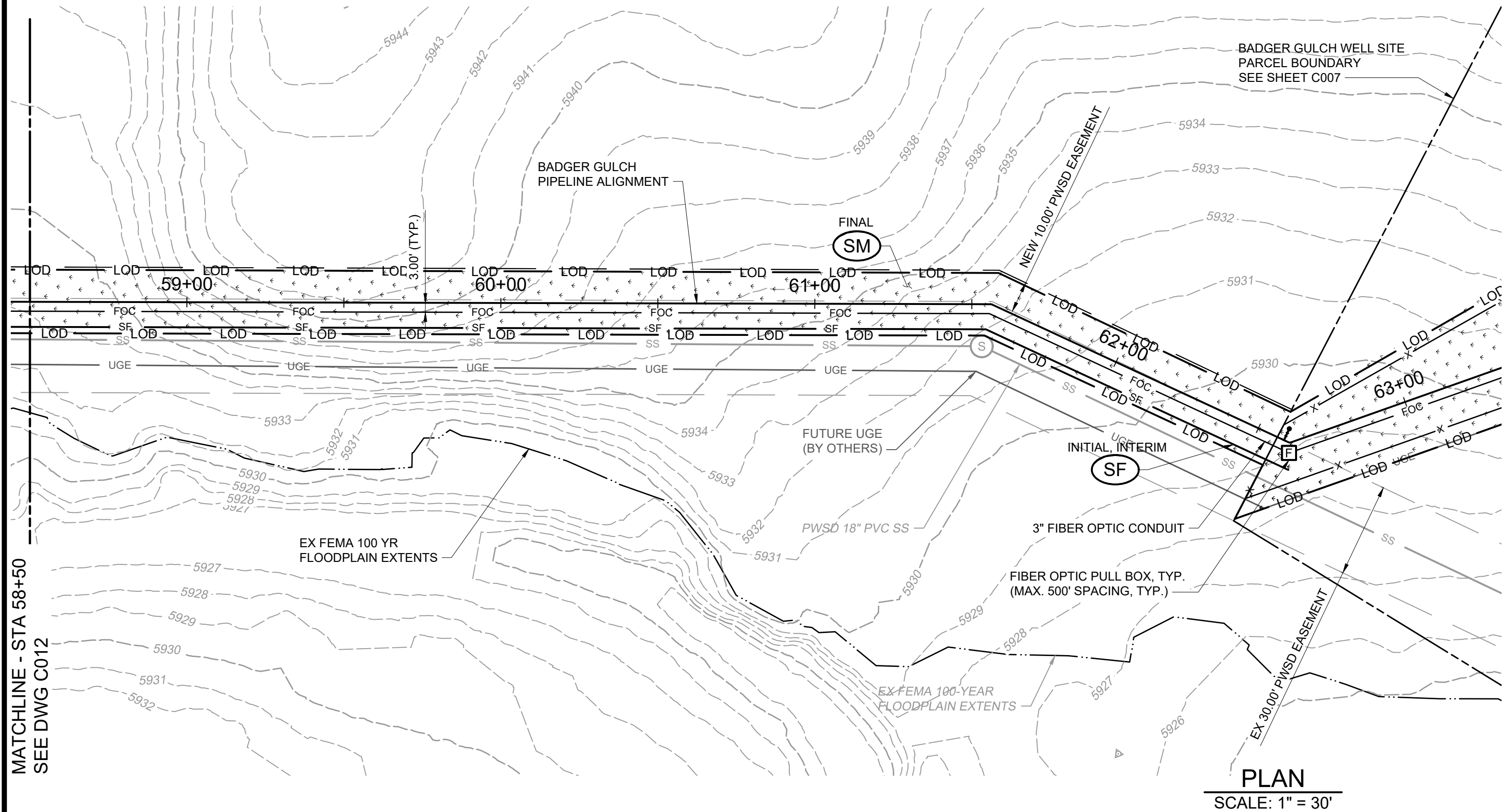
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NOTES:

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PLAN
SCALE: 1" = 30'

REV	ISSUED FOR	DATE	BY

PROJECT ENGINEER:	R. VEANG
DESIGNED BY:	B. LAMY
DRAWN BY:	L. DESKINS
CHECKED BY:	E. FORD
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE	0 1/2" 1"

BID PACKAGE

Hazen

HAZEN AND SAWYER
6251 GREENWOOD PLAZA BLVD, SUITE 275
GREENWOOD VILLAGE, CO. 80111

PARKER WATER & SANITATION DISTRICT
PARKER, COLORADO

BADGER GULCH WELLS
AND IMPROVEMENTS

CIVIL

BADGER GULCH PIPELINE AND WELL SITE
PIPELINE GESC PLAN IV

DATE:	SEPTEMBER 2025
HAZEN NO.:	70069-008
CONTRACT NO.:	
DRAWING NUMBER:	C012

CITY OF LONE TREE
DATE
THESE CONSTRUCTION PLANS HAVE BEEN REVIEWED BY THE CITY OF LONE TREE FOR DRAINAGE AND GRADING AND EROSION CONTROL IMPROVEMENTS ONLY.
ENGINEERING DIVISION ACCEPTANCE BLOCK

Appendix D: Engineer's Opinion of Probable Cost



CITY OF LONE TREE

GESC Permit Opinion of Probable Cost

Project: Denver Basin Well Sites Phase II	Date: September 12, 2025
--	---------------------------------

BMP No.	BMP	ID	Unit	Installation Unit Cost	Quantity	Cost
1	Check Dam	CD	LF	\$ 24.00		\$ -
2	Compost Blanket	CB	SF	\$0.36	7,160	\$ 2,577.49
3	Compost Filter Berm	CFB	LF	\$ 2.00		\$ -
4	Concrete Washout Area	CWA	EA	\$ 100.00	1	\$ 100.00
5	Construction Fence	CF	LF	\$ 2.00	6,870	\$ 13,739.31
6	Construction Markers	CM	LF	\$ 0.20		\$ -
7	Curb Sock	CS	LF	\$ 8.00		\$ -
8	Dewatering	DW	EA	\$ 600.00	1	\$ 600.00
9	Diversion Ditch	DD	LF	\$ 1.60	103	\$ 165.15
10	Erosion Control Blanket	ECB	SY	\$ 5.00	591	\$ 2,956.85
11	Inlet Protection	IP	LF	\$ 20.00	24	\$ 480.00
12	Reinforced Check Dam	RCD	LF	\$ 36.00		\$ -
13	Reinforced Rock Berm	RRB	LF	\$ 9.00		\$ -
14	RRB for Culvert Protection	RRC	LF	\$ 9.00		\$ -
15	Sediment Basin	SB	AC (1)	(2)		\$ -
16	Sediment Control Log	SCL	LF	\$ 2.00	25	\$ 49.20
17	Sediment Trap	ST	EA	\$ 600.00		\$ -
18A	Seeding and Mulching - Mobilization	SM	EA	\$ 1,000.00	1	\$ 1,000.00
18B	Seeding and Mulching - Installation	SM	AC	\$ 750.00	4.3	\$ 3,232.50
19	Silt Fence	SF	LF	\$ 2.00	8,000	\$ 16,000.00
20	Stabilized Staging Area	SSA	SY	\$ 2.00	1,900	\$ 3,800.00
21	Surface Roughening	SR	AC	\$ 600.00		\$ -
22	Temporary Slope Drain	TSD	LF	\$ 30.00		\$ -
23	Temporary Stream Crossing	TSC	EA	\$ 1,000.00		\$ -
24	Terracing	TER	AC	\$ 600.00		\$ -
25	Vehicle Tracking Control	VTC	EA	\$ 1,000.00	2	\$ 2,000.00
26	VTC with Wheel Wash	WW	EA	\$ 1,500.00		\$ -
27	Temporary Batch Plant Restoration		AC	\$ 5,000.00		\$ -
(1) Upstream Tributary Acre						SUB-TOTAL \$ 46,700.50
(2) SB Cost = \$1000 +\$200(Upstream Tributary Acres)						15% CONTINGENCY \$ 7,005.08
						GESC SURETY TOTAL (1) \$ 53,705.58

NOTE: (1) **MINIMUM SURETY shall be \$2,500.00** (Per Section 16-31-110 of City Zoning Code) (Rev. 1-18-12)