Delta Conveyance Design & Construction Authority
Technical Memorandum

Subject:	**Exploration and Testing Work Procedures Overview**
Project feature:	Geotechnical
Prepared for:	California Department of Water Resources (DWR)/Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	Files
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1. Overview

The Exploration and Testing Work Procedures are comprised of this document and four other documents prepared by the teams that have been formed by the Delta Conveyance Design and Construction Authority's (DCA) Geotechnical Consultant (GC). Each of the teams have distinct job functions, although there are considerable dependencies and inter-related work in the planning, performance, and preparation of deliverables for the geotechnical subsurface investigation program.

The teams, key personnel, and their respective Exploration and Testing Work Procedures (or Standards) are provided in Table 1-1. The primary activities required for the team members are contained within their respective standards.

Table 1-1. GC Teams and Standards

Team	Key Personnel	Standard
Pre-field Coordination and Permitting Team (PCPT)	PCPT Leader Permit Coordinator Scheduler Field Clearance Inspector	Pre-Field Coordination and Permitting Standards
Exploration Team (ET)	Exploration Team Leader Exploration Team Inspector Field Runner	Field Exploration Standards
Data Processing Team (DPT)	Data Processing Team Leader Data Processing Team Staff	DCA Boring and CPT Logging Standards and Work Procedures
Laboratory Team (LT)	Laboratory Team Leader Sample Runner	Laboratory Standards

2. Team Responsibilities

The following describes the responsibilities of each group (team) involved with the geotechnical aspects of the project:

Delta Conveyance Design & Construction Authority (DCA):

- Design and construction of the Delta Conveyance Project.
- Lead in determining geotechnical exploration locations and types.
- Reviews and comments on all GC deliverable documents.

The Department of Water Resources Delta Conveyance Office (DCO):

- Provides oversight of DCA's design and construction activities.

The Department of Water Resources, Division of Operations and Maintenance Office (O&M, DWR):

- Future owner of the project infrastructure after construction is completed.

GC Health, Safety, Security and Environmental Management (HSSE) Team:

- Prepares the GC HSSE Plan and guides HSSE implementation for the GC throughout the project.

GC Technical Execution Management Team (TEMT):

- Directs and oversees GC teams to achieve technical work products.
- Technical interface between DCA and the GC teams.
- Develops key planning documents (Geotechnical Exploration Plan and specific Geotechnical Work Instructions for explorations).

GC Pre-field Coordination and Permitting Team (PCPT):

- Takes direction from and reports to the TEMT regarding priorities for and status of work.
- Coordinates with DCA's Field Coordinator and DCO's field work teams (right of way, environmental, cultural teams, and public relations).
- Prepares documents to support DCA in obtaining permits and access, including encroachment permits, temporary entry agreements, and 408 permits.
- Performs site clearances with DCA and DCO staff to assess access issues, routes, best locations, equipment needs, restoration requirements, etc.
- Coordinates with subcontractors (utility clearance, traffic control, access, drillers, etc.).
- Prepares GC Field Briefing Packets with all necessary information for the ET field personnel.
- Briefs GC ET staff on site requirements.

Exploration Team (ET):

- Takes direction from and reports to the TEMT regarding priorities for and status of work.
- Oversees execution of all geotechnical exploration activities assigned to the GC.
- Prepares field logs of borings, wells, and test pits.
- Manages GC field personnel and subcontractors (utility clearance, traffic control, access, drillers, etc.).
- Maintains facilities to support exploration activities.

Data Processing Team (DPT):

- Takes direction from and reports to the TEMT regarding priorities for and status of work.
- Conducts training for new field and Data Processing Team personnel.
- Annotates sample inventory to note sample quality for potential testing purposes.
- Maintains sample storage inventory.
- Reviews soil samples in laboratory and edits field logs, as appropriate, in accordance with quality control guidelines.
- Obtains raw CPT data from ET, perform quality control data processing, and coordinate with GIS/GAIA Team to generate final CPT logs/gINT data tables.
- Prepares gINT logs of borings and CPT logs.
- Performs quality control review of laboratory soil classifications and coordinates document updates with LT, as necessary.
- Updates gINT logs based on quality control review and laboratory test results.

- Coordinates with ET regarding compression and shear (P-S) wave velocity logging, pressuremeter testing, and geophysical testing data processing and quality control.

Laboratory Team (LT):

- Takes direction from and reports to the TEMT regarding priorities for and status of work.
- Oversees execution of all geotechnical and environmental testing assigned to the GC.
- Manages GC team laboratories work distribution and work products.
- Enters laboratory data into gINT and upload to DCA SharePoint site.
- Confirms team laboratories maintain certifications.
- Coordinates testing at specialty laboratories.

Data Integration and Reporting Team (DIRT):

- The DIRT team is not currently active in this year's scope of work.

3. Project Team

A list of the GC Team members and their contact information is provided in the following Table 3-1.

Table 3-1. GC Team Contact List

Name	Company	Role	Email Address	Phone Number
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Name	Company	Role	Email Address	Phone Number
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A list of key DCA and DCO personnel is provided in Table 3-2 below.

Table 3-2. DCA and DCO Contact List

Name	Company/ Organization	Role	Email Address
Andrew Finney	DCA	EDM Geotechnical and Field Work Lead	andrewfinney@dcdca.org
Robert Oller	DCA	EDM Field Coordinator	robertoller@dcdca.org
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Arasan Singanayaham	DWR	DCO Geotechnical Engineer	arasan.singanayaham@water.ca.gov
Pat Clark	DWR	DCO Public Outreach Lead	patricia.clark@water.ca.gov
Quentin Green	DWR	DCO Real Estate Professional	quentin.green@water.ca.gov

4. Workflow

Attached to this document is a workflow diagram (Attachment 1) that identifies the various project teams (DCO, DCA, HSSE, TEMT, PCPT, ET, DPT, LT, and DIRT) and displays the inner workings of the project teams and interactions with other groups within the DCP. Detailed within the workflow diagram is the interaction between each team to complete an investigation.

In the early stages of the site exploration program, the PCPT will be working with the TEMT, DCA and DCO to arrange for site access, apply for necessary permits, and put together Field Briefing Packets for the upcoming exploration program. The Field Briefing Packets along with all supporting documentation will be handed to the ET for implementation. A field briefing meeting will be held between TEMT, PCPT and ET to discuss specific work instructions that may differ from the general Exploration and Testing Work Procedures. The ET will be responsible for coordinating all subcontractors, procurement of supplies, and will meet the DCA field coordinator at the site at the designated time.

At the end of each work shift, daily field reports and partial field logs will be transmitted by the ET to the DPT and TEMT for review and further input to the work instructions. Upon completion of a boring or CPT, field logs and samples will be transmitted to the Geotechnical Data Processing Center for further review by the DPT. The DPT will assign geotechnical and environmental lab testing, which will be reviewed by TEMT, DCA and DCO.

The LT will take the completed laboratory assignments, and coordinate sample deliveries to geotechnical and environmental testing labs. The LT is responsible for quality control review of lab results received which are then are provided back to DPT for inclusion in the draft deliverable. DPT will adjust the boring logs to account for laboratory test results and assemble the final package for review by TEMT, DCA and DCO.

5. Document History and Quality Assurance

Reviewers listed below have completed an internal quality review check and approval process for this deliverable that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

			Approval Names and Roles			
Rev.	**Date**	**Version Description**	**Prepared by**	**Internal QC review by**	**Consistency review by**	**Approved for submission by**
0	08/31/2020	Initial submission	William Schmierer / Pre-Field Coordination and Permitting Team Leader	Deron van Hoff / TEMT Lead	Deron van Hoff / TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
1	10/16/2020	Incorporate DCA review comments	William Schmierer / Pre-Field Coordination and Permitting Team Leader	Deron van Hoff / TEMT Lead	Deron van Hoff / TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
2	11/20/2020	DCO Submission	William Schmierer / Pre-Field Coordination and Permitting Team Leader	Deron van Hoff / TEMT Lead	Deron van Hoff / TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
3	02/19/2021	Final Draft	William Schmierer / Pre-Field Coordination and Permitting Team Leader	Deron van Hoff / TEMT Lead	Deron van Hoff / TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
This interim document is considered preliminary and was prepared under the responsible charge of Ward Andrew Herlache, Geotechnical Engineering License 2149.						

Attachment 1. Draft Workflow Diagram

Notes:
Collaborative Review
Purple Outline – Review
Blue Outline – Documented Quality Control Point
Dashed Line – Not in Current Scope of Work

Subject:	**Pre-Field Coordination and Permitting Standards**
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Contents

Attachments

Acronyms and Abbreviations

AGOL	ArcGIS Online
CPT	Cone Penetration Test
Dashboard	Subsurface Explorations Encroachment & Permit Status Dashboard
DCA	Delta Conveyance Design and Construction Authority
DCO	Delta Conveyance Office
DCP	Delta Conveyance Project
DFR	Daily Field Report
DPT	Data Processing Team
DWR	Department of Water Resources
DWR-PN	Department of Water Resources Parcel Number
EDM	Engineering Design Manager
ET	Exploration Team
GC	Geotechnical Consultant
GEP	Geotechnical Exploration Plan
GPS	Global Positioning System
HASP	Health and Safety Plan
HSSE	Health, Safety, Security, and Environment
IDW	Investigation Derived Waste
IS/MND	Initial Study Mitigation Negative Declaration
LMA	Local Maintaining Agency
PCPT	Pre-field Coordination and Permitting Team
PPE	Personal Protective Equipment
QAM	Quality Assurance Manager
QMP	Quality Management Plan
ROW	Right-of-Way
TEP	Temporary Entry Permit
USA	Underground Service Alert

1. Introduction

This document presents the typical daily workflow and standard work procedures for the Pre-Field Coordination and Permitting Team (PCPT) as part of the Delta Conveyance Project (DCP). The PCPT is a part of the Geotechnical Consultant (GC) Team working for the Delta Conveyance Design and Construction Authority (DCA). The DCA works under oversight of the DWR Delta Conveyance Office (DCO).

The PCPT Standards should be read in conjunction with the following documents to maintain consistency and minimize repetition between related documents. These documents may be updated as necessary to reflect additional tasks and exploration methods authorized during the duration of the project.

- Field Exploration Standards;
- Laboratory Standards; and
- DCA Boring and CPT Logging Standards and Work Procedures.

1.1 Purpose and Scope

The purpose of this document is to outline procedures and daily workflow processes for the various PCPT tasks. The PCPT is responsible for the execution of initial site clearance activities and creating the Field Briefing Packets for the DCP field investigations under the GC. PCPT's activities will occur in the weeks and months prior to the Exploration Team (ET) starting their geotechnical investigation and continue on as the investigation proceeds.

1.2 Pre-Field Coordination and Permitting Team

The PCPT is responsible for the coordination between DCA and the GC ET to provide access and ensure the exploration locations are cleared for operations.

- PCPT Leader:
  - Coordinate the pre-field program activities with team members,
  - Develop future documents for program implementation as needed,
  - Provide technical guidance and oversight in program execution,
  - Provide program status and collected information to the GC Team and DCA,
  - Submit various permit applications on behalf of DCA,
  - Manage team charges relative to the budget and report to the Project Management Team,
  - Indicate to the ET that exploration locations are cleared for operations,
  - Consolidate information into Field Briefing Packets for the ET, and
  - Complete the PCPT QC Checklist (Attachment 1).
- Field Clearance Inspector:
  - Stake out exploration locations for field clearance by other groups from DCA and for the purpose of contacting Underground Service Alert (USA),
  - Complete PCPT Site Clearance Form, and
  - Ensure that equipment can access the exploration location.

- Permit Coordinator:
  - Contact Local Maintaining Agency (LMA) permitting authorities,
  - Complete and submit Caltrans Encroachment Contractor Double Permits,
  - Complete LMA permit applications and transmit to DCA and DCO for review and signature, and
  - Coordinate with DCA and DCO to respond to comments from LMA regarding applications.
- Scheduler:
  - Responsible for coordinating DCA field clearance activities with the anticipated ET schedule,
  - Schedule site clearances with concurrence from the DCA Field Work Coordinator,
  - Ensure that a sub-meter global positioning (GPS) unit is in the field with data link to the DCA ArcGIS Online for sharing data between various DCO and DCA teams,
  - Maintain electronic system to track order and duration of future explorations,
  - Coordinate with the ET to schedule Exploration Inspectors and exploration crews, and
  - Revise anticipated exploration durations based upon completed explorations to refine anticipated project resources.

1.3 Confidentiality and Public Relations

Given the high-profile nature of the project, a resident or other non-DCA parties may visit the site during the initial site clearance visits. Since field personnel represent the DCA, they should conduct themselves and their work in a professional manner, should be courteous, organized, systematic and in control of the field activities. If appropriate, they should initially greet the visiting party and ensure that they are aware of Health, Safety, Security, and Environmental (HSSE) guidelines pertaining to the project. Individuals that have not received project specific training and are not wearing the appropriate personal protective equipment (PPE) should be excluded from entering the work zone.

All field data collected for the Delta Conveyance Project is to be kept confidential. Field personnel should not comment on subsurface conditions or share project information with site visitors unless previously authorized by the DCA; this will avoid future complications in client relations and interactions with other project team professionals. This is particularly applicable to discussions with individuals not directly associated with the DCA. A tactful verification of a visitor's identity should be made. The field personnel should follow the communication protocol established for the project.

When non-client related visitors request project specific details, they should only be provided with either pre-prepared information or contact information for the DCA’s field coordinator.

2. Onboarding and Training

2.1 Onboarding

All field staff must be on the list of approved personnel for the DCP. Personnel new to the project should familiarize themselves with this document. PCPT personnel will be required to have completed project specific training prior to assignment of any PCPT task.

2.2 Training

Field personnel will undergo training in each of the sections listed below, as applicable to their assigned tasks. Training will be logged and tracked by the PCPT Lead or other appropriate personnel.

2.2.1 Health and Safety

All field personnel will receive HSSE training provided by the PCPT Lead, ET Lead, or HSSE team. The HSSE training will align with the project HSSE plan developed by the GC. All PCPT personnel must read and sign the project HSSE plan prior to the start of any PCPT tasks.

2.2.2 Environmental and Cultural Training

Personnel working in the field at exploration locations will be required to complete the Environmental and Cultural Training course as required in the Initial Study Mitigated Negative Declaration (IS/MND).

2.2.3 Dashboard

PCPT personnel will be trained on accessing the Subsurface Explorations Encroachment & Permit Status Dashboard (dashboard) located on ArcGIS online (AGOL) to gather and check for appropriate permits required for individual properties. PCPT personnel will determine if any necessary permits are missing from the dashboard prior to conducting site visits and prior to indicating that the borings are ready for the ET.

2.2.4 PCPT Site Clearance Visit

Training will be provided to all appropriate field personnel on the components of a site clearance visit. Personnel will be trained on site clearance visit documentation and activities, which include, but are not limited to:

- Permits;
- Marking Exploration Locations for USA;
- Photo documentation;
- Site observations (overhead power lines, steep terrain, navigable roadways, gates, access issues, etc.); and
- Field forms.

2.2.5 USA Ticket

PCPT personnel will be trained on calling in USA North 811 tickets after the site clearance visit and ensuring that the completed USA ticket is relayed to the appropriate team. The PCPT team will also be responsible for providing the ET with utility clearance notifications. Both the PCPT and ET will be responsible for verifying all member utilities have responded to the USA ticket.

2.2.6 Exploration Team Field Packet

PCPT personnel will be trained to create the GC Field Briefing Packets. Training will include the following:

- Components of the GC Field Briefing Packet;

- Where to access each packet component;
- Order of each GC Field Briefing Packet;
- Who to contact if a packet component is missing; and
- Documentation of packet progress and completion.

3. Field Planning – Site Clearance Visits

The purpose of the site clearance visits is to evaluate the details of a property prior to any exploration activities. These details include assessing site access to the exploration location, coordinating work restrictions and site impacts with affected landowners, working with biological and cultural team members to assess the access route and exploration location, evaluating constraints due to permitting conditions, and utility locating. The site clearance visit will be attended by the PCPT personnel, Exploration Field Superintendent, surveyor, biological monitor, cultural monitor, and other DCA/DCO personnel. Several documents are required to be compiled prior to the start of any PCPT site clearance visit including the Site Clearance Form, the Right-of Way (ROW) Site Visit Form, dashboard permits, Temporary Entry Permits (TEPs), access route maps, and HSSE plan. If the appropriate forms and paperwork are not completed prior to a scheduled site clearance visit, the site clearance visit shall not be conducted.

3.1 PCPT Site Clearance Form

A Site Clearance Form is required for each property and shall be completed by PCPT personnel in the field during the site clearance visit. The Site Clearance Form will be used as a first check regarding the details of the property. Multiple explorations may be listed on one Site Clearance Form if the explorations are planned to take place on the same DWR Parcel Number (DWR-PN). The blank Draft Site Clearance Form is included as Attachment 2. The Site Clearance Form will include information such as:

- Name(s) of PCPT personnel who conducted the site clearance visit;
- Names of other people attending the Site Clearance;
- Date and time of site clearance visit;
- Planned exploration identification names;
- Property address and DWR-PN;
- Information regarding any access issues at the site (gates, bridges, navigational issues, narrow points along access route, etc.);
- Visual presence of overhead power lines;
- Indications of underground utilities near the property boundary;
- On-property hazards;
- Proximity of planned explorations to a levee or body of water;
- Active wells present on-property; and
- Reason for moving originally planned exploration location (i.e., environmental concerns, overhead powerlines, property owner request, etc.).

Each section of the Site Clearance Form should be filled out completely. No sections are to be left blank. For any sections that do not have an appropriate answer or response, “N/A” (not applicable) should be inserted into the box. It is imperative that the Site Clearance Forms be legible, thorough, and complete with a signature of the PCPT personnel who conducted the site clearance visit.

3.2 ROW Site Visit Form

A completed ROW Site Visit Form may be available if the ROW agent has visited the site prior to the start of a site clearance visit. The ROW Site Visit Form provides information regarding landowner requests and property details. This form is also to be included as part of the Field Briefing Packet. It is important to read the ROW Site Visit Form prior to accessing a property. A blank Draft ROW Site Visit Form is included as Attachment 3.

3.3 Dashboard Permits

The DCA Dashboard is the central location for information regarding a specific property. All permits will be accessed and gathered from the dashboard. Prior to mobilizing to a property for a site clearance, the permit list will be reviewed and checked to ensure that all necessary permits have been acquired and are uploaded to the dashboard. If any necessary permits are missing from the dashboard, the team is not to mobilize for a site clearance visit. The PCPT Lead or site clearance visit scheduler should be notified if any permits are missing from the dashboard so the property can be flagged, and the dashboard updated when complete.

Various permits may be required for a given site to perform the exploration. Not all permits will be needed at each site. Permits may include, but are not limited to the following:

Land Based Explorations:

- IS/MND;
- Encroachment (for explorations on public right-of-ways, in state or county parks, or on levees of Local Maintaining Agencies); and
- Central Valley Flood Protection Board (for explorations on State Plan of Flood Control levees).

Over-Water Explorations:

- California Fish and Game Code Section 1600, Streambed Alteration Agreement;
- Central Valley Flood Protection Board Encroachment Permit;
- U.S. Army Corps of Engineers, Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, Nationwide Permit 6;
- Regional Water Quality Control Board Clean Water Act Section 401;
- Letter of Concurrence from U.S. Fish and Wildlife Service for federal species under the Endangered Species Act under their jurisdiction; and
- Letter of Concurrence from National Oceanic and Atmospheric Agency Fisheries Unit for federal species under the Endangered Species Act under their jurisdiction.

Copies of all pertinent permits will be maintained at the work site during all field activities. ET work will not begin until all permits for a site are obtained.

3.4 Temporary Entry Permits

A TEP is required for each site prior to entry and are acquired by the DCA ROW Agents. The TEP provides landowner permission for field personnel to access a property for services such as site clearance visits, staging, parking, performing exploration for geotechnical and geological analyses, and sampling.

The PCPT Lead will maintain controlled access of all GC personnel working at field sites including a log of personnel currently in the field and an appropriate check-in and check-out process for daily activities. The PCPT Lead, in coordination with the DCA field coordinator, will also track the total days that are remaining for parcel access on each TEP.

At sites that require a court order for access, the court order document will be included as part of the TEP. Site access to any property will not be allowed unless accompanied by a copy of the signed TEP.

3.5 Access Routes

Access routes approved by the landowner will be brought to the site during the PCPT site clearance visit. Access routes will be checked for viability during the site clearance visit. Additionally, access route maps will be included in the Field Briefing Packets. All access routes should be strictly adhered to as directed by the EDM field coordinator.

3.6 GC Health and Safety Plans

Each team personnel needs to read, understand, and sign the project HSSE Plan prior to conducting any field work activities. A copy of the HSSE shall be carried by personnel at all times in either electronic or hard copy form when conducting field work activities.

3.7 PCPT Field Supplies

Site clearance kits will be provided for each field team and will include at a minimum the following items:

- Toolbox,
- Survey flagging (white and pink),
- Stakes and hammer,
- Survey paint (white and pink),
- Survey whiskers (white and pink),
- Caution tape,
- Pencils, pens, waterproof permanent markers, erasers,
- Flashlight and batteries,
- Clip board,
- Tape measure,
- DCA Contact Card,
- Camera,
- Field notebook, and

- GPS (as needed)

Site clearance kits are to be used exclusively for DCP.

3.8 PCPT Site Clearance Form Submittal

Site Clearance Forms will be completed in electronic or hard copy. When the PCPT staff have completed a day of field work, all hard copy documentation shall be scanned and filed for access by the PCPT Lead for review and tracking purposes. No completed Site Clearance Form or other site documentation are to be kept by field personnel.

3.9 PCPT Site Clearance Form Review

The PCPT Lead, or other appropriately trained personnel, will review each Site Clearance Form individually for quality and completeness prior to including the Site Clearance Form in the Field Briefing Packet. All Site Clearance Forms must be legible, complete, include the signature of the PCPT personnel who completed the site clearance visit, and must include site documentation photos and notes, if applicable. After review, each Site Clearance Form will be scanned individually and uploaded onto the appropriate online drive. Site Clearance Form electronic files shall be labeled by their representative DWR-PN.

4. Field Briefing Packets

A key role of the PCPT, in coordination with DCA, is to create the GC Field Briefing Packets for each DWR-PN. DCA and DCO will be provided the packets for review. The packets are required in order for the ET to schedule and complete explorations at that property. Components to be included in the Field Briefing Packets are outlined in the sections below and included in Attachment 4.

4.1 ROW Site Visit Form

The ROW Site Visit Forms (if a field a visit was performed by the ROW agents) are to be included as the front page of each Field Briefing Packet. The ROW Site Visit Forms include the property owner, address, DWR-PN, and site-specific information gathered by the ROW Agents. The ROW Site Visit Forms can be obtained from the DCA SharePoint. Each property is sorted by DWR-PN.

4.2 PCPT Site Clearance Form

The PCPT Site Clearance Forms are to be included behind the ROW Site Visit Forms in the Field Briefing Packet. The PCPT Site Clearance Forms can be obtained from the DCA SharePoint and are sorted by DWR-PN.

4.3 TEPs

TEPs are required to be included as part of the GC Field Briefing Packet. These permits are required before any exploration activities can begin at a property. Physical paper copies of the TEPs will be provided to the Field Clearance Inspector and/or Exploration Inspector by the DCA Field Coordinator.

4.4 Access Route Maps

Access route maps are to be included in the Field Briefing Packets. Finalized access route maps can be accessed on the DCA SharePoint and are sorted by DWR-PN.

4.5 USA Ticket and Clearances

After a property has been properly marked for USA by the PCPT staff and the site clearance has been completed, designated PCPT team personnel will call in a USA North 811 ticket for each property, which will include all explorations planned to take place on that DWR-PN. When calling in USA tickets, personnel should use the following information regarding contact and project information:

- Name of PCPT staff who conducted the site clearance visit;
- Phone number of the PCPT staff who conducted the site clearance visit; and
- DCA USA ticket email address.

After a USA ticket has been called in and the confirmation email has been received, the USA ticket confirmation will be included in the Field Briefing Packet. Individual member's responses to the USA Ticket will also be included in the Field Briefing Packets. It is the responsibility of the PCPT and ET to track the individual member's responses and incorporate them into the Field Briefing Packet.

In instances where individual members call the PCPT staff directly with questions or clearance, it is the responsibility of the PCPT personnel to take notes of the conversation and email the information to the DCA USA ticket email address for tracking. The subject line should include the DWR-PN and the utility company.

4.6 DCA Boring and CPT Logging Standards and Work Procedures

All field engineers or geologists will be provided with a copy of the DCA Boring and CPT Logging Standards and Work Procedures. This document shall be carried by personnel at all times in either electronic or hard copy form when conducting field work activities. These logging standards are to be used and followed by all field loggers for DCP.

4.7 Exploration and Testing Work Procedures

All field engineers or geologists will be provided with a copy of the Exploration and Testing Work Procedures. This document shall be carried by personnel at all times in hard copy form when conducting field work activities. Exploration and Testing Work Procedures are to be used and followed by all field loggers for DCP.

4.8 Geotechnical Exploration Plan and Geotechnical Work Instructions

The Geotechnical Exploration Plan (GEP) and Geotechnical Work Instructions are documents that are more specific to the current scope of field exploration. A copy of each of these plans is required to be included in the Field Briefing Packet. Any trench shoring plans and Cal OSHA trench permits will be included in the geotechnical Work Instructions. The GEP and work instruction documents can be obtained from the DCA SharePoint Site.

4.9 HSSE Plan

The HSSE Plan has been prepared by the HSSE Team and will be provided to each field team and should be maintained at the jobsite during all work hours. The HSSE Plan will include emergency response plans specific to an exploration site or area (such as an island with one entry/exit route). Potential hazards for the work location and type of work to be completed will be identified in the HSSE, along with mitigation measures to lower the risk of harm to individuals on site.

5. Quality Assurance and Quality Control

5.1 Quality Assurance

Quality assurance of pre-field coordination and field activities will be conducted through a review/checking process wherein the field activities conducted are compared against the established procedures outlined in the Quality Management Plan (QMP) and this document. These procedures establish a consistent, systematic approach to all field activities in accordance with industry standards, with a focus on providing high quality field and laboratory data to meet the requirements of the DCP Program. In addition to planning for quality and implementing established procedures, periodic audits will be conducted by the Quality Assurance Manager (QAM). The audits will be used to document the quality procedures in use and to monitor and/or identify when measures need to be added to improve upon established procedures to ensure high quality data is delivered.

5.2 Quality Control

Quality control measures will be employed throughout the duration of the pre-field coordination and permitting activities of the DCP to review/check various activity details which are to ensure providing quality data for the project. Training records will be kept ensuring documenting when all field staff have received awareness training for all established approved procedures. Training will also be provided to review Lessons Learned and to review the findings of any audits which would require a revision to a procedure. Work products, such as Site Clearance Forms and Field Briefing Packets, will be reviewed for completeness and accuracy by the PCPT Lead or other appropriately trained PCPT personnel.

6. Health and Safety

6.1 Health, Safety, and Security Plan

All field personnel should be familiar with the project HSSE Plan. Safety is the responsibility of all field personnel on each investigation team.

6.2 Daily Safety Meeting

Tailgate safety meetings are to be conducted daily with all on-site personnel, including subcontractors, and other members of the DCA Team. The daily meeting should be held immediately upon arrival at the jobsite, prior to the commencement of any work. During the meeting, the work to be completed that day should be discussed along with the potential hazards of the day’s work. Participants in the daily safety meeting are encouraged to speak up freely and to identify potential safety hazards and discuss steps to be taken to reduce the risk of personal harm.

6.3 Changed Conditions

As conditions change in the field, such as weather, traffic, personnel changes, etc., brief discussions on hazards imposed by those changes should be conducted. New workers or visitors to a worksite should be briefed on the information contained in the HSSE Plan.

6.4 Incident Reporting

Reporting of an incident should take place as soon as it is safe to do so. In the case of a medical emergency, emergency services should be contacted first as outlined in the HSSE Plan. All emergencies and lesser incidents should be called into the PCPT Lead and the field personnel’s direct supervisor. Incidents should be noted in the Daily Field Report (DFR) and on an incident reporting form.

7. Communication

Communication and documentation of field activities is critical to ensure the effectiveness and timeliness of the field operations. The PCPT personnel performing the site clearance visits are responsible for keeping the PCPT Lead up to date on daily field activities and provide appropriate documentation. Notification will be provided by frequent phone conversations, emails, or text messages (at least daily).

7.1 Field Briefing Packets for Site Clearance

PCPT site clearance visit packets will be assembled and reviewed by the PCPT Lead prior to PCPT staff arriving on-site to conduct a site clearance visit. Site clearance visit packets are to be reviewed by the PCPT staff and discussed with the PCPT Lead prior to commencement of field work. Components of the site clearance visit packets are included above in Section 3.

7.2 Daily Field Reports

DFRs are to be completed throughout the day and submitted at the end of the day. Hard copy DFRs along with the Site Clearance Forms are to be scanned and emailed to the PCPT Lead at the end of each day. Additionally, DFRs and Site Clearance Forms should be uploaded onto the Fugro SharePoint site in a designated folder. All fields in the DFR should be filled in completely with no sections left blank. For any sections that do not have an appropriate answer or response, “N/A” (not applicable) should be inserted into the box.

8. Document History and Quality Assurance

Reviewers listed below have completed an internal quality review check and approval process for this deliverable that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

			Approval Names and Roles			
Rev.	Date	Version Description	Prepared by	Internal QC review by	Consistency review by	Approved for submission by
0	08/31/2020	Initial submission	Stacy Mann /Deputy Pre-Field Coordination and Permitting Team Leader	William Schmierer /Pre-Field Coordination and Permitting Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
1	10/16/2020	Incorporate DCA review comments	Stacy Mann /Deputy Pre-Field Coordination and Permitting Team Leader	William Schmierer /Pre-Field Coordination and Permitting Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
2	11/20/2020	DCO Submission	Stacy Mann /Deputy Pre-Field Coordination and Permitting Team Leader	William Schmierer /Pre-Field Coordination and Permitting Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
3	02/19/2021	Final Draft	Stacy Mann /Deputy Pre-Field Coordination and Permitting Team Leader	William Schmierer /Pre-Field Coordination and Permitting Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache / GC Geotechnical Engineering Manager
This interim document is considered preliminary and was prepared under the responsible charge of Ward Andrew Herlache, Geotechnical Engineering License 2149.						

Attachment 1. PCPT QC Checklist

PCPT QC Checklist

Element Name and Review Aspect

	PROJECT MANAGEMENT	Yes	No	NA	Comments (and notes)
1	**Training Record Documentation**				
	Evidence that field staff are trained attended the Field Work Training (protocols for environmental, cultural, and biological areas).				
	Evidence that team members are trained in external contact procedures.				
	Evidence that team members are trained in permit and access requirements.				
	Evidence that team members have reviewed the HSE Plan.				
	Evidence that team members are trained in appropriate pre-field procedures.				
	Other, specify:				
2	**Pre-Field Site Clearance Packet**				
	The PCPT lead or designated personnel reviews final DCA figures				
	The PCPT lead or designated personnel reviews ROW Agent Initial Site Visit Form.				
	LMA encroachment permts are in place.				
	The PCPT lead or designated personnel verifies that initial site clearance packets contain correct location maps and access approvals.				
	Other, specify:				
4	**ET Packet**				
	PCPT confirms receipt of TEP from DCA Field Coordinator and incorporation into ET Packet.				
	The PCPT lead or designated personnel verifies that a USA Ticket has been called in and all responses have been uploaded onto the SharePoint and are included in the ET Packet.				
	The PCPT lead or designated personnel verifies that survey, biological, and cultural data has been uploaded onto the SharePoint and is included in the ET Packet.				
	Other, specify:				
5	**Graphical Presentation of Data For Field Investigation Packets**				
	The PCPT lead verifies correctness of Field Investigation packets.				
	Other, specify:				
6	**Communication, Internal and External**				
	Evidence that all internal and external communication is in accordance with project requirements.				
	Other, specify:				

Reviewer Name:
Review Contact Email:
Review Date:

Attachment 2. Draft Site Clearance Form

COUNTY / DWR PROPERTY #/ LOCATION	
DATE / TIME	
SITE EVALUATOR(S) NAME	

Documentation Check List Prior to On-Site Activities

	Y/N/NA	**Electronic or hard copy document on-site? Y/N/NA**	**Remarks**
1. Temporary Entry Permit (TEP) acquired for access to property?			
2. Owner notification process complete?			
3. HSSE reviewed prior to on-site activities?			

If the answer to any of the above questions is No, obtain the proper documents and/or review the appropriate material. Do not start work until the answers are Yes to all the above questions

On-Site Activities Check List

	Complete?	**Remarks**
1. USA Site (50 foot radius around each point) – spray paint, stakes, flagging, etc. (as appropriate)		
2. Photo documentation of site (potential hazards, access issues, exploration location, pre and post-work conditions, etc.)		

Site Clearance Form

	Y/N	Remarks
Exploration Access Checklist		
1. Are the roadways on the Parcel navigable for equipment?		
2. Is there soft or wet ground?		
3. Steep or uneven terrain?		
4. Would the roads be navigable if wet?		
5. Are there any gates or narrow points along access route?		
6. Does the gate have a lock? If so, what is the code or key?		
7. Are there any bridges on the Parcel?		
8. Other navigational issues (traffic control, etc.)?		
9. Any reasons the location(s) would inconvenience the owner or tenant (crops, residences, access)?		

Notes:

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Site Evaluator(s) Signature(s):____

Site Clearance Form

EXPLORATION NAME	
DATE / TIME	
SITE EVALUATOR NAME	

Geotechnical Site Evaluation for Exploration Activities

Exploration Checklist		
1. Is the area flat and clear of vegetation?		
2. Are there any overhead obstacles for the exploration equipment? (power lines, trees, etc.)		
3. Is the proposed hole closer than 150 feet from the levee centerline?		
4. Are there any indications of underground utilities? (paddles, signs, irrigation lines, culverts)		
5. Close proximity to active wells? – pumping, agricultural, domestic, etc.		
6. Environmental Condition cleared? (proximity to trees, waterways, vegetation) – *consult with Environmental Scientist onsite*		
7. Cultural Resources cleared? – *consult with Cultural Resources Specialist onsite*		
8.		

Notes:

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Site Evaluator(s) Signature(s):____

Attachment 3. Draft ROW Site Visit Form

ROW Agent Initial Check List

EXPLORATION NAME(S)		
COUNTY / DWR PROPERTY #/ LOCATION		
DATE / TIME		
ROW Agent Name(s)		

On-Site Activities Check List

	Complete?	Remarks
1. Photo documentation of site (potential hazards, access issues, exploration location, pre and post-work conditions, etc.)		

Geotechnical Site Evaluation for Exploration Activities

	Y/N	Remarks
Exploration Access Checklist		
1. Overhead power lines, trees, objects?		
2. Steep or uneven terrain?		
3. Are the roadways to the exploration site navigable for equipment?		
4. Would the roads be navigable if wet?		
5. Are there any gates or narrow points along access route?		
6. Does the gate have a lock? If so, what is the code?		
7. Do you have to drive over any bridges?		
8. Other navigational issues (traffic control, etc.)?		

Notes:

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Attachment 4. Field Briefing Packet Contents and Responsibilities

Field Briefing Packet Contents and Responsibilities
Pre-Field Coordination and Permitting Standards
Delta Conveyance Project

Packet (in order)	GC	DCA	DCO	ENV
Site Specific Permit Packet (to be assembled by DCA)				
Contact List		x		
Permit Agency Contacts and Conditions of Permits		x		
Encroachment Permit (as applicable)		x		
TEP (as applicable) with Parcel Map (with any edits from site clearance)		x		
IS/MND		x		
Other Enviro Permits (as applicable)		x		
Public contact card (project flyer)		x		
Site Specific Exploration Packet (to be assembled by PCPT Lead)				
Listing of Exploration	x			
Exploration Location Map	x			
Traffic control plan (as applicable)	x			
Hospital route map	x			
USA Tickets and Clearances	x			
GEP	x			
Exploration Standards & ASTM D2488	x			
Health & Safety Plan (firm / agency specific)	x	x	x	x

Subject:	**Field Exploration Standards**
Project feature:	Geotechnical
Prepared for:	California Department of Water Resources (DWR)/Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	Files
Date/Version:	February 19, 2021/Final Draft
Reference no.:	GDE-GE-Field Exploration Standards-02192021

Contents

Attachments

Tables

Acronyms and Abbreviations

COC	Chain of Custody
CPT	Cone Penetration Test
CVP	Central Valley Project
DCA	Delta Conveyance Design and Construction Authority
DCO	Delta Conveyance Office
DCP	Delta Conveyance Project
DFR	Daily Field Report
DPT	Data Processing Team
DWR	Department of Water Resources
EDM	Engineering Design Manager
ET	Exploration Team
GC	Geotechnical Consultant
GDPC	Geotechnical Data Processing Center
GEP	Geotechnical Exploration Plan
HSSE	Health, Safety, Security, and Environmental
IDW	Investigation Derived Waste
LEL	Lower Explosive Limit
PCPT	Pre-field Coordination and Permitting Team
PID	Photo-ionization detector
PVC	Polyvinyl Chloride
QAM	Quality Assurance Manager
QMP	Quality Management Plan
ROW	Right of Way
SWP	State Water Project
TEMT	Technical Execution Management Team
TEP	Temporary Entry Permit
USA	Underground Service Alert
VWP	Vibrating Wire Piezometer

1. Introduction

This document presents the exploration standards and work procedures established by the Delta Conveyance Design and Construction Authority (DCA) for the Geotechnical Field Exploration Program for the Delta Conveyance Project (DCP). Subsurface investigation programs, regardless of how well they may be planned, must be flexible to adjust to variations in subsurface conditions encountered during drilling. As a result, the Geotechnical Consultant (GC), DCA, and the Department of Water Resources (DWR) Delta Conveyance Office (DCO) must be available to confer with the field crews and be present as needed during the field investigation. From the GC's side, this involves the Technical Execution Management Team (TEMT) which will be the primary interface with DCA and DCO, the Pre-field Coordination and Permitting Team (PCPT), the Exploration Team (ET), the Laboratory Team (LT), and the Data Processing Team (DPT). From the DCA and DCO sides, this involves engineering representatives, the DCA Field Coordinator, environmental staff (biologists and cultural resources specialists), right of way agents, and public outreach staff. Communication with these groups will be established and maintained from the pre-planning phase of field work through complete execution to discuss unusual field observations and changes in scope which need to be made collaboratively while field work is in progress.

The Field Exploration Standards should be read in conjunction with the current versions of the following documents to maintain consistency and minimize repetition between related documents. These documents will be updated as necessary to reflect additional tasks and exploration methods authorized during the duration of the project.

- Exploration and Testing Work Procedures Overview,
- Pre-field Coordination and Permitting Standards,
- Laboratory Standards, and
- DCA Boring and CPT Logging Standards and Work Procedures.

1.1 Purpose and Scope

The purpose of these standards is to define procedures and daily workflow processes for the various field investigation methods for obtaining subsurface information for the DCP. In addition, contingency plans are included to provide a consistent response to unexpected conditions that may be encountered during exploration activities.

The currently approved DCP geotechnical field exploration program scope of work (Fugro Task Order # 0004) includes the following field activities:

- Performing soil borings and sampling soils,
- Conducting downhole testing including geophysical surveys (P-S logging),
- Performing field screening and gas monitoring,
- Managing and disposing of Investigation Derived Waste (IDW),
- Advancing seismic and conventional cone penetration tests (CPTs) and performing pore pressure dissipation tests,
- Collecting soil samples for environmental and geotechnical testing, and
- Performing surface geophysical surveys on Bouldin Island.

Other field activities that may be approved under future task orders include the following:

- Excavating test pits,
- Installation of piezometers,
- Installation of pumping wells,
- Performing borehole gas monitoring,
- Performing environmental sampling of groundwater from wells,
- Performing other downhole geophysical surveys (in addition to P-S logging) and in-situ testing and measurements,
- Performing surface and aerial geophysical surveys,
- Excavating fault investigation trenches,
- Performing aquifer pumping tests,
- Piezometer and well development,
- Groundwater level monitoring,
- Test pile driving, and
- Test embankment construction.

1.2 Project Related Documents

The following documents are referenced in or related to this report:

- Exploration and Testing Work Procedures Overview,
- Pre-Field Coordination and Permitting Standards,
- DCA Boring and CPT Logging Standards and Work Procedures,
- Laboratory Standards,
- Geotechnical Exploration Plan (GEP),
- Work Plan for Geophysical Test Program,
- Field Briefing Packets,
- Quality Management Plan for Geotechnical Exploration Program, and
- Health Safety Security and Environmental Management Plan.

Exploration team members will familiarize themselves with the project related documents listed above and all associated project requirements.

1.3 Exploration Team

The GC Exploration Team is responsible for the execution of the GEP for the DCP. Execution and documentation of the investigation will be in accordance with the QMP, HSSE plan, right of entry and Temporary Entry Permits (TEPs), permit requirements, biological and cultural requirements, and work instructions for individual field tasks. These documents will be provided in a Field Briefing Packet prepared for each parcel which is to be explored. Roles and responsibilities of the GC Exploration Team include the following:

- Exploration Team Leader
  - Coordinate the exploration program activities with team members,
  - Develop documents for program implementation,
  - Provide technical guidance and oversight in program execution,
  - Provide weekly progress reports, including task order costs and schedule to the GC Project Manager,
  - Provide program status and collected information to the GC Team,
  - Perform contract and subcontract administration and monitoring, and
  - Provide access to supplies for field teams.
- Exploration Inspector
  - Confirm no utility conflicts at exploration location,
  - Confirm safe conditions for operation and perform safety tailgate meeting,
  - Review site-specific Work Instructions with subcontractors,
  - Review and implement TEP/Right of Way (ROW) requirements,
  - Inspect and record exploration activities in accordance with DCA Soil and CPT Logging Standards and Work Procedures,
  - Record blow counts and/or push pressures during soil sampling (if applicable),
  - Record groundwater level and any fluctuations (if applicable),
  - Inspect drill cuttings and soil samples retrieved from the borehole,
  - Collect, package, and label soil samples (if applicable), in accordance with Work Instructions,
  - Inspect and classify soil samples per DCA Boring and CPT Logging Standards and Work Procedures and maintain a log of sampling information and sample descriptions,
  - Record any deviations from the GEP and Work Instructions,
  - Notify the ET Leader of exploration refusal or any unexpected conditions and ask for direction,
  - Inspect and record in-situ testing and measurement of in-situ properties and installation of instrumentation per Work Instructions,
  - Record disposal of excess cuttings in accordance with Work Instructions,
  - Prepare a daily field report (DFR) of exploration activities including start and set-up times, delays, issues encountered, progress, site visitors, and daily stop times, and
  - Transport soil samples to the Geotechnical Data Processing Center (GDPC) or other approved temporary storage facility.
- Field Runner
  - Collect soil samples and transport them to the Geotechnical Data Processing Center (GDPC),
  - Deliver field supplies to the Exploration Inspector as needed, and

- Relay messages between the ET Leader and Exploration Inspector if/when cellular service is unreliable.

1.4 Confidentiality and Public Relations

Given the high-profile nature of the project, a resident or other non-DCA parties may visit the site during the field exploration. Since field personnel represent the DCA, they should conduct themselves and their work in a professional manner, should be courteous, organized, systematic and in control of the field activities.

The field personnel should follow the communication protocol established for the project as outlined in Section 1.6 below. If appropriate, field staff should initially greet any visiting party and courteously verify a visitor's identity and relationship with the DCA. If DCA affiliated, field personnel should acquaint the visitor with the HSSE guidelines pertaining to the project. Individuals that have not received project-specific training and are not wearing the appropriate PPE should be excluded from entering the work zone. If the visitor is not affiliated with the DCA then follow the communication protocol below and provide them with either pre-prepared information or contact information for the DCA's public relations staff.

All field data collected for the DCP is to be kept confidential. Field personnel should not comment on subsurface conditions or share project information with site visitors unless authorized by the DCA. This will avoid future complications in client relations and interactions with other project team professionals.

1.5 Communication Protocol

Given the high-profile nature of the project, all GC field personnel should refrain from providing opinions, statements, or field data to members of the public or press. Should GC field personnel be approached by members of the public or the press with questions regarding the DCP or the work they are doing, they should be referred to the DCA field coordinator.

2. Onboarding and Training

2.1 Onboarding

All field staff must be on the list of approved personnel for the DCP to be on-site during the geotechnical field exploration program. All Exploration Team personnel will have completed project-specific training before they will be assigned to work in the field. Personnel new to the project should familiarize themselves with this document and the documents listed in the Project Related Documents section and have completed all required trainings. A record will be kept of all personnel present during all initial training sessions. Field staff who are not able to attend a live training session will complete the training by viewing a recorded session. Upon completion, a signed form indicating that the training session was watched and understood will be sent to the ET Lead to be entered into the training record. The training record will be reviewed prior to assigning personnel to field tasks to ensure the proper training has been completed. Access to any property will not be allowed unless applicable training has been completed.

2.2 Field Training

Table 2-1 below presents the training that will be available for ET field personnel, the party responsible for conducting the training, and the availability of the training.

Table 2-1. Field Training

Training	Responsible Party	Training Availability
Awareness Training (environmental, biological, and cultural resources)	DCA and DWR	Recorded Video (preferred) On-site by DCA Biologist (as needed)
HSSE Orientation and PPE Requirements	GC – HSSE Lead	Recorded Video
Communication Protocol	GC – ET Lead	Signed Form
Work Instructions	GC – TEMT/ET Lead	Document and Personal Discussion
Exploration Logging and Soil Classifications	GC – DPT Lead	Standards and Webinar/Recorded Video
Quality Control Measures to Preserve Field Data and Sample Integrity	GC – DPT Lead	Standards and Webinar/Recorded Video
Field Equipment Use, Calibration, and Operation	GC – ET Lead	Standards and Personal Discussion
Daily Field Report Documentation and Processing	GC – ET Lead	Standards and Personal Discussion

Training will be provided prior to the start of field work and as needed as new staff are onboarded to the project.

3. Field Planning

3.1 Field Briefing Packets

Field Briefing Packets will be prepared for each parcel which is to be explored. The package will include geotechnical and environmental work instructions for each exploration, TEPs, all other permits required for each exploration, utility clearance, access route maps, calibrations for equipment used, site restoration guidelines, and traffic control plans. Further description of the Field Briefing Packets and the responsibilities for who is preparing each portion is provided in the PCPT Standards.

In advance of field operations, the Field Briefing Packets will be reviewed by the ET Leader, the Exploration Inspectors, and the subcontractors, as necessary. The package is intended to provide the field staff with information and documentation needed to complete the field tasks; however, field personnel are encouraged to reach out to the ET Leader when questions or issues arise that are not addressed.

3.1.1 Geotechnical and Environmental Work Instructions

A summary of field activities to be conducted at each exploration location will be provided in the geotechnical work instructions prepared by the TEMT. The work instructions will include at a minimum the following information:

- Exploration type and dimensions;
- Geotechnical and environmental sampling types, depths, and intervals;
- In-situ testing to be performed;
- Down hole geophysical surveys to be completed;
- Any instrumentation to be installed; and

- Borehole completion.

3.1.2 Temporary Entry Permits

A TEP will be prepared by the ROW agents with the DCA and is required for each site on private property prior to any site entry. The TEP provides permission for field personnel to access the proposed exploration locations for non-construction services such as staging, parking, performing exploration for geotechnical and geological analyses, and sampling. At sites that require a court order for access, the court order document will be included as part of the TEP. The DCA field coordinator should be contacted with any questions, concerns, or disputes relating to site access.

The ET Lead will maintain controlled access of all personnel working at field sites including a log of personnel currently in the field and an appropriate check-in and check-out process for daily activities. The ET Lead will track the total days that are remaining for parcel access on each TEP and report it to the DCA field coordinator on a regular basis and if field work is anticipated to extend beyond the dates permitted by the TEP.

Site access to any property will not be allowed unless accompanied by a copy of the executed TEP.

3.1.3 Other Permits/Requirements

Other permits/requirements may be required for a given site to perform the exploration. Not all permits will be needed at each site. Permits may include but are not limited to the following:

3.1.3.1 Land Based Explorations

- Initial Study Mitigated Negative Declaration (ISMND).
- Encroachment (for explorations in state or county parks and roadways, or on levees of Local Maintaining Agencies).
- Central Valley Flood Protection Board (for explorations on State Plan of Flood Control levees).

3.1.3.2 Over-Water Explorations

- California Fish and Game Code Section 1600, Streambed Alteration Agreement.
- Central Valley Flood Protection Board Encroachment Permit.
- Letter of Concurrence from State Lands Commission.
- U.S. Army Corps of Engineers, Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, Nationwide Permit 6.
- Regional Water Quality Control Board Clean Water Act Section 401.
- Letter of Concurrence from U.S. Fish and Wildlife Service for federal species under the Endangered Species Act under their jurisdiction.
- Letter of Concurrence from National Oceanic and Atmospheric Agency Fisheries Unit for federal species under the Endangered Species Act under their jurisdiction.
- U.S. Coast Guard notification and anchorage permit.

Copies of all pertinent permits will be given to the ET Exploration Inspector and will be maintained at the work site during all field activities. Exploration work will not begin until all permits for a site are obtained.

3.1.4 Utility Clearance

Each exploration will be evaluated for overhead and underground utilities. Underground Service Alert (USA) North will be contacted a minimum of 2 working days, excluding the day of contact, prior to any subsurface investigation. A USA ticket that includes a ticket number, as well as clearance date, expiration date, call back to extend date, and utility contact numbers will be obtained for each work area and will be included in the work instruction package. The USA ticket will be maintained at the work site during all activities that penetrate the ground surface.

USA North member utility owners will mark the approximate locations of their underground utilities within the defined work area using paint and/or flagging. A private utility locator will also be employed to mark the locations of private utility lines within the work area. Proposed exploration locations will be adjusted by the PCPT team prior to mobilization of the field crew. As required by USA North, the upper 5 feet of all subsurface explorations will be hand excavated.

3.1.5 Access Routes

Access routes approved by the landowner will be included in the TEP contained in the Field Briefing Packets. All access routes should be strictly adhered to as directed by the DCA field coordinator. Access routes may require the construction of temporary access roads, which will be constructed prior to mobilization of the exploration crew. Temporary access roads will be removed upon completion of field explorations.

3.1.6 Traffic Control Plans

Traffic control plans will be prepared by the PCPT as part of State, county, or city encroachment permits. The ET Lead will provide the traffic control plans to the traffic control subcontractor and will coordinate scheduling. A copy of the approved encroachment permit and traffic control plans will be maintained at the work site at all times.

3.2 Exploration Supplies and Hand-Held Equipment

Exploration supplies will be provided for each field team. Field supplies are to be used exclusively for DCP and must be returned to ET team. Field staff are responsible for checking field supply lists prior to heading to the field and at the end of each work shift to ensure that no broken equipment or supplies are in use, and that all equipment and supplies are accounted for at the end of the daily work shift.

Required PPE is discussed in the HSSE Plan and includes DCA logo vests and hard hats. DCA logo vehicle magnets are also required for all vehicles used while engaged in DCP field tasks. DCA logo vests, hard hats, and magnets will be assigned to individual field staff and will be tracked to limit the numbers distributed.

3.3 Work Site Management

The field team shall carry out operations to minimize inconvenience to residences and businesses at or near the working area, as defined in the TEPs and Field Briefing Packets. In gaining access to and from exploration sites along roadways, the exploration team shall observe all applicable traffic regulations regarding the movement of their vehicles, equipment, and personnel. Vehicles shall travel on roadways only in the direction of normal traffic flow, and at no time shall they cross the traffic stream.

If approved in the TEP, exploration rigs and contained equipment may be left at the worksite overnight and on non-working days only when the exploration has been started but has not yet been completed. All other equipment, supplies, vehicles, and materials should be removed from the worksite at the end of the shift. The subcontractor shall not locate any rigs in a manner that will inhibit access by the public to public areas. Equipment stored during non-working hours shall be located so that it will not impede traffic flow or be a hazard to the traveling public, residence, or business.

3.4 Field Procedures

Various field procedures and techniques are to be used during this Geotechnical Field Exploration Program to collect field data, provide soil samples for geotechnical and environmental testing, and to conduct other field activities. Daily field procedures and techniques are outlined in the Attachments and include the following:

1) General Daily Workflow Guidelines,
2) Sample Handling and Storage Guidelines,
3) Borehole and CPT Backfill Guidelines,
4) Vibrating Wire Piezometer Installation Guidelines,
5) Test Well Installation Guidelines,
6) Standard Field Forms, and
7) Fact Sheets for Geotechnical Exploration Program.

3.5 Locating Explorations

Exploration locations will be marked in the field by the PCPT prior to mobilization of the field crew using a handheld GPS device with sub-meter accuracy. Upon arrival of the field crew an assessment will be made to determine if the exploration can be performed at the marked location. If the exploration needs to be moved due to biological or other reasons, the new exploration location will be approximately measured from the marked location and noted in the daily field report. Also, a handheld GPS device with a 5-meter accuracy (such as cell phone or similar) will be used to approximately measure the new location.

3.6 Termination and Backfill of Boreholes and CPTs

All boring and CPT explorations shall extend to the proposed exploration depth as per the approved GEP. If poor soil conditions (e.g., unconsolidated fill, organic materials, soft, fine-grained soils, or loose cohesionless materials) are encountered at or near the proposed termination depth, the ET Lead should be contacted before termination. The ET Lead will discuss the soil conditions encountered with the TEMT and/or the EDM to decide whether or not to deepen the exploration before being terminated.

Boreholes shall not be terminated before reaching the final depth proposed unless approved by the ET Lead, or designated representative. CPT probes may be terminated if refusal is reached or an obstruction is encountered at a depth shallower than the proposed depth.

Explorations terminated before reaching the required depth, due to an obstruction or other reasonable cause not permitting completion by standard procedures, may be replaced by a supplementary exploration of the same type adjacent to the location of the original and advanced to the required depth. However, penetration to the termination depth of the original exploration may be made without sampling, utilizing any approved and permitted drilling method selected by the subcontractor and approved by the ET Lead. Samples and/or readings shall be taken from the supplementary exploration from the elevation at which the original exploration was terminated in the manner specified by the exploration work instructions.

Upon reaching final exploration depths, the boreholes and CPT holes are to be backfilled in accordance with State Well Standards as discussed in Attachment 3. Following grouting, the top of the exploration will be resurfaced in accordance with access agreements and TEP requirements.

3.7 Investigation Derived Waste (IDW) Management

Hazardous substances are not anticipated to be encountered during subsurface explorations. However, precautions will be taken to minimize health risks and identify potentially contaminated soil and groundwater using field screening methods and equipment such as noting unusual odors or staining, and using a portable photo-ionization detector (PID), combustible gas meter, and pH testing kits, as deemed appropriate.

Soil cuttings, drilling mud, and excess grouting materials, often referred to as Investigation Derived Waste (IDW), will be containerized in either steel drums or roll off bins at the subsurface exploration site. All drums are to be labeled to show date filled, contents, project name and location, and the name and phone number of the field manager. An inventory of drums and/or roll off bins for each parcel will be prepared. IDW will be left on site until completion of the exploration unless access agreement requirements or site conditions require removal sooner.

Upon completion of the exploration, the contents of the drums and/or roll off bins will be tested for contaminants and then transported to a suitable disposal site. The IDW will be transported under either a non-hazardous waste manifest or hazardous waste manifest depending on the waste characterization. For selected properties, if required by the TEPs, drums will be removed to a temporary holding facility offsite until testing for waste characterization and disposal can be completed. Field screening of the IDW may be conducted prior to transport to either temporary holding facilities or permanent disposal sites. IDW field screening may include the use of methods and equipment listed above, with liquid wastes primarily screened for pH; liquid IDW with a pH of 2 or less, or 12.5 and greater are considered corrosive characteristic hazardous wastes, and must be handled, transported, and disposed of as hazardous waste. A waste disposal subcontractor will handle the testing and disposal of all IDW.

4. Field Exploration Methods

4.1 Cone Penetration Tests

4.1.1 Cone Penetration Test Method Overview

CPT soundings will be performed using a truck- or track-mounted, 20- to 30-ton CPT rig in general accordance with ASTM D 5778. The ton designation refers to the push capacity. Typical CPT operation includes using a truck-mounted CPT rig. For rough terrain or where low, tire-pressure access is required owing to site conditions, a lighter, track-mounted rig may be needed. However, lighter equipment will probably be inadequate to advance to depths greater than 100 feet.

A conventional instrumented cone assembly includes a cone tip with a 60-degree apex and a base area of 15 square centimeters (cm^2), a sleeve segment with a surface area of 200 cm^2, and a pore-pressure transducer above the cone tip. During testing, the instrumented cone is hydraulically pushed into the ground at a rate of about 2 centimeters per second (cm/s). Cone tip resistance, sleeve friction and pore pressure are digitally recorded every second. As the cone tip advances, additional cone rods are added so a "string" of rods advances through the soil continuously. The cone and sleeve resistance data are corrected for overburden stress and pore pressure, and corrected values are used to correlate to soil behavior type and derive geotechnical parameters, such as undrained shear strength of clay, friction angle of sands, and equivalent SPT N-values.

Based on past experience, CPTs may not be able to achieve the desired target depth of 200 feet at all locations. This can be for a variety of reasons, including high rod friction, high tip resistance, and/or excessive deflection of the rods due to low lateral resistance in the upper soils. A CPT test program will be conducted at up to four locations during the FY20/21 exploration program to determine the efficacy of a Fugro proprietary bentonite injection system where early refusal is encountered using conventional CPT procedures. Depending on the results of the test program, bentonite injection may be used at selected locations to achieve the final CPT depth where refusal due to excessive rod friction is expected to be encountered. At locations where very soft soils are known to be present in the near surface, casing will be advanced to provide lateral support of the CPT rod and thereby reduce rod deflection.

The ET Exploration Inspector will obtain a copy of the field (uncorrected) CPT data from the CPT contractor immediately after completion of the sounding which will be submitted to the DPT. The field CPT data will be processed by the DPT staff to create the CPT logs.

Additional information regarding the field activities associated with cone penetration testing can be found in the fact sheets included in Attachment 7.

4.1.2 Pore Pressure Dissipation Tests

Dissipation tests will be conducted in accordance with ASTM D 5778 to determine pore pressure dissipation of the soil. The dissipation test is generally performed in more pervious layers (predominantly coarse-grained and non-plastic silt layers) to evaluate the piezometric surface of the groundwater and in less pervious layers (predominantly fine-grained soils) to evaluate consolidation characteristics. Dissipation tests can provide an indication of static pore pressure at test depth and the height of the groundwater column above the CPT tip. The dissipation test in a less pervious layer measures the rate of decay of the large excess pore water pressures generated during penetration of the piezocone through saturated fine-grained soils. Dissipation tests in non-pervious layers can also provide information on time-dependent consolidation parameter (coefficient of consolidation).

4.1.3 Seismic CPTs

Seismic CPTs (SCPT) may be used to obtain downhole seismic shear wave velocity measurements at approximately 10-foot intervals. A seismic cone assembly is like a conventional cone assembly, but also includes a three-component array of geophones. A horizontal shear wave is induced in the ground by striking a steel beam at the surface with a hammer. The first arrivals of the shear wave can be evaluated to determine the shear wave velocity profile with depth.

4.1.4 Calibration of CPT Equipment

CPT equipment shall be calibrated according to ASTM D 5778 or ISO 22476-1:2012 and must have been conducted within the previous 12 months or 3,000 meters of sounding prior to the use of the cone penetrometer. The calibration certificate shall include calibration results of the load cells, pore pressure transducer and the inclinometer. Certificates shall be contained in the field briefing packet and provided to the DCA to confirm that the cone penetrometer calibration is current for the duration of its use.

4.2 Soil Drilling and Sampling

4.2.1 Drilling Methods

4.2.1.1 Mud Rotary Wash Drilling

Mud rotary wash borings may be advanced using continuous soil coring methods using either the 134 mm GeoBarrel or Geobor-S systems. These systems involve triple tube wireline drilling, which has been specially developed for core drilling and undisturbed sampling in a wide variety of soil and rock formations. Drilling fluid consisting of water and bentonite is introduced into the drill hole and circulates to the surface through the annulus between the borehole wall and the core barrel. Drilling fluid discharges from a collar into a tub, allowing cuttings to settle and separate from drill fluid. Drill fluid is then re-circulated down the borehole. Additional drill fluid is introduced as the borehole gets deeper and to replace fluids lost to the formation. The drilling fluid reduces friction, cools the coring bit and returns drill cuttings to the surface. As the hole advances, casing may be installed to reduce fluid loss to the formation, to seal off artesian flow conditions, and/or to stabilize an unstable hole. The 134 mm GeoBarrel produces PQ size core measuring approximately 85 mm in diameter while the Geobor-S produces S size core, or 102 mm in diameter. Larger diameters enhance drilling performance while obtaining high-quality core samples compared to smaller diameter systems. This system will likely be used for the deeper borings (200 to 500 feet) to collect continuous samples throughout the potential tunnel horizon and because of the higher production rates than in conventional rotary wash methods at depth; however, it requires more equipment and is a more labor intensive operation than conventional rotary wash drilling.

Shallower borings (less than 200 feet) will likely be advanced using more conventional rotary wash methods. In this method, drilling is achieved by the rotation of a drill bit which is mounted at the end of a drill pipe string. The drill bit cuts the soil into small pieces which are removed by pumping drilling fluid (typically water with bentonite or other additives) down through the drill pipe and the drill bit. As with the GeoBarrel and Geobor-S systems, the drilling fluid then circulates to the surface through the annulus between the borehole and drill pipe carrying the soil cuttings. Drilling fluid discharges from a collar into a tub, allowing cuttings to settle and separate from drill fluid. Drill fluid is then re-circulated down the boring. Additional drill fluid is introduced as the borehole gets deeper and to replace fluids lost to the formation. The drilling fluid reduces friction and cools the drill bit. Soil cuttings in the return fluid provide an indication of the type of soil being excavated but is not as reliable as obtaining a sample or continuous soil core.

Sampling approaches and techniques are discussed in section 4.2.2 below. Additional information regarding the field activities associated with mud rotary wash drilling can be found in the fact sheets included in Attachment 7.

4.2.1.2 Hollow Stem Auger Drilling

Hollow stem auger drilling is conducted by simultaneously turning and providing down force on the augers. As the augers rotate into the ground, the soil cuttings are lifted to the surface. Each auger flight is 5 feet long, and successive auger lengths are bolted together as the boring progresses. A center plug is used to prevent soils from filling the hollow stem of the augers and is removed during sampling. Upon removal of the plug, soil sampling tools can be attached to a drill string that passes through the hollow inner diameter of the augers.

Since mud rotary wash drilling methods obscure the groundwater level, selected borings may be started using hollow stem auger techniques and converted to mud rotary wash once the groundwater level is measured. Additionally, hollow stem auger drilling will be used when drilling through or adjacent to a levee to a depth of at least 10 feet below the landside toe of the levee. The hollow stem augers will then be removed and replaced with conductor casing that matches the outside diameter of the hollow stem augers. Once the conductor casing is installed, mud rotary wash drilling methods may be used to advance the borehole.

4.2.2 Sampling

While drilling with hollow-stem augers, sampling will proceed through the hollow-stem augers in advance of the auger. The soil samples are collected in hollow samplers that are pounded into the ground by a mechanized hammer attached to the drill rig or are pushed using the hydraulics of the drill rig.

While utilizing rotary wash methods, samplers will be lowered through the drilling fluid on drill rods to the bottom of the hole. Split-barrel samplers, which require a hammer blow to penetrate the soils, are attached to a drill string for both conventional rotary wash and for GeoBarrel and Geobor-S drilling. Thin-walled samplers can be attached to a wireline for GeoBarrel and Geobor-S and pushed using the hydraulics of the drill rig.

Continuous soil coring using 134 mm GeoBarrel or Geobor-S will be used for borings intended to provide stratigraphy and geotechnical design parameters for tunnel reaches and for shafts. This provides an opportunity to observe the entire soil profile. Discrete soil samples at 5- to 10-foot depth increments may be collected for both the GeoBarrel and Geobor-S borings as well as for the conventional rotary wash borings. These are obtained using a combination of SPT, thick-walled split-barrel samplers and thin-walled samplers.

4.2.2.1 Split-Barrel Sampling

Different types of split-barrel samplers may be used, depending on the soil conditions encountered. The specific types are described below. The sampler is attached to NWJ (2-5/8 inch-diameter) drill rods and advanced using a 140-pound automatic hammer with a 30-inch drop. The sampler is driven 18-inches and the number of blows required to advance the sampler, typically in 6-inch increments, are noted on the boring logs. If significant gravel layers are encountered, the number of blows to advance the sampler in 1-inch increments will be recorded.

Standard Penetration Test (SPT)

Standard penetration tests will be conducted in accordance with ASTM D1586 using an unlined 18- or 24-inch long, 2-inch outside diameter (OD), 1-3/8-inch constant inside diameter (ID) split-barrel sampler (SPT sampler). SPT samplers that have room for liners (1.5-inch ID) should not be used. Samples will be collected from the sampler and placed in glass jars with lids, labeled with permanent ink, and stored for transport to the Geotechnical Data Processing Center (GDPC). Sample handling and transport is described in Attachment 2.

Thick Wall Split-Barrel Sampler

Samples will also be collected in a thick wall, lined, 18-inch long, 3.0-inch OD, 2.5-inch ID split-barrel sampler. The liners are either 6-inch long brass or stainless-steel tubes. The split-barrel sampler is attached to a slough barrel so that slough at the bottom of the drill hole does not compress the sample during sampling. Split-barrel sampling will be performed in general accordance with ASTM D1586 and ASTM D3550. Samples from the lined sampler will be capped with plastic caps, the caps taped, labeled with permanent ink, and stored for transport to the GDPC. Sample handling and transport is described in Attachment 2.

4.2.2.2 Thin-Walled Sampling

A thin-walled sampler will be used to obtain relatively undisturbed samples of cohesive soils for laboratory strength and consolidation testing. Thin walled sample tube collection will be in accordance with ASTM D1587. Different types of samplers will be used depending on the soil conditions encountered. A hydraulic piston sampler, such as an Osterberg sampler, Gregory Undisturbed Sampler (GUS), or Dames and Moore Sampler, will be used primarily in soft soil deposits to minimize sample disturbance. Samples will be collected using either 3-inch OD Shelby tubes or 2.5-inch OD Dames and Moore thin-wall tubes. A Shelby tube may be pushed with the hydraulics of the rig in stiff soil deposits, where sample recovery is limited using the piston sampler. When primarily hard soil deposits are encountered, the rotary Pitcher barrel sampler may be used. Samples will be labeled and handled in accordance with ASTM D4220 and ASTM D1587. Samples will be kept out of direct sunlight and placed in a custom Shelby tube carrier. The entire sample carrier will be secured with rope or cable to the body of the transporting vehicle for delivery to a temperature-controlled area at the GDPC. Sample handling and transport is described in Attachment 2.

4.2.2.3 134 mm GeoBarrel or Geobor-S Coring

Core sampling will consist of triple tube wire-line coring systems with core runs up to 5 feet long. The 134 mm GeoBarrel produces PQ size core measuring approximately 85 mm while the Geobor-S produces S size core, or 102 mm. In between core runs, the samplers mentioned previously can be taken from within the drill casing. Where other samplers are used, the core run will be advanced through the split-spoon or thin-walled sample interval and then recover the remaining 3 to 3.5 feet of a 5-foot drilling run. Cored soil samples will be retrieved and extruded onto a logging tray (134 mm Geobarrel) or retrieved in clear plastic liners (Geobor-S). After logging, core samples will be retained in core boxes for transport to the GDPC. Sample handling and transport is described in Attachment 2.

4.2.2.4 Pitcher Barrel Sampler

A Pitcher Barrel Sampler may be used with conventional mud rotary wash methods and with the 134 mm GeoBarrel to collect undisturbed samples of hard clays within a 3” OD Shelby tube if soils cannot be sampled with thin-walled sampling techniques. The Geobor-S system does not need a Pitcher Barrel sampler because the cores are contained within clear plastic liners.

4.2.2.5 Calibration of Hammer Energy

The hammer used to collect SPT samples shall be calibrated according to ASTM Standards including ASTM D1586, ASTM D4633 and ASTM D6066, and must have been conducted within the previous 12 months prior to the use of the hammer assembly. The SPT energy calibration shall be included in the field briefing packet and provided to the DCA to confirm that the calibration is current for the duration of the drilling program.

4.2.2.6 Sampling Interval

Soil sampling using either SPT, split-barrel or thin-walled sampling techniques will typically occur approximately every 5 feet from the ground surface to the final depth of the boring. The sampling interval may be extended to 10 feet in soil zones that are not considered to be of primary importance to the alternatives evaluation or geotechnical design of the DCP. Within specified zones, sampling will be continuous using core sampling techniques along with discrete split-spoon or thin-walled sampling at 5- or 10-foot intervals.

Sampling intervals will be included in the specific work instructions for each boring location to be included in the Field Briefing Packets to be distributed to the Exploration Team prior to mobilization to the site.

4.2.2.7 Environmental Sampling

Environmental samples will be collected from depths between approximately 0 to 10 feet and 100 to 160 feet. The shallow samples will be collected from various locations across the Delta including where ground disturbing activities are planned, and deeper samples are to be collected in zones associated with potential tunneling. The purpose of environmental sampling and testing is to identify levels of naturally occurring constituents and potential contaminants in soil and groundwater.

Samples for environmental chemical testing will be collected and preserved in accordance with industry standard methods used to preserve the integrity and quality of samples slated for environmental testing. Samples will be collected concurrent with geotechnical samples. Sample barrels will be brushed and cleaned with water and an anionic soap solution, followed by a clean water rinse to minimize cross-contamination between sample depths.

A baggie sample of the sampler shoe contents will be collected from each environmental sample depth to allow observation by an environmental professional of any noticeable odors, and obvious discoloration or chemical impact. The baggie sample will then be allowed to come to vapor pressure equilibrium and then the baggie headspace will be checked with a PID to check for any observable volatile organic compound concentrations.

Samples from the sample barrel at the required sample depths will be collected and preserved in discrete, pre-cleaned containers, which will be capped or closed, and be maintained in an ice-filled chest or refrigerator pending transfer under chain of custody to a California certified environmental testing laboratory.

4.3 Rock Coring

Drilling in rock is a similar process to mud rotary wash drilling using continuous core soil sampling methods. Generally, soil boring methods are used in the overburden soils and decomposed/soft rock conditions until recoverable rock material is encountered. Depending on the purpose of the exploration and the type of information required, soil boring methods may continue until refusal on resistant rock. Once rock is encountered, the soil drilling tooling is replaced with rock coring tooling that may include a diamond encrusted or carbide tipped core bit. The type of core bit used is dependent on the rock conditions encountered and is determined in the field by an experienced rock core driller. Drilling mud is flushed through the drill stem to cool the core bit and to flush cuttings to the surface.

Rock core samples are collected using a triple tube system and brought to the surface with a wireline. The rock core will be extruded from the core barrel on to an examination tray for inspection by the geologist. HQ size (2.5-inch diameter) rock cores will be collected in 5-foot runs and stored in 5-foot long core boxes. The rock will be logged in accordance with the rock logging standards described in the Boring and CPT Logging Standards.

4.4 In-Situ Borehole Testing

In-situ testing in boreholes may include P-S suspension logging, field vane shear tests, pressuremeter tests, and packer tests. These methods are described below. All data collected from in-situ borehole testing will be transmitted to the DCA for review.

4.4.1 P-S Logging

The P-S suspension logging method is used to determine the compression (P) and shear (S) wave velocities within a fluid-filled borehole. The information from P-S logging is used to determine low-strain shear modulus and Poisson's ratio of soils and provides geotechnical parameters required for site response analysis.

The method typically uses a 7-meter-long probe that uses a downhole pressure wave energy source and two geophone receivers spaced 1 meter apart. Armored four conductor cable is used to lower the tool into the borehole and is connected to a data recording system located at the ground surface. The high-energy hammer generates the pressure wave in the borehole fluid. Seismic waves (P & S) transmit along the borehole wall and are received at each geophone location which is then transmitted through the cable to the data recording system.

P-S logging will be performed in borings drilled by mud rotary wash methods as it will provide a fluid-filled hole of appropriate size. The borehole diameter should be determined based on the subcontractor's equipment. P-S logging may be widely distributed across the Delta, especially within gaps in existing shear wave velocity data, to understand regional variations in subsurface stratigraphy.

4.4.2 Field Vane Shear Testing

Vane Shear Tests (VSTs) will be performed to measure the peak and remolded undrained shear strength of fine-grained materials. Vane shear equipment typically consists of a rectangular vane mounted to a rod system. The size of the vane is selected based on the anticipated undrained shear strength of the material. The vane is advanced by pushing a protective housing through the soil, and then extending the vane outside the housing about 18 inches prior to performing the shear test. The vane is rotated from the surface by a motorized assembly at a rate of 6 degrees rotation per minute. Peak strength is typically obtained within 2 to 5 minutes but may take as long as 20 minutes for certain soil types. Data are collected electronically using a mechanical chuck/torque transducer mounted on the drive head that measures torsion between the drive assembly and the drill rig clamp. Data will be monitored using a laptop computer with readings recorded at one-second intervals (1 Hz).

4.4.3 Pressuremeter Testing

Pressuremeter testing will be conducted in the field within selected boreholes in general accordance with ASTM D4719-07. ASTM D4719-07 was withdrawn from the ASTM Standards in 2016, and a replacement standard has not been published. A pressuremeter consists of a probe with a flexible membrane placed over a series of sensors. At selected depths during drilling, or upon completion of the borehole, pressuremeter tests will be conducted by lowering a pressuremeter with a cable. The flexible membrane is then pressurized with air and deforms the sidewalls of the borehole. The sensors measure the pressure within the probe and displacement of the membrane. The data is transmitted to a data acquisition system at the ground surface.

Tests consist of a series of unload-reload cycles (loops) developed by inflating and deflating the membrane until the material displays peak strain. The unload-reload loops will be used to evaluate the soil's elastic and plastic behavior. Real time monitoring of test results ensure proper inflation of the membrane and allow the experienced professional to confirm contact with the borehole wall. The quality of the test results is assessed in the field and is used to inform the driller to adjust methods as necessary. Upon completion of the test, the probe will be removed from the borehole.

4.4.4 Packer Testing

In-situ hydraulic conductivity testing (packer testing) will be conducted in the field by pressurizing water within isolated sections of the soil or rock borehole. A hydraulic, wireline packer system will be used for testing.

During drilling (single packer) or upon completion of drilling (single or straddle packer) in selected borings, the test conditions will be established from consideration of the soil or rock conditions and in-situ groundwater pressures. The in-situ groundwater pressures for each test interval will be estimated from either the initial depth where groundwater was encountered during drilling or measurements of stabilized drill fluid levels during drilling. The drill crew will purge drill cuttings from the hole by flushing the borehole with clean water. The drill crew will then remove the specified amount of drill rod to expose the test interval. The drill will deploy the packer testing system and collect and store water on-site as needed to perform testing. The GC Exploration Inspector on-site will make necessary measurements of the configuration, control the test pressures (stages), and record test data. Upon completion of testing, the drill crew will extract the packer test system from the borehole and advance to the next test interval.

During each test stage, clean water will be pumped into the test interval at a constant pressure. The downhole pressure will be estimated using a pressure gauge at the surface, which records real time pressure, and a pressure transducer within the test section, which can be retrieved upon extraction of the packer assembly.

4.5 In-Situ Well Testing

In-situ testing in wells is not currently planned. If performed at a later date, testing may include pumping or aquifer tests and slug tests. These methods are described below. All data collected from in-situ well testing will be transmitted to the DCA for review.

4.5.1 Pumping Tests

Selected borings may be converted to pumping wells. In some instances, a new hole will be drilled for the pumping well. The borehole diameter will be a minimum of two inches larger than the well casing diameter. The pumping well casing diameter will vary from 8 to 12 inches. Design of the pumping well, including casing depth and size will take into consideration the presence of laterally discontinuous freshwater and brackish water zones, taking care not to deplete the freshwater zones being used by the landowner. Casing slot size and filter pack material will be designed based on the gradation of the soils at the screen interval. Centralizers will be installed on the casing. A sanitary seal of bentonite pellets will be placed above the filter pack. The remaining borehole will be backfilled with cement bentonite grout with up to 5 percent bentonite by weight.

Generally, there will be two types of pumping tests: a step drawdown test and a constant rate test. The step drawdown test is used to determine the sustainable pumping rate for the constant rate test and to estimate well losses. These include recording data during pumping and recovery. Detailed pumping test procedures will be developed for each test location and will be submitted for review and approval to the DCA and DCO.

4.5.2 Slug Tests

Slug tests may be performed at selected standpipe piezometer locations. The term “slug test” is used to describe a rising- or falling-head aquifer test in a single monitoring well or piezometer to determine in-situ hydraulic conductivity. A falling-head slug test involves recording the drop in water level in a well after a rapid rise in water level caused by the rapid insertion of a solid cylinder (the slug). A rising-head test records the increase in water level following the rapid removal of the slug from the well. The rate of water level recovery (rising or falling) is a function of the hydraulic conductivity of the soil in the immediate vicinity of the well screen.

Groundwater measurements during a slug test will be recorded by a pressure transducer that is lowered into the well in a small diameter slotted casing before testing to ensure that water levels in the piezometer have returned to equilibrium. The pressure transducer can be set to record data in a stepped interval with a short interval at the beginning of the test and a longer interval as the water level changes less rapidly. A slug test plan will be developed by the GC and approved by the DCA and DCO for each location tested and will be based on the soils encountered at the screened zone of the piezometer.

4.6 Groundwater Measurements

Groundwater is anticipated to be encountered at relatively shallow depths throughout the Delta. Depth to groundwater will be measured using a variety of methods over the duration of the project including direct measurements during and after drilling, pore pressure dissipation tests in CPTs, measurements in standpipe piezometers, and measurements from vibrating wire piezometers. These methods are discussed below.

4.6.1 During and After Drilling

Most borings will be initially drilled using hollow stem auger methods until groundwater is encountered. The initial depth to groundwater will be measured by the ET supervisor and noted on the field logs. In borings that switch to a mud rotary wash drilling method, the initial depth to groundwater will be the only measurement taken. In borings that extend to the target depth using hollow stem augers, the depth to groundwater will be measured upon reaching the target depth and will be recorded on the field logs.

4.6.2 Pore Pressure Dissipation Tests

Depth to groundwater will be estimated using pore pressure dissipation tests during CPT soundings as described in Section 4.1.2 above.

4.6.3 Standpipe Piezometers

Standpipe piezometers can be installed to measure the piezometric water level at selected locations and depths. The installation of the piezometer will be defined in the GEP. The standpipe piezometer typically consists of a well screen (2-inch Schedule 40 PVC with 0.20-inch slotted screen) and a riser pipe (2- to 4-inch Schedule 40 PVC pipe) that is installed in a borehole. The zone around the well screen is backfilled with sand and a bentonite seal is placed above that to isolate the measurement zone. The remainder of the borehole is backfilled with a cement bentonite grout. The top of the riser pipe is fitted with a locking, water resistant well cap and a secure cover encased in concrete is installed flush with the ground surface of the boring.

Wells are to be developed following California DWR Bulletins 74-81 and 74-90. Acceptable methods of development include mechanical surging, over-pumping and pump surging, air development, and water jetting. Care shall be taken during development so that no damage to the well structure or to the natural barriers to the movement of groundwater occurs.

Following completion of the standpipe piezometer, pore water flows into the standpipe until a pressure equilibrium is reached. The water level in the pipe then represents the pore-water pressure in the soil around the measurement zone. A pressure transducer will be installed in the standpipe piezometer and set to record depth to groundwater at a set interval. Monitoring will occur on a regular basis to be determined prior to installation of the pressure transducer.

4.6.4 Vibrating Wire Piezometers

Vibrating wire piezometers (VWP) can be installed to measure in-situ water pressures using pressure transducers. Multiple nested vibrating wire piezometers may be installed in a single borehole at depths defined in the GEP. The transducers measure water pressure at the depth of installation within the borehole. Installation of the vibrating wire piezometers will use the grouted-in-installation method of permanent installation summarized in Attachment 4. Because the instruments are grouted in, the installations will be part of the borehole backfilling process which will occur following the conclusion of any in-situ downhole testing. The backfilling procedure includes grouting each of the boreholes with a cement-bentonite grout mixture to close off hydraulic communication between different levels within each of the boreholes.

Each instrument shall be factory and field calibrated before being grouted into place from bottom up. The instruments will be calibrated in the factory before shipping, and prior to installation in the borehole. The field calibration is performed according to the manufacturers' specifications in the instruction manual, which involves submerging the instrument in water for fifteen minutes and taking a "zero" reading. The wires connecting to each instrument will also be color-coded for easy maintenance and identification.

The pressure transducers will be installed separately at a designated elevation by positioning a prefabricated string of transducers and tremie pipe that is suspended in the open borehole. The string of transducers will be assembled in the field by the drilling subcontractor. Each transducer will be tested for proper operation prior to being lowered into the open hole. Once positioned in the hole at selected depths, the entire instrument string will be grouted into place with a cement-bentonite grout mix. The grout mix ratio will consist of approximately 94 pounds of Portland cement, 25 pounds Quick-Gel bentonite and 35 gallons of water. For VWPs, this grout mix may be used to backfill the entire borehole.

The groundwater monitoring data consist of the following information recorded by the pressure transducers:

- Transducer designation and wire color,
- Date and time,
- Battery power,
- Temperature,
- Pressure reading, and

- Temperature reading.

The field calibration data required for reduction include:

- Transducer designation,
- Surface elevation of well,
- Wire color,
- Serial number of sensor,
- Wire length,
- Gauge factor,
- Field readout,
- Sensor depth, and
- Sensor elevation.

The field calibration data for the vibrating wire transducers will be recorded according to the manufacturer's instruction manual. Ultimately, the information of interest is the formational fluid pressure, which can be interpreted as the hydrostatic pressure exerted by an overlying column of water, and the location of the groundwater table.

Groundwater monitoring will help to establish the degree of connectivity within the groundwater system and seasonal variations (i.e. rainy season, prolonged drought, withdrawal from local wells etc.) with respect to hydraulic head being measured by the transducers. Measured variations in water pressure measured by the transducers will reflect the equivalent variations in groundwater levels at each of the transducers. The transducers can be manually read or connected to a datalogger programmed to record at a set interval. The dataloggers will be accessed, the stored data retrieved, and the batteries replaced regularly. The actual monitoring schedule will be developed and implemented per the GEP. Dedicated data logging equipment would be installed in a recessed utility vault, flush mounted with the ground surface at each borehole.

4.7 Test Pits and Trenches

4.7.1 Test Pits

Test pits are temporary excavations that are used to observe the near surface soil conditions and collect bulk soil samples. Test pits are generally excavated, inspected, and backfilled on the same day because they are not supported by shoring. Trenches are excavations that are shored and may be kept open for up to several months to observe subsurface geologic features such as faults. Test pits may be excavated in areas of surface installations. The procedure generally consists of removal and stockpiling of the topsoil using a backhoe or excavator equipped with a minimum 24-inch wide bucket. The remainder of the test pit soil is kept separate from the topsoil and the excavation is deepened to an initial depth of less than 5 feet. There will be no entry of an unprotected test pit that is 5 feet in depth or greater. The end of the excavation should be sloped for entry/exit or a ladder should be lowered into the test pit. In addition, a Competent Person, as defined in Cal OSHA regulations, must inspect the test pit to ensure its safety and stability. Heavy equipment and surcharge loads must be kept at least 2 feet away from the excavation and the air must be tested with a gas meter to ensure healthy levels of oxygen and the absence of toxic gases.

After the test pit is approved by the competent person, the test pit may be entered to observe the soil conditions on the sidewalls and the bottom of the excavation.

The wall of the test pit may be smeared with soil from the bottom of the excavation and must be cleaned, using a geologic hammer/pick, or other tool prior to logging. A log of one of the test pit walls will be prepared in accordance with the Boring and CPT Logging Standards and Work Procedures. The dimensions and orientation of the trench, and the trench wall that is logged will be noted on the field log. Bulk samples may be collected in burlap or plastic sacks and sample jars.

If required, the test pit may be deepened beyond 5 feet, however, logging of soils will be completed by observing and sampling excavated soils rather than entering the test pit. Upon completion the test pit will be backfilled in reverse order with the excavated soil, placing the topsoil at the top. Backfilled soils will be compacted using a sheepsfoot compaction wheel.

4.7.2 Trenches

Prior to excavation of exploratory trenches, a Cal OSHA Annual Excavation Permit must be secured, and Cal OSHA must be notified of the dates of the planned excavation. In addition, shoring must be designed by a qualified engineer. Exploratory trenches are generally excavated with a backhoe or excavator equipped with a 2-foot wide bucket and may extend to depths of 15 feet or greater. Shoring should be placed as trenching progresses in accordance with the shoring design. Entry/exit ladders should be provided at the ends of the trench and then every 50 feet so that a ladder is present within 25 feet of any given point within the trench. Ladders should extend 3 feet above the trench and be tied off at the surface. In addition, a competent person must inspect the trench to ensure its safety and stability. Trench safety inspections should be conducted at the beginning of each shift and after a rainstorm. Heavy equipment and surcharge loads must be kept at least 2 feet away from the excavation and the air must be tested with a gas meter to ensure healthy levels of oxygen and the absence of toxic gases. The trench may be entered only after it is approved by the Competent Person.

The walls of the trench may be smeared with soil from lower layers and must be cleaned, using a geologic hammer/pick, or other tool prior to logging. A log of one or both of the trench walls will be prepared in accordance with the Boring and CPT Logging Standards and Work Procedures and following generally accepted standards for logging geologic features. The dimensions and orientation of the trench, and the trench walls that are logged will be noted on the field log. Bulk samples may be collected in burlap or plastic sacks and sample jars.

At the end of each shift trenches will be completely covered with plywood and secured with temporary fencing capable of keeping wildlife out. Upon completion the trench will be backfilled in reverse order with the excavated soil, placing the topsoil at the top and removing shoring as backfill progresses. Backfilled soils will be compacted using a sheepsfoot compaction wheel.

5. Health and Safety

5.1 Health Safety Security and Environmental Management Plan

A health, safety, security and environmental management plan (HSSE) has been prepared by the HSSE Team and will be provided to each field team and should be maintained at the jobsite during all work hours. The HSSE Plan will include emergency response plans specific to an exploration site or area (such as an island with one entry/exit route). Potential hazards for the work location and type of work to be completed will be identified in the HSSE, along with mitigation measures to lower the risk of harm to individuals on site.

All field personnel, including geologists, engineers, loggers, technicians, environmental monitors, and drill crews, should be familiar with the HSSE Plan, as well as any additional requirements of the project or governing agency. Safety is the responsibility of all field personnel on each investigation team.

5.2 Daily Safety Meeting

Tailgate safety meetings are to be conducted daily by the ET Exploration Inspectors with all on-site personnel, including subcontractors, DCA representatives, DCO representatives, and biological and cultural monitors. The daily meeting should be held immediately upon arrival at the jobsite, prior to the commencement of any work. During the meeting, the work to be completed that day should be discussed along with the potential hazards of the day's work. Participants in the daily safety meeting are encouraged to speak up freely and to point out potential safety hazards and discuss steps to be taken to reduce the risk of personal harm. All participants in the daily safety meeting will sign a form indicating their participation in the meeting. Any visitors to the site will also be required to review safety with the Exploration Inspector and sign the daily safety meeting form.

5.3 Monthly All Hands Safety Meeting

At the commencement of each season of field work, and at least once a month during the field season an all hands safety meeting is to be held. The meeting should include all field personnel that may be working that month, including backup field staff and subcontractors as available. The monthly meeting will be directed by the Project Health and Safety lead or the Exploration Team lead and will focus on lessons learned from the previous month of field work.

5.4 Changed Conditions

As conditions change in the field, such as weather, traffic, personnel changes, etc. brief discussions on hazards imposed by those changes should be conducted and recorded on the daily safety meeting form. New workers or visitors to a worksite should be briefed on the information contained in the HSSE.

5.5 Incident Reporting

Reporting of an incident should take place as soon as it is safe to do so. In the case of a medical emergency, emergency services should be contacted first as outlined in the HSSE. All emergencies and lesser incidents should be called into the Exploration Team lead and the field personnel's direct supervisor. Incidents should be noted in the daily field report and on an incident reporting form.

6. Field Documentation

Communication and documentation of field activities is critical to ensure the effectiveness and timeliness of the field operations. The ET Exploration Inspectors are responsible for keeping the ET Lead up-to-date daily on all exploration activities and provide appropriate documentation. Notification will be provided by the GC Exploration Inspector to the ET Lead via frequent phone conversations, emails, or text messages (at least daily) and draft daily field reports with photographs. If cell service is not available at the exploration site, communication will take place at the beginning or end of each day before arrival or after leaving the exploration site. An ET runner may also visit the exploration site to communicate with the ET

Exploration Inspector as needed. If immediate direction is needed, such as encountering unexpected subsurface conditions, the ET Exploration Inspector may leave the exploration site, drive to a safe location where cell service is available and contact the ET Lead or other team member. The ET Lead will in turn communicate with the TEMT and/or EDM via frequent phone conversations (at least daily) and provide draft interim field data. This coordination effort is essential for scheduling, notification requirements, minimizing delays in field explorations, field testing, and laboratory testing activities.

6.1 Work Instructions/Field Packets

Work instructions, as discussed above are to be reviewed by the field team and discussed with the Exploration Team lead prior to commencement of field work.

6.2 Soil Boring Logs

Soil boring logs will be prepared in accordance with the Boring and CPT Logging Standards and Work Procedures. As discussed in the Boring and CPT Logging Standards and Work Procedures, all fields in the header and footer of field logs are to be filled, including dates of work, boring identification number, logger/geo-professional, drilling method, etc. Soil descriptions are to be as complete as possible and include at a minimum the required descriptors indicated in Table 3-4 – Soil Classification Descriptive Sequence of the Boring and CPT Logging Standards and Work Procedures. Draft field logs are to be scanned or photographed and emailed to the ET Lead at the end of each day.

6.3 Daily Field Reports

Daily field reports (DFRs) are to be completed throughout the day and submitted at the end of the day to the ET Lead. All fields in the DFR should be filled, including site visitors, exploration progress, and photographs.

6.4 Subcontractor Quantities

At the end of each day, the subcontractor will submit a daily field report and quantities form to be reviewed and signed by the field geologist/engineer. This documentation is to be submitted to the ET Lead at the end of each day with the DFR.

6.5 Sample Inventory

An inventory of number and types of samples obtained from each investigation will be prepared and maintained by the ET. This will provide a list of samples that can be verified upon transport and delivery of samples to the Data Processing Team (DPT) at the Geotechnical Data Processing Center (GDPC).

6.6 Drum Inventory

An inventory of drums for Investigation Derived Waste (IDW) management will be prepared for each boring. The inventory will include the date of delivery to the storage area and will be provided to the waste disposal subcontractor before the drums are picked up.

7. Sample Handling and Transport

In order to minimize disturbance and exposure of samples to weather conditions, at the end of each day, the samples will be transported to the Geotechnical Data Processing Center (GDPC) or other approved temporary secure storage area. Alternatively, an ET "runner" may pick up samples toward the end of the day and transport them to the GDPC. Samples taken to a temporary storage area will be transported to the GDPC the next working day. Other details regarding sample handling and transport are discussed in the attachments.

8. Special Considerations

8.1 Artesian Conditions

Flowing artesian conditions can potentially occur in the San Joaquin-Sacramento Delta. It is important that proper precautions are taken so that when artesian conditions are encountered, the flows be controlled. Uncontrolled artesian flows can remove fines from the subsurface and over a period time lead to the development of collapse features ("sinkhole") at the ground surface. Typical mitigations include use of casing to seal off the confined aquifer zone or to raise the "top of the hole" above the static water elevation. Additives to drilling fluid can also be used to increase the density of the drilling fluid to counteract the artesian pressures. Additives may include bentonite or bentonite-barite mixtures. The Exploration Inspector should contact the Exploration Team Lead immediately upon encountering artesian conditions. If the flowing artesian conditions cannot be stopped, the drilling crew should backfill the hole with a high-density cement grout. Extra bentonite powder, barite, cement, and casing should be brought to each exploration where artesian conditions may be encountered. A flowing well work sheet is provided in Attachment 6.

8.2 Flowing Sands

Flowing sand conditions need to be controlled when encountered. This condition is generally controlled by having drilling fluid of sufficient density to create enough hydrostatic pressure at the depth where flowing sands are encountered. Flowing sands can also be controlled by extending casing through the zones where they are encountered. Continued removal of flowing sands from the borehole can lead to surface collapse features ("sinkholes").

8.3 No Recovery

In general, if there is no recovery during a sampling event, a second attempt should be made using either a different sampling method or with the use of a sample catcher. The hole should then be advanced to a depth immediately below the lost/re-samples sample depth and another attempt should be made to obtain a sample. If there is no recovery at the lower depth the procedure above should again be followed and the hole advanced to the next prescribed sample depth.

8.4 Contaminated Soils/Water

If soils or water are expected or found to be contaminated at a specific location, all samplers will be triple rinsed at the boring locations between each use. Triple rinsing should be performed in plastic buckets using clean water, clean water mixed with an anionic solution, then clean water. Upon completion of the borings the contaminated water (IDW) should be placed in labeled drums and left on site until contaminant testing is completed.

Equipment used during drilling and CPT explorations at contaminated sites will be decontaminated prior to the start of use and immediately following exploration activities. The augers, samplers, and tooling used will be transported to a staging area where a decontamination station will be established. The decontamination station will include inflatable ponds where steam cleaning and rinsing can be completed. Once decontaminated, the equipment and tools will be transported back to the new boring/CPT location.

8.5 Field Screening

Field screening will be performed with photo-ionization detectors (PIDs) and/or gas detectors supplied by GC ET capable of measuring the lower explosive limit (LEL), methane, hydrogen sulfide, and carbon monoxide. The detectors are to be calibrated every day and calibration records are to be kept with the detectors.

The detectors will be operated by the Exploration Team's field staff, which has been specifically trained in the operation of the detector.

- Field screening will be used for the following purposes:
  - Screening of the breathing zone to ensure that proper safety precautions within the work zone are followed,
  - Screening open exploration holes, drill pipe or well pipe atmospheres to assist in proper PPE management, and
  - Screening of selected soil and ground water samples following the headspace baggie method to assist in waste management decisions.
- All field screening measurements are to be documented in written daily field reports.

Additional field screening guidelines are provided in the HSSE Plan.

9. Quality Assurance and Quality Control

9.1 Quality Assurance

Quality assurance of field exploration activities will be conducted through a review/checking process wherein the field activities conducted are compared against the established procedures outlined in the Quality Management Plan (QMP) and this document. These procedures establish a consistent, systematic approach to all field activities in accordance with industry standards, with a focus on providing high quality field and laboratory data to meet the requirements of the DCP Program. In addition to planning for quality and implementing established procedures, periodic audits will be conducted by the Quality Assurance Manager (QAM). The audits will be used to document the quality procedures in use and to monitor and/or identify when measures need to be added to improve upon established procedures to ensure high quality data is delivered.

9.2 Quality Control

Quality control measures will be employed throughout the duration of the field exploration activities of the DCP to review/check various activity details which are to ensure providing quality data for the project.

Training records will be kept documenting when field staff have received awareness training for all established procedures. Training will also be provided to review Lessons Learned and to review the findings of any audits which would require a revision to a procedure. Work products, such as DFRs, soil boring logs, and CPT records will be reviewed for completeness and accuracy by the ET Lead. DFRs will note whether staff and equipment on any given day are “fit for service and work”. Field tools and equipment which need calibration, will be calibrated in accordance with manufacturer instructions and at regular intervals based on industry standards as shown in Table 8-1 below. The operation of field tools and equipment will also be checked and documented on the DFR to ensure that the equipment is “fit for use” and capable of making measurements when in use. Geotechnical and environmental samples collected for testing will be reviewed by the ET and Laboratory Testing Leads to ensure sample conditions, handling, transport, storage, and management practices conducted will result in samples that meet the quality needs of the project.

Table 9-1. Equipment Calibration Schedule

Equipment/Tool	Calibration Schedule	Responsible Party
Drill Rig Hammer	Yearly	Drilling Contractor
CPT Cone	Yearly or 3,000 meters of sounding	CPT Contractor
Gas Meter	Monthly	ET Lead
PID	Daily	ET Exploration Inspector

10. Document History and Quality Assurance

Reviewers listed below have completed an internal quality review check and approval process for this deliverable that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

Rev.	Date	Version Description	Approval Names and Roles			
			Prepared by	Internal QC review by	Consistency review by	Approved for submission by
0	08/31/2020	Initial submission	James Wetenkamp /Exploration Team Leader	Steven Wiesner /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Project Manager
1	10/16/2020	Incorporate DCA review comments	James Wetenkamp /Exploration Team Leader	Steven Wiesner /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Project Manager
2	11/20/2020	DCO submission	James Wetenkamp /Exploration Team Leader	Steven Wiesner /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Project Manager
3	02/19/2021	Final Draft	James Wetenkamp /Exploration Team Leader	Steven Wiesner /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Project Manager
This interim document is considered preliminary and was prepared under the responsible charge of Ward Andrew Herlache, Geotechnical Engineering License 2149.						

Attachment 1. General Daily Workflow Guidelines

Field work will be performed in accordance with the geotechnical work instructions contained in the GC Field Briefing Packets provided to the Exploration Team (ET) from the Pre-Field Coordination and Permitting Team (PCPT) and the Technical Execution Management Team (TEMT). The Field Briefing Packets will be specific to a single exploration or group of explorations in a designated area and will contain the following information as appropriate for the type of exploration:

1.1 Field Briefing Packets

A description of the documents comprising Field Briefing Packets is included in the PCPT Standards.

The GC Field Briefing Packets will be reviewed by the ET Lead for completeness and request clarifications or additional information from the PCPT or TEMT as required. The ET Lead will provide a copy to the ET Exploration Inspector. The ET Exploration Inspector should review the Field Briefing Packets and ask ET Lead for additional clarifications on the work to be performed, access, and permitting requirements should they have questions prior to and during field operations. Additional field packets will be provided by the DCA for information regarding environmental concerns, and cultural and biological resources.

1.2 Daily Workflow Checklist

In general, the on-site field exploration team will consist of an Exploration Inspector, an exploration drilling or CPT crew, an environmental/biological monitor, and at some locations a traffic control subcontractor or a Barge Master/Vessel Captain. A DCA field coordinator will be responsible for coordinating access to each site and maintaining primary contact with property owners. GC HSSE personnel, the ET Lead, and representatives of the TEMT, DCA, or DCO may be on site on an intermittent basis to observe conditions. Daily workflow for each field exploration team may consist of the following activities as appropriate for the type of exploration. This list is also included in Attachment 6 as a standard field form.

- Daily health, safety, security, and environment (HSSE) tailgate meeting. For over-water, discuss with Barge Master/Vessel Captain any safety concerns for the day (weather, tide, etc.).
- Review of Field Briefing Packets with exploration subcontractor.
- Daily inspections of trench stability by the Competent Person
- Equipment inspections.
- Site clearance by environmental/biological monitor.
- Site clearance by utility locator (private and USA north)
- For land explorations, hand auger the upper 5 feet of each exploration location per USA North 811 requirements.
- Shore trenches in accordance with the trench shoring plan.
- Perform logging and complete all applicable forms for documentation of daily activities.
- Check the fluid containment systems to prevent leakage into water/soil.
- Advance explorations and sample per geotechnical work instructions.
- Perform in-situ testing (pressure meter, downhole geophysics, etc.) per geotechnical work instructions.

- Cover trenches at the end of each day with plywood and secure with temporary fencing.
- Complete the explorations (backfill or instrumentation installation) per geotechnical work instructions and in accordance with permits and California Well Standards.
- Label samples collected in accordance with logging standards.
- Drum and label Investigation Derived Waste (IDW; i.e., cuttings and drilling fluids).
- Place drums in the designated area upon completion of exploration after no additional waste will be generated.
- Site restoration in accordance with the TEP.
- Documentation of crops damaged by access and investigation activities (photographs before and after site access).
- Obtain, review, and sign the exploration subcontractor's daily field report and quantities form at the end of each day.
- Report status of site to the DCA Field Coordinator.
- Field sample collection by the ET Exploration Inspector or an ET runner and taken to a temporary secure storage area or the Geotechnical Data Processing Center (GDPC) toward the end of each day. Samples obtained after the runner leaves are not to be left on site and should be taken to an approved storage facility. Samples collected from overwater explorations may be left on the vessel until the exploration is completed if it is deemed unsafe to transport samples on the skiff daily.
- Store and transport Shelby tube samples in upright racks designed for Shelby tubes.
- Store samples obtained from borings using continuous coring methods in core boxes.
- Document daily activities (DFRs, logs, inventories, instrumentation, etc.), scan or photograph, and sent to the ET Lead at the end of each day.
- Collect a digital copy of raw CPT data or a scanned/photographed printout of raw CPT data and email to the ET Lead at the end of each day.
- Deliver to the GDPC or other approved facility at end of each day the environmental samples and Chains of Custody (COCs). Email copies of the COCs to the ET Lead at the end of each day.
- Support the ET Exploration Inspector by delivering field supplies as needed. Additional field supplies will also be available at the GDPC.
- The ET Lead (or designees) to review daily documentation from each field exploration team the following day for:
  - Field data measurements to confirm suitability of intended use,
  - Daily reports are complete and capturing the field data needed,
  - Samples and sample inventory, and
  - COCs for environmental or groundwater samples.

The ET Lead will provide feedback to the ET Exploration Inspector based on the documentation review. Field quantities will be entered into the production tracking sheet based on DFRs (ET Exploration Inspector and subcontractors). Progress will be used to plan and update the field schedule.

When an exploration has been completed, and all field documentation has been reviewed the samples and documentation will be submitted to the Data Processing Team (DPT) for review. The DPT will review the samples and field logs for completeness and for accuracy of soil descriptions. Errors and consistent inaccuracies will be discussed with the ET Lead who will work with the ET Exploration Inspector (soil logger) to improve the quality of the field logs.

Attachment 2. Sample Handling and Storage Guidelines

Persons responsible for soil sample handling and storage shall follow ASTM standards and protocol including the following:

- ASTM D1586, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
- ASTM D1587, Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.
- ASTM D3550, Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils.
- ASTM D4220, Standard Practices for Preserving and Transporting Soil Sample.

Soil samples shall be consecutive and sequentially numbered and in accordance with the naming conventions established for this project. Soil samples shall be properly labeled in the field prior to being transported for testing and storage. Labelling and storage requirements are as follows:

2.1 Samples in Tubes and Jars

- Label samples using a black permanent marker.
- Orient sample identification such that the top and bottom of sample is readily identifiable.
- Use duct tape or electrical tape in the field to seal the end caps on the sample tubes and use wax to seal the end caps on the Shelby tubes upon arrival at the GDPC.
- Store/transport Shelby tubes in an approved rack in an upright position and away from direct sunlight/heat; care should be taken during driving to avoid motions that could disturb the samples.
- Write sample identification on a label and affixed to glass jars.
- Seal jar samples and store/transport away from direct sunlight/heat.
- Store bulk samples in bins, plastic bags, or buckets with lids.
- Label all samples in accordance with the recommendations in the Boring and CPT Logging Standards and Work Procedures document.

2.2 Sample Preservation for Environmental Testing

- Soil samples for environmental testing will be retained in pre-cleaned containers appropriate for the testing to be conducted. Containers will include stainless steel or plastic sleeves, sealed with Teflon sheets and plastic end caps, or laboratory provided clean 8-ounce glass jars.
- Soil sample containers will be sealed, labelled, stored in ice-filled chests or under refrigeration, until transported, under chain-of-custody documentation, to the receiving analytical chemistry laboratory.
- Each label will be waterproof, durable, and be able to retain indelible ink markings when wet. The following information will be included on all sample labels:
  - Date,
  - Time,
  - Project Number,
  - Sample ID number,
  - Sample Depth, and
  - Initials of field personnel that collected the sample.

- Chain of Custody documents need to accompany the samples to the laboratory. Chain of Custody documents need to be completely filled out, including the identification of the testing methods to be used and the laboratory turn-around time required.
- Samples are to be delivered to the analytical laboratory as soon as practical, bearing in mind that some testing methods require testing within short hold times.

Attachment 3. Borehole and CPT Backfill Guidelines

3.1 Purpose and Scope

The following requirements pertain to the backfill of geotechnical boreholes and CPTs, and decommissioning of instrumentation wells for the Delta Conveyance Project (DCP). Backfill of borings occurs at the completion of any drilling, sampling, and testing from within a borehole and typically requires site restoration. Decommissioning of instrumentation wells occurs at the end of the period of instrumentation monitoring and typically involves either leaving the instrument in the ground or removing the instrument and backfilling the hole.

Both the backfilling and decommissioning of boreholes is a short-duration activity, usually completed in less than one day. The usefulness of non-instrumented boreholes ends once the drilling, sampling, and in-situ testing are completed and as such the borehole is backfilled as the final step in the work performed at the site at the time of drilling. On the other hand, instrumentation wells are required to perform for long durations and will require a future mobilization to the site for decommissioning of the instrument, which could occur from months to years after the instrument was installed.

Boreholes shall be backfilled in compliance with requirements of the California Department of Water Resources, the California Department of Public Health, and the California Environmental Protection Agency. Any deviations from the requirements and instructions provided below will be included in the geotechnical work instructions.

3.2 Grouting Requirements

The California Department of Water Resources (Bulletins 74-81 and 74-90, and Statewide Advisory, dated September 2015) require grouting of boreholes with a cementitious grout, to seal off hydraulic communication between different levels within a borehole. The grout will consist of approximately 47 pounds of Portland cement, 2.5 pounds of bentonite, and 3 gallons of water.

Mix the grout material using a mechanical paddle device or recirculation with a grout pump. Manual mixing is prohibited. Mixing activities should continue until a smooth, lump-free consistency is achieved.

Place the cement grout in the borehole using a tremie pipe to fill the hole from the bottom of the borehole up to the top (or to some point below the top of the borehole as defined in the Work Instructions). The grout pipe shall be slowly withdrawn as the grout is pumped. Pumping of the grout shall continue until undiluted grout exits the hole at the surface (or until the calculated volume of grout has been pumped, as directed in the Work Instructions). This procedure will remove any excess water and drill cuttings from the borehole and ensure the integrity of the grouted hole. In agricultural areas the upper 5 feet of the exploration hole will be backfilled with topsoil.

The next day, or at least 12 hours after grouting, the borehole should be inspected for settlement of the grout column and additional grout or soil added as needed.

3.3 Borehole Backfill Data Sheet

Complete a borehole backfill data sheet. Submit the completed backfill data sheet to the ET Lead for review and reference upon completion of the borehole. Record:

- The total volume of the grout pumped into the borehole, and
- The volume of additional grout after inspection for settlement.

3.4 Additional Consideration for Instrumented Boreholes

A different type of grout mix shall be selected according to the field instrument type being used (e.g., inclinometers, piezometers, extensometers, etc.) and the given ground conditions. Use the grout mix presented in Table 1 of the VWP Installation Guidelines for sealing piezometers in boreholes and note that the amount of bentonite shown in Table 1 shall only be used as a guide.

Grout mixing should start with water and cement (or fly ash, if any) first. Avoid using bentonite alone, as it is not a volumetrically stable material and can influence both piezometer and displacement measurements when it keeps hydrating or desiccating. It is also often very difficult to place successfully. Where necessary, bentonite can be added to the mix to lower the permeability where required for sealing.

Grout stability is important during both the liquid and set conditions. The liquid grout consistency should be as thick as possible, yet liquid enough to be pumpable. Correct monitoring of this property requires field experience. Field crews tend to err towards the more liquid end of the spectrum, resulting in bleeding during liquid conditions and cracks after the grout has set.

Strength is often used to characterize a grout for deformation-type instruments, but modulus of deformation should ideally be the basis for judging the compatibility of the grout with ground conditions.

3.5 References

ASTM D-4380-12, Standard Test Method for Density of Bentonitic Slurries, 2012.

Department of Water Resources, 1981; Water Well Standards, State of California, DWR Bulletin 74-81.

Department of Water Resources, 1990; California Well Standards, Supplement to DWR Bulletin 74-81; DWR Bulletin 74-90.

Attachment 4. VWP Installation Guidelines

4.1 Purpose and Scope

The purpose of this memorandum is to provide guidance for consistent Vibrating Wire Piezometer (VWP) installation in a boring, handling, and storage to be used by the exploration field team for the Delta Conveyance Project (DCP).

4.2 Guidelines for Installing Vibrating Wire Piezometers

It must be emphasized that no two installations will be the same and it is essential that modifications of the following procedures will be required to meet specific site conditions. The users shall follow the specific instructions set forth by the VWP manufacturer if such specific site conditions arise. Prior to VWP installation, factory and on-site calibration certificates together with signed data sheets shall be submitted with installation documentation and Daily Field Report.

4.2.1 Pre-installation Preparation

4.2.1.1 Zero Pressure Readings

Upon receipt of the VWPs, the zero reading shall be checked and taken. Note that a thermistor is included inside the body of the piezometer. VWP differ from most other pressure sensors in that they indicate a reading with no pressure applied. ZERO or BASE readings can vary significantly between sensors. Therefore, it is essential that the zero reading be taken both at the office and again in the field prior to VWP installations to ensure that the piezometer(s) is/are functional. Procedures to be undertaken when measuring the zero readings are as follows:

- Do not directly handle the piezometer body when recording the zero readings as this will cause local temperature gradients across the piezometer that will distort the readings.
- Do not allow the piezometer to freeze once it has been filled with water.
- Obtain zero readings with the sensor oriented in the same direction in which it will be finally installed. For example, for the VWP in a vertical borehole, the zero readings shall be taken with the sensor oriented in the vertical direction.
- Follow the calibration data supplied with each gage and a zero reading at a specific temperature and barometric pressure (refer to manufacturer's user manual).
- Establish an initial zero reading in accordance with manufacturer's suggested procedures.

4.2.1.2 Checking the VWP Performance in the Borehole

It is essential to check the VWP performance inside a water-filled borehole or below the groundwater table in the field. The following procedure can be taken:

- Lower the VWP to a point below the surface of a water body.
- Allow 15-20 minutes for the VWP to come to thermal equilibrium. Use a readout box to record the reading at that level.
- Using the manufacturer's factory calibration factor, calculate the change in water depth and compare the calculated change in depth with the measured depth increment. The two values should be roughly the same.

Please note that there are instances that can affect the checking procedure:

- The density of the in-situ water may not be 1 gm/cc if it is saline or turbid.
- The water level inside the borehole may vary during the test due to displacement of the water level as the cable is raised and lowered in the borehole. This effect will be greater where the borehole diameter is small.
- Alternatively, if a dip-meter is available, lower the VWP tip to a measured depth below the water surface, allow the temperature to stabilize, then take a reading. Calculate the elevation of the water surface using the given factory calibration factor. Compare this to the elevation measured using the dip-meter.

4.2.1.3 Preparation for Installation

Prior to the installation, it is essential to establish and confirm details of the installation to be carried out. Order instruments from the manufacturer considering both the anticipated grout and water pressures for selected depths of the VWPs. Some of the main considerations are listed below:

- Intended elevation and depth of the piezometers.
- Borehole installation type. (In this case, the borehole is fully grouted.)
- Cable marking – cables shall be marked with unique identification. Markings shall be repeated at regular intervals along the cable where multiple cables are to be grouped together, so that in the event of cable damage, there may be a chance that the identification could be exposed and the cables re-joined. Multiple cable marks are particularly important close to the end of the cable. The spacing of markings can be between 10 to 30 feet.
- Tools necessary to carry out the installation including:
  - Fiber measuring tape with a weight added to the end for borehole depth measurement and cable length measurement,
  - Dip-meter to measure ground water levels,
  - Shovel for placing and leveling fill by hand,
  - PVC pipe to which VWP can be adhered to,
  - Wire cutters and strippers,
  - Vibrating wire readout unit for checking the piezometer function,
  - Cable marking system/equipment (e.g., colored PVC tapes),
  - Grout mixing and placing equipment to mix cement-water-bentonite in the field, and
  - PVC tape and Gorilla tape.

4.2.2 Installation Procedures in Boreholes

4.2.2.1 Installation Procedure

This section provides a procedure for installing either single or multiple piezometers in a single borehole. Instead of using a filter pocket or pushing the tip of the piezometer into the parent material, the piezometers are suspended in a borehole and the borehole is backfilled with a suitable bentonite-water-cement grout. VWPs will be installed at predetermined depths below ground surface. The following is a step by step installation process for the VWP that shall be used in a borehole.

- Drill the borehole below the required depth and select desired interval for installing the VWPs. Flush the borehole with water or biodegradable drilling mud to remove drilling fluids and cuttings.
- On a case by case basis, some boreholes may require that drilling mud remain in the hole in order to maintain stability, and the team will communicate with the ET Lead for scenarios such as this.
- Field calibrate the instruments by placing them in a bucket of water to saturate the pore-stone tips and record a zero reading at the elevation and atmospheric pressure in the boring (see Zero Readings above).
- Check the VWP performance inside the borehole as stated above.
- If feasible, use the drill rods or casing to maintain the borehole stability until the instruments are inserted and ready for grouting. In some cases, open hole installation may be preferable.
- Construct the instrument string. This includes using one or more tremies to grout the borehole and control the instrument depth.
  - For deeper installations (deeper than 200 feet), consideration should be given to using screw, electrical and/or gorilla tape together with a PVC or iron pipe (or tied to a tremie or tremies) and a sacrificial steel wireline to help hold the weight of the instrument and reduce the risk of the instrument string collapsing under its own weight. For holes deeper than 1,000 feet, use hose clamps to secure the instrument in place with the downhole PVC or iron pipe.
  - For shorter installations (less than 200 feet in depth), attach the VWP to the tremie using electrical tape and gorilla tape as it is lowered downhole. Tape the cables and joints every 5 to 10 feet to reinforce and prevent the string from getting tangled up as it is inserted.
  - If installed with a PVC or iron pipe, tape the piezometer to the pipe as recommended by the manufacturer.
- After the instrument string is downhole, the cable ends are nested and the excess tremie(s) are trimmed to allow pulling drill rods over the assembly. Carefully pull drill rods or casing in sequence (or stages) while the borehole is being grouted through the tremies (see instructions for grout mix details and handling below). This is to ensure that the piezometers remain supported and undisturbed while any drill rods or casing is removed and the grout reaches an initial set.
- Terminate the installation as specified. It is important to terminate the cables above ground level in a waterproof enclosure or with a waterproof connector. Protect the installation from construction traffic or vandalism and mark its location with a highly visible stake.
- Prepare to top off the grout using a tremie or a free fall method again after a couple of days.
- In the final step of the installation, trim the cables, install the vault, and attach the data loggers which are programmed to take readings at a given frequency to be determined by the TEMT, subject to the approval of the DCA.
- Allow a few days for the grout to cure before collecting readings using the readout box.
- The initial 2 to 3 readings are mainly to check that the system is working correctly. It could take a month or more for the effects of drilling (elevated water level) to equilibrate.

4.2.2.2 Bentonite-Water-Cement Grout Mix

The general rule for installing VWPs using bentonite-water-cement grout mix is to mimic the strength of the surrounding materials (soil/rock). The emphasis is on controlling the water-cement (W:C) ratio. The higher the W:C ratio, the lower is the strength of the grout mix. This can be accomplished by mixing the cement with the water first. The most effective way of mixing is in a 50- to 200-gallon barrel or tub using the drill-rig pump to circulate the mix. Any kind of bentonite powder used to make drilling mud, combined with Type 1 or 2 Portland Cement, can be used. The exact amount of bentonite added will vary somewhat. Table 1 below shows two possible mixes for strength of 4 psi and 50 psi for soft to hard soils, respectively.

Table 1. Bentonite-Water-Cement Ratios for Two Grout Mixes

Application	**Grout for Medium to Hard Soils**		**Grout for Soft Soils**	
Materials	Weight	Ratio by Weight	Weight	Ratio by Weight
Water	30 gallons	2.5	75 gallons	6.6
Portland Cement	94 lbs. (1 sack)	1	94 lbs. (1 sack)	1
Bentonite	25 lbs. (as required)	0.3	39 lbs. (as required)	0.4
Notes	The 28-day compressive strength of this mix is about 50 psi, similar to very stiff to very hard clay. The modulus is about 10,000 psi		The 28-day strength of this mix is about 4 psi, similar to very soft clay. The modulus is about 800 to 1,200 psi.	

- Mix cement with water first, then mix in the bentonite and adjust the amount of bentonite to produce a grout with the consistency of heavy cream. If the grout is too thin, the solids and the water will separate. If the grout is too thick, it will be difficult to pump.
- Other compounds may be added to alter the grout mix characteristics:

1. Expanding agents to introduce small bubbles into a cement and water mix as it cures to prevent it from shrinking.
2. Plasticizers to allow it to flow more freely through small tremie pipes.
3. Filters to provide weight and/or bulk to the mix for use where grout may have a tendency to flow through the borehole walls.

The grout shall be tremied into the borehole via a tremie pipe. No pumping of the grout into the hole is allowed as it may pose a danger of over-ranging or damaging the VWP. The grout may need to be installed in “lifts” on successive days as to not “over-range” the sensors. The grout exerts a higher pressure on the sensor than water, and the maximum allowable overburden pressure will need to be calculated before the grouting is initiated.

4.2.3 Handling and Storage

4.2.3.1 Handling

Though VWPs are a robust device, they are precision measuring instruments sensitive to malfunction if struck or damaged during installation. Therefore, they and their associated equipment should be handled with care during pre-installation, transportation, storage, and installation.

Once the VWPs are received from shipment, they must be inspected in accordance with the manufacturer’s suggested instructions, after which time they must remain in their original packaging for storage and transportation.

Do not allow cables to be damaged by sharp edges, rocks for example, and do not exert force on the cable as this may damage the internal conductors and could render the installation useless.

4.2.3.2 Storage

All equipment shall be stored in an environment that is protected from direct sunlight. Store cables and associated equipment in a dry environment to prevent moisture from migrating along inside them in the event of prolonged submersion of exposed conductors.

Storage areas shall be rodent-free as rodents have been known to damage connecting cables.

If the piezometer is supplied with a pre-saturated filter or has been saturated on site, it must be kept at a temperature above zero degrees Centigrade. Otherwise, damage could be caused to the diaphragm.

4.2.3.3 Approval of Vibrating Wire Piezometers

The TEMT are responsible for selection of high-quality vibrating wire piezometers compatible to the environments that they are subject to.

Selection of the VWPs shall consider quality, durability, cost, and ability to achieve the expected functions.

Approval of types and brands of vibrating wire piezometers by the DCA is not required.

4.3 Limitations

These guidelines are not intended to address all requirements applicable to transporting or storing, handling, and installations of VWPs in a completely grouted borehole. In particular, the VWP equipment shall be installed in accordance with the manufacturer’s recommendations. It is the responsibility of the user of these guidelines to establish a good baseline for successfully installing the VWPs in place for groundwater pressure measurement that is one of the key subsurface parameters for design of deep tunnels proposed for the DCP.

Attachment 5. Well Installation Guidelines

5.1 Purpose and Scope

The purpose of this document is to provide guidance for consistent well (standpipe piezometer and test well) installation for the Delta Conveyance Project.

5.2 Guidelines for Installing Wells

The guidelines provided below for the installation of wells that are installed in boreholes are in accordance with the California Department of Water Resources, California Well Standards Bulletins 74-81 and 74-90. It must be emphasized that no two installations will be the same and it is essential that modifications of the following procedures will be required to meet specific site conditions and purpose of the well (monitoring, sampling, extraction, or any combination thereof). Prior to well installation, the boring log will be reviewed and a well design will be submitted for approval to the TEMT. Upon approval of the well design, the well installation may proceed.

5.2.1 Preparation for Installation

Prior to the installation, it is essential to establish and confirm details of the installation to be carried out. Some of the main considerations are listed below:

- Diameter and thickness of casing and screen (i.e., 2-, 4-, or 6-inch diameter, Sch 40 or 80 PVC, or 8- to 12-inch steel slotted or louvered screen).
- Screen slot size.
- Threaded flush joint connections (any wells intended for sampling should not have glued joints).
- Tip depth.
- Length of screen.
- Length of blank.
- Length of sump.
- Hole diameter must be a minimum 4 inches greater than casing diameter (hole may require reaming).
- Centralizers, no more than 12 inches in length and no closer than 10 feet apart.
- Filter sand gradation.
- Sealing materials: bentonite pellets and grout.
- Length of filter pack.
- Length of transition seal (bentonite pellets on top of filter sand), generally 3 to 5 feet.
- Annular seal, regulations require minimum of 20 feet, unless approved by regulatory agency. Shallow groundwater conditions minimum of 10 feet.
- Length of casing stickup above existing ground surface, minimum of 3 feet or above known flood level
- Protective casing with locking cap.
- Bollards.

Generalized schematic of test well provided below in Figure 1.

5.3 Installation Procedures in Boreholes

5.3.1 Installation Procedure

This section provides a procedure for installing a standpipe piezometer (piezometer) in a single borehole. Each piezometer will be designed based on subsurface conditions encountered and the purpose of the well.

- Drill the borehole below the required depth. Borehole should be a minimum of 4 inches larger than the casing diameter specified; if necessary, borehole should be reamed to the minimum diameter required.
- Flush the borehole with water or biodegradable drilling mud to remove drilling fluids and cuttings.
- On a case by case basis, some boreholes may require that drilling mud remain in the hole in order to maintain stability. The field engineer/geologist will communicate with the Exploration Team field supervisor for scenarios such as this.
- Assemble and insert screen and blank casing with centralizers into borehole.
- Place filter sand around screen and at least 2 feet above the top of screened interval.
- Place transition seal and allow to hydrate, 30 minutes to 1 hour.
- Place annular seal via tremie pipe.
- Install surface protective casing with locking cap.
- Install surface pad consisting of concrete, 4 inches thick x 2 feet width x 2 feet length.
- Install bollards, this will consist of 3 posts in a triangular shape around the base of piezometer.

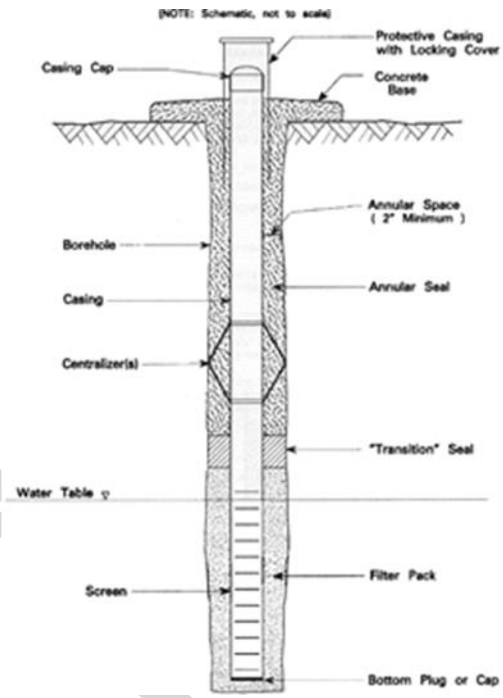

Figure 1. Test Well Schematic

5.4 Well Installation and Documentation

The ET Exploration Inspector will be given a proposed construction diagram of the well and will record actual depths and dimensions of installation and construction of wells. This also includes calculated hole volume verses volume of grout used in annular seal.

Construction details will be used to file well completion reports with the California Department of Water Resources.

5.5 Limitations

These guidelines are not intended to address all requirements applicable to test well construction for the Delta Conveyance Project.

Attachment 6. Standard Field Forms

The following field forms are attached:

- Daily Workflow Checklist.
- Field Equipment and Supply Checklist.
- Vehicle and Equipment Readiness Checklist.
- Daily Tailgate Safety Meeting.
- Daily Field Report.
- Soil Boring Log.
- Geotechnical Sample Chain of Custody.
- Environmental Sample Chain of Custody.
- Drum Inventory.
- Well Development Log.
- Grout Backfill Record.
- Steady State Gas Monitoring (Field Screening) Log.
- Water Level Monitoring.
- Test Pit Log.
- Flowing Well Worksheet.

Daily Workflow Checklist

Yes	No	N/A	
☐	☐	☐	HSSE tailgate meeting. Barge Master/Vessel Captain any safety concerns.
☐	☐	☐	Review of Field Briefing Packets with exploration subcontractor.
☐	☐	☐	Trench stability inspection by a competent person.
☐	☐	☐	Equipment inspections.
☐	☐	☐	Site clearance by environmental/biological monitor.
☐	☐	☐	Site clearance by utility locator (private and USA north)
☐	☐	☐	Hand auger the upper 5 feet of each exploration location.
☐	☐	☐	Shore trenches in accordance with the trench shoring plan.
☐	☐	☐	Perform logging and complete all applicable forms.
☐	☐	☐	Check the fluid containment systems to prevent leakage into water/soil.
☐	☐	☐	Advance explorations and sample per geotechnical work instructions.
☐	☐	☐	Perform in-situ testing per geotechnical work instructions.
☐	☐	☐	Cover trenches at the end of day and secure with temporary fencing.
☐	☐	☐	Complete backfill or instrumentation installation per work instructions.
☐	☐	☐	Label samples collected in accordance with logging standards.
☐	☐	☐	Drum and label Investigation Derived Waste.
☐	☐	☐	Place drums in the designated area upon completion of exploration.
☐	☐	☐	Site restoration in accordance with the TEP.
☐	☐	☐	Documentation of crops damaged (photographs before and after site access).
☐	☐	☐	Obtain, review, and sign the exploration subcontractor's daily field report.
☐	☐	☐	Samples transported to GDPC or approved storage facility.
☐	☐	☐	Store and transport Shelby tube samples in upright racks.
☐	☐	☐	Store continuous core samples in core boxes.
☐	☐	☐	Send DFR and Logs to ET Lead at the end of the day.
☐	☐	☐	Send CPT logs to the ET Lead at the end of each day.
☐	☐	☐	Environmental samples and CoCs delivered to GDPC. CoCs emailed to ET Lead.
☐	☐	☐	
☐	☐	☐	
☐	☐	☐	
☐	☐	☐	
☐	☐	☐	
☐	☐	☐	

____
Area/Location of Work

____ _______________
Print Name and Sign — Date

Field Equipment Checklist

Yes	No	N/A	Item
☐	☐	☐	Field Briefing Packet
☐	☐	☐	PPE including DCA hard hat, vest, and magnets
☐	☐	☐	Field Boring Log forms
☐	☐	☐	Field Daily Report forms
☐	☐	☐	Drum labels
☐	☐	☐	Drum Inventory forms
☐	☐	☐	Environmental Chain of Custody forms
☐	☐	☐	Pencils, pens, and waterproof permanent markers
☐	☐	☐	Clipboard with cover
☐	☐	☐	Pocket knife or small spatula
☐	☐	☐	Munsell Soil Color Charts
☐	☐	☐	Water bottle for adding moisture to soil samples
☐	☐	☐	Torvane and pocket penetrometer
☐	☐	☐	Scale
☐	☐	☐	HCl
☐	☐	☐	Shallow metal pan.
☐	☐	☐	Rock hammer
☐	☐	☐	Stakes & survey tape
☐	☐	☐	Caution tape
☐	☐	☐	Safety/environmental monitoring equipment
☐	☐	☐	Compass
☐	☐	☐	Hand level
☐	☐	☐	GPS device
☐	☐	☐	Magnifying lens
☐	☐	☐	Sample tubes, caps, and liners as required
☐	☐	☐	Sample transport containers
☐	☐	☐	Glass jars for geotechnical soil samples
☐	☐	☐	Plastic bulk bags or five-gallon buckets for bulk samples
☐	☐	☐	Environmental sample jars (if required)
☐	☐	☐	An electronic water level meter
☐	☐	☐	Tape measure and measuring wheel
☐	☐	☐	A large flat-blade screwdriver, and soil knives for handling soil samples
☐	☐	☐	A digital camera (check batteries and memory card)
☐	☐	☐	A cell phone and/or satellite phone (check charge)
☐	☐	☐	PID
☐	☐	☐	Gas Meter
☐	☐	☐	Cooler and ice for storing environmental samples
☐	☐	☐	Soil logging cheat sheet

____
Area/Location of Work

______________________________ ______________
Print Name and Sign Date

Vehicle and Equipment Readiness Checklist

Yes	No	N/A	
☐	☐	☐	Registration and Insurance documentation
☐	☐	☐	Tires in good condition and properly inflated
☐	☐	☐	Headlights, brake lights, and turn signals operational
☐	☐	☐	Fuel level sufficient to get to destination and back
☐	☐	☐	Brakes operating properly
☐	☐	☐	Fluid levels (brake, oil, coolant, power steering, etc.)
☐	☐	☐	Absence of leaking fluids beneath vehicle
☐	☐	☐	Other ______________________________

Yes	No	N/A	360 Degree Walk Around
☐	☐	☐	Leaking fluids beneath vehicle
☐	☐	☐	Cracked windshield
☐	☐	☐	Dirty windows and/or mirrors
☐	☐	☐	Obstructions in drive path
☐	☐	☐	Other ______________________________
☐	☐	☐	Other ______________________________

____
Area/Location of Work

______________________________________ ______________
Print Name and Sign Date

DCA	**DAILY TAILGATE SAFETY MEETING**	DATE:
	Exploration No.:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Speaker/Safety Lead:	Start Time/End Time:

Subcontractors Present:

Weather:

Summary of Safety Topic Discussed

Field Staff Signatures			
Name	Signature	Company	Date

Reviews	
Task Order Manager:	Date:
Project Manager:	Date:
Safety Coordinator:	Date:

Please forward this completed form to the Safety Office

DCA	DAILY FIELD REPORT	DATE:
	Exploration No.:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Geologist/Engineer:	Start Time/End Time:

Weather:

Summary of Driller's Activities

Exploration No.	*Start Time:*	*Stop Time:*	*Total Time:*	*Footage:*	*Activiy/ Comments (Mob/Demob Drilling, CPT Advancement, or Grouting)*

Personnel/Equipment:	*Arrival:*	*Departure:*	*Hours:*	*Comments:*

Drill Rig or CPT No.:
Support Truck No.:
Hammer or Cone No.:

NOTES

Time	**Activity**

DCA	DAILY FIELD REPORT	DATE:
	Exploration No.:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Geologist/Engineer:	Start Time/End Time:

Time and Equipment

Item #	Item:	Unit	Start Time	End Time	Total
	LAND-BORINGS				
1	**Truck**-Mounted Drill Rig Call up (first day)	EA			
2	Track-Mounted Drill Rig Call up (first day)	EA			
3	**Truck**-Mounted Drill Rig Drill and Sample, Rig No.	HR			
4	Track-Mounted Drill Rig Drill and Sample, Rig No.	HR			
5	**Truck**-Mount Drill Clean-up, Move/Set-up between sites	HR			
6	Track-Mount Drill Clean-up, Move/Set-up between sites	HR			
7	Piezometer Installation and materials	HR			
8	Standby Time (only at Engineer's direction)	HR			
9	Portable toilet with service	DAY			
10	Traffic Control	DAY			
11	Additional Labor	HR			
	Other				
	OVER-WATER BORINGS				
12	Mob/Demob Drill Ship/Barge (First Day)	EA			
13	Marine Drilling/Sampling/Testing including Materials	HR			
14	Standby Time with Licensed Captain	HR			
15	Stanby Time with Drill Crew (at geo/eng direction)	HR			
16	Marina Fees (for docking support vessel)	DAY			
	Other				
	MATERIALS				
18	55 Gal Drums	EA			
19	Alternate Cutting Storage Conainer	EA			
	Monitoring Equipment				
	OTHER				
20	Hammer Energy Testing	EA			
21	Drill Waste and Cutting ID Testing and Offsite Trans (Per Boring)	EA			
22	Providing Special Equipment				

Delta Conveyance Design & Construction Authority	LOCATION COUNTY APN LAT/LONG ELEV NAVD88 CA SPCS ZONE 2 | 3	DELTA CONVEYANCE PROJECT BORING IDENTIFICATION NUMBER DC ___-___-___ SHEET _____ of _____

DRILLING CONTRACTOR	FIELD LOGGER	DATE/TIME STARTED
OPERATOR/HELPER	REVIEWER	DATE/TIME COMPLETED
DRILL MAKE/MODEL	HAMMER SYSTEM/DROP	GROUND ELEV./BASIS
DRILLING METHODS, DRILL BIT SIZE/TYPE		WATER LEVEL DURING DRILLING
ROD DIA./TYPE	CASING DIA./ TYPE	WATER LEVEL AFTER DRILLING

Depth, feet	FIELD CLASSIFICATION OF MATERIALS GROUP NAME (USCS SYMBOL), consistency/relative density, Munsell color (Munsell hue-chroma), moisture; % cobbles or boulders; % gravel, sand, or fines; particle size range, angularity, shape; plasticity; cementation; description of cobbles/boulders; other	Drilling Method	Sample Interval & Method	PID	Sample Number	Blows/6 in.	Recovery/ Interval (in.)	PP or TV, tsf	REMARKS, SAMPLE NAME and INSTALLATION NOTES
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

Key: **S**-SPT, **MC**-Mod Cal Sampler, **SC**-Standard Cal Sampler, **B**-Bag/Grab, **ST**-Shelby Tube, **PB**-Pitcher Barrel, **PS**-Piston Sampler, **V**-Sonic **DM**-Dames & Moore thin-wall tube sampler, **GB**-Geobarrel 134 mm Continuous Sample, **GS**-Geobor-S 146 mm Continuous Sample

Delta Conveyance Design & Construction Authority

LOCATION		DELTA CONVEYANCE PROJECT
COUNTY	APN	BORING IDENTIFICATION NUMBER
LAT/LONG	ELEV NAVD88	DC - -
CA SPCS	ZONE 2 | 3	SHEET ____ of ____

Depth, feet	FIELD CLASSIFICATION OF MATERIALS GROUP NAME (USCS SYMBOL), consistency/relative density, Munsell color (Munsell hue-chroma), moisture; % cobbles or boulders; % gravel, sand, or fines; particle size range, angularity, shape; plasticity; cementation; description of cobbles/boulders; other	Drilling Method	Sample Interval & Method	PID	Sample Number	Blows/6 in.	Recovery/ Interval (in.)	PP or TV, tsf	REMARKS, SAMPLE NAME and INSTALLATION NOTES
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
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41									
42									

Key: **S**-SPT, **MC**-Mod Cal Sampler, **SC**-Standard Cal Sampler, **B**-Bag/Grab, **ST**-Shelby Tube, **PB**-Pitcher Barrel, **PS**-Piston Sampler, **V**-Sonic **DM**-Dames & Moore thin-wall tube sampler, **GB**-Geobarrel 134 mm Continuous Sample, **GS**-Geobor-S 146 mm Continuous Sample

Delta Conveyance Design & Construction Authority

LOCATION		DELTA CONVEYANCE PROJECT
COUNTY	APN	BORING IDENTIFICATION NUMBER
LAT/LONG	ELEV NAVD88	DC ___-____-___
CA SPCS	ZONE 2 | 3	SHEET ______ of ______

DRILLING CONTRACTOR	FIELD LOGGER	DATE/TIME STARTED
OPERATOR/HELPER	REVIEWER	DATE/TIME COMPLETED
DRILL MAKE/MODEL	HAMMER SYSTEM/DROP	GROUND ELEV./BASIS
DRILLING METHODS, DRILL BIT SIZE/TYPE		WATER LEVEL DURING DRILLING
ROD DIA./TYPE	CASING DIA./ TYPE	WATER LEVEL AFTER DRILLING

Depth, feet	FIELD CLASSIFICATION OF MATERIALS GROUP NAME (USCS SYMBOL), consistency/relative density, Munsell color (Munsell hue-chroma), moisture; % cobbles or boulders; % gravel, sand, or fines; particle size range, angularity, shape; plasticity; cementation; description of cobbles/boulders; other	Drilling Method	Sample Interval & Method	PID	Sample Number	Blows/6 in.	Recovery/ Interval (in.)	PP or TV, tsf	REMARKS, SAMPLE NAME and INSTALLATION NOTES

Key: **S**-SPT, **MC**-Mod Cal Sampler, **SC**-Standard Cal Sampler, **B**-Bag/Grab, **ST**-Shelby Tube, **PB**-Pitcher Barrel, **PS**-Piston Sampler, **V**-Sonic **DM**-Dames & Moore thin-wall tube sampler, **GB**-Geobarrel 134 mm Continuous Sample, **GS**-Geobor-S 146 mm Continuous Sample

	Geotechnical Sample Chain of Custody	DATE:
	Exploration No.:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Shipped by:	Shipped to:

SAMPLE NUMBER	**DEPTH (ft)**		**DATE**	**No. OF CONTAINERS**	**COMMENTS**
	From	To			

Relinquished by: (printed name & signature)	Date	Received by: (printed name & signature)	Date	Comments

Shipment prepared by: ______________________ Date: ________ Shipment Method: ______________

Receiving laboratory: Return original form after signing for receipt of samples to:

DCA

Project Name:

Phase/Task:

L.P. NO. (PO NO.)	SAMPLERS: (Name/Signature)
	LAB NAME:

	Lab ID	Date MM/DD/YY	TIME HH:MM:SS	Sample I.D.	Matrix	Container type	No. Con-tainers	**Analysis** PAHs - 8270SIM	Butyltin - SM4500NH3	Ammonia - SM4500NH3	Nitrate/Nitrite - SM4500 NO3	Metals CAM 17 - ICP/MS	Mercury - 7471	Methyl Mercury - 1631	Hexavalent Chromium - 7196	TPH with Containers - 8015M/5035	Organochlorine Pesticides & PCBs - 8080	Herbicides - 8151	VOCs - 8260	SVOCs - 8270	Total Organic Carbon - Walkley-Black	Salinity as Chloride - CL-SM2520	pH - 904D	Remarks
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14																								
15																								

Chain of Custody Record

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Relinquished by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time
Relinquished by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time

Instructions/Remarks:

Send Results to:

DCA	**DRUM INVENTORY**	DATE:
	Exploration No.:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Lab Samples Taken to:	Date Lab Samples Taken:

DRUM No.	LABEL	WASTE		ORIGIN OF CONTENTS
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	
	☐ Non-Hazardous ☐ Unclassified Date:	☐ Soil ☐ Water ☐ Other:	☐ Full ☐ Partial ☐ Empty	

Location of Drums (attach a site plan): ____________________

____

____

Comments: ____________________

____

____

____

____

Field Representative *PRINT NAME*

Field Representative *SIGNATURE*

Date

WELL DEVELOPMENT LOG

DATE:

Well Number:

M T W Th F S Su

Sheet of

Standard Agreement No.:
Task Order No.:

Recorded By:

Start Time/End Time:

Method		Date of Development
Hand Pump		Development Criteria
Submersible Pump		
Bailer		Remarks
Other		

INSERT PURGE VOLUME CALCULATION HERE

Development Log					**Cumulative Total Removed**		**Water Characteristics**				**Comments**
Date	Time		Method	Water Removed (Gal)	Gal	Well Volumes	pH	Conductivity µS/cm	Turbidity (NTU)	Temperature (°F)	
	Begin	Finish									

DCA	**Grout Backfill Record**	DATE:
	Exploration No:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Recorded By:	Start Time/End Time:

Depth to Water (ft): ________ Groundwater not encountered ☐ Boring Type: CPT ☐

Mud Rotary ☐ Auger ☐

Hole Diameter (in) ________ Inclination (degrees) ________

Hole Depth (ft) ________ Vertical ☐

Instrumentation/Well Casing:

☐ Vibrating Wire Piezometer (VWP) Installed

☐ Well Casing Installed

VWP Tremie Pipe Left in Hole (diameter, in) ________

Well Casing Outside Diameter (inches) ________

Casing or Tremie Length (feet) ________

Annulus Grout ☐ Inside Grout ☐

Sealing Materials

Full Depth Seal ☐Yes ☐No If no, sealing interval: From: ________ (ft bgs[1]) To: ________ (ft bgs)

Proportions used: ________ gallons of water per 94# sack of cement ________ % Bentonite

Calculated Grout Volume[2]: ________ gallons Actual Grout Volume: ________ gallons

Bentonite Chips: Diameter (in) ________ Calculated bags needed: ________ Actual bags used: ________

Placement:

☐ From Surface or ☐ Tremie ☐ Flush Thread or ☐ Drill Steel

Diameter ________ in

Revisit Site for Settlement: Date of Visit: ________

Settlement: ________ ft. Grout to top off: ________ gallons Backfill Date: ________

Directions:

This form is to be completed for each borehole and sounding by the individual logging the boring/sounding or the CPT Technician.

[1] bgs means below ground surface

[2] hole diameter ______ (in) times hole diameter ______ (in) times total depth _____ (ft) times 0.0408 = ______ gallons of grout.

____

Field Representative *Signature*

____

Field Representative *Print Name*

	STEADY STATE GAS MONITORING LOG	DATE:
	Well Number:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Recorded By:	Start Time/End Time:

CALIBRATION				
Instrument Type/Model Number	**Instrument Serial Number**	**Time of Calibration**		
		Before	**During**	**After**

READINGS

Monitoring Point	Time (xx:xx)	Depth (ft)	H_2S	VOC	CH_4	O_2	CO
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							
Sample No.							
Breathing Zone							

	Water Level Monitoring Log	DATE FROM:
	Exploration No.:	DATE TO:
Standard Agreement No.: Task Order No.:	Measured by:	M T W Th F S Su Sheet of

Date	Depth to Water	Casing Elevation	Water Elevation	Comments

TEST PIT LOG

DCA	**TEST PIT LOG**	DATE:
	Exploration No.:	M T W Th F S Su
		Sheet of
Standard Agreement No.:	Task Order No.:	Start Time/End Time:

DATE STARTED DATE COMPLETED	GROUND ELEVATION ELEVATION BASIS	EXCAVATION DIMENSIONS
EXCAVATION CONTRACTOR	EXPLORATION LOCATION (LAT./LONG & DATUM)	FIELD LOGGER
BUCKET TYPE/SIZE	OPERATOR'S NAME HELPER'S NAME	FIELD LOG REVIEWER
EXCAVATOR MAKE AND MODEL	GROUND WATER READING: DURING EXCAVATION AFTER EXCAVATION (DATE-TIM	

Depth, feet	SAMPLE INFORMATION		FIELD LITHOLOGY DESCRIPTION AND CLASSIFICATION					FIELD NOTES			DISCONTINUITIES			
	Sample Type, Symbol	Sample Number	Soil Description: Soil Type, Particle-Size Range, Particle Angularity, Particle Shape, Particle Hardness, Dry Strength, Dilatancy, Toughness, Color, Odor, Reaction to HCl, Structure, Cementation Rock Mass Description: Formation and Rock Type, Color, Grain/Particle-Size, Bedding, Discontnuity Density/Spacing	USCS Symbol	Water Content	Density / Consist.	Plasticity	Percent Gravel	Percent Sand	Percent Fines	Rel. Hardness / Strength	Weathering Grade	Discon. Spacing	Discon. Type

SKETCH/NOTES:

DCA	**Flowing Well Worksheet**	DATE:
	Exploration No:	M T W Th F S Su
		Sheet of
Standard Agreement No.: Task Order No.:	Recorded By:	Start Time/End Time:

1. Enter the total depth of the borehole. ______ feet

2. Enter artesian head above ground surface. ______ feet

3. Add steps 1 & 2 to find total feet of hydrostatic head. ______ feet

4. Convert feet of hydrostatic head to downhole hydrostatic head pressure (DHHP) in pounds per square inch by dividing answer in step 3 by 2.31 ft/psi. ______ psi

5. Enter the grout density. ______ lb/gal

6. Determine the pressure per foot of grout by multiplying the grout density (answer to #5 above) by 0.052. ______ psi/ft

7. Calculate the downhole grout pressure (DGP) by multiplying the answer to #6 by the answer to #1. ______ psi

8. Can the flow be controlled by the grout weight? If #7 is greater than #4 the flow can be controlled by the grout weight. If not, the grout density must be increased. ______

____
Field Representative *Signature*

____
Field Representative *Print Name*

Attachment 7. Fact Sheets for Geotechnical Exploration Program

DCA
DELTA CONVEYANCE **DESIGN**
& CONSTRUCTION AUTHORITY

Truck-Mounted Cone Penetrometer Testing (also known as CPT)

Cone Penetrometer Tests will be performed at various locations within the proposed Delta Conveyance project area. Cone Penetrometer Tests are completed using the truck similar to that shown in Image 1. These tests are performed by pushing a cone shaped rod, as shown in Image 2, into the ground using a hydraulic ram mounted inside of the truck, as shown in Image 3. As the probe is pushed into the ground, gauges and pressure sensors within the probe continuously measure various soil and groundwater properties during each test. The data are recorded on a computer and then processed to produce a log of geologic conditions.

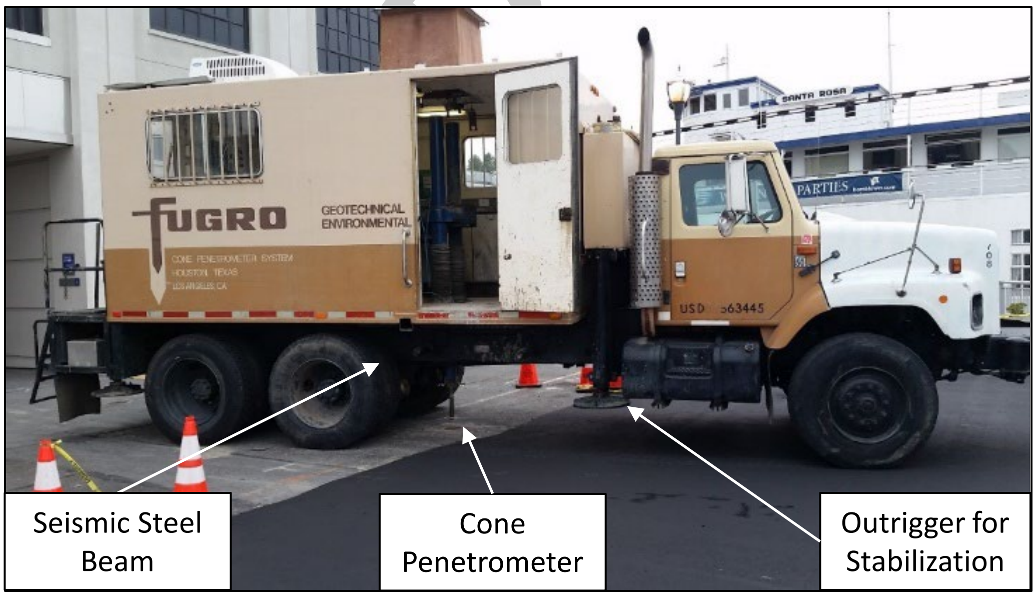


Image 1. Cone Penetrometer Testing Rig

Image 2. Cone Penetrometer

Image 3. CPT Hydraulic Ram

DCA
DELTA CONVEYANCE **DESIGN**
& CONSTRUCTION AUTHORITY

Truck-Mounted Cone Penetrometer Testing (also known as CPT)

Field Procedure

After acquiring permits and performing public and private utility locates, the Cone Penetrometer Testing crew will advance a hand auger to a depth of 5 feet to reduce the possibility of striking a buried utility line. If the area to be tested is paved, a hole will be cored. The hand auger hole will then be backfilled with the excavated material prior to starting the test. The testing rig will then be aligned over the exploration location and outriggers will be extended to stabilize the rig. Wood blocks will be placed under the outriggers to distribute the load and limit ground disturbance, as required. If the ground is too soft for mobilization of a Truck-Mounted Cone Penetrometer Testing rig, mats will be used, or a Track-Mounted Cone Penetrometer Testing rig will be deployed.

The probe will then be advanced through the bottom of the rig in 3.3-foot increments using the onboard hydraulics. Threaded rods are added after each advancement until the final depth is achieved. If required, the seismic shear wave velocity of the soil will be measured at regular intervals. This is accomplished by striking a steel beam attached to the rig with a sledgehammer and recording seismic wave travel times using a sensor within the Cone Penetrometer Cone probe.

If hard objects are encountered at shallow depths (e.g. bricks or concrete debris) that prevent the probe from progressing, the rig will relocate a few feet from the original location and another test will be attempted. Upon completion, the rods and the CPT probe will be extracted, and a grout pipe will be inserted in the hole. The hole will be backfilled as described below.

CPT Abandonment

CPT holes will be backfilled with grout in accordance with State and County requirements. Where required, the County inspection office will be notified.

Surface Restoration

Restoration will be conducted in accordance with temporary entry permit.

Anticipated Duration

CPT explorations will be conducted to depths ranging from about 175 to 200 feet below ground surface and will take about 1 or 2 days to complete depending on site access and subsurface conditions.

Typical Properties for a Truck-Mounted CPT Rig						
Vehicle	Weight (lbs)	Length (feet)	Width (feet)	Height (feet)	Required Overhead (feet)	Work Area Required
3 Axle - 5030 CPT Truck	50,000 [1]	34	10	14	17	12 feet wide by 70 feet long
(1) For reference, a fully loaded tandem trailer tomato haul truck weighs approximately 60,000 lbs						

Track-Mounted Cone Penetrometer Testing (also known as CPT)

A Track-Mounted Cone Penetrometer Testing Rig may be deployed instead of a Truck-Mounted Cone Penetrometer Testing rig in cases of difficult site access or soft ground. Track-Mounted Cone Penetrometer Tests will be performed at various locations within the proposed Delta Conveyance project area and are completed using a rig similar to that shown in Image 1. These tests are performed by pushing a cone shaped rod, as shown in Image 2, into the ground using a hydraulic ram mounted inside of the truck, as shown in Image 3. As the probe is pushed into the ground, gauges and pressure sensors within the probe continuously measure various soil and groundwater properties during each test. The data are recorded on a computer and then processed to produce a log of geologic conditions.

Image 1. Cone Penetrometer Testing Rig

Image 2. Cone Penetrometer

Image 3. CPT Hydraulic Ram

DCA
DELTA CONVEYANCE **DESIGN**
& CONSTRUCTION AUTHORITY

Track-Mounted Cone Penetrometer Testing (also known as CPT)

Field Procedure

After acquiring permits and performing public and private utility locates, the Cone Penetrometer Testing crew will advance a hand auger to a depth of 5 feet to reduce the possibility of striking a buried utility line. If the area to be tested is paved, a hole will be cored. The hand auger hole will then be backfilled with the excavated material prior to starting the test. The testing rig will then be aligned over the exploration location and outriggers will be extended to stabilize the rig. Square pads will be placed under the outriggers to distribute the load and limit ground disturbance, as required.

The probe will then be advanced through the bottom of the rig in 3.3-foot increments using the onboard hydraulics. Threaded rods are added after each advancement until the final depth is achieved. If required, the seismic shear wave velocity of the soil will be measured at regular intervals by placing a steel beam under the back outriggers of the rig. The crew will strike the steel beam with a sledgehammer and record seismic wave travel times using a sensor within the Cone Penetrometer Cone probe. If hard objects are encountered at shallow depths (e.g. bricks or concrete debris) that prevent the probe from progressing, the rig will relocate a few feet from the original location and another test will be attempted. Upon completion, the rods and the CPT probe will be extracted, and a grout pipe will be inserted in the hole. The hole will be backfilled as described below.

CPT Abandonment

CPT holes will be backfilled with grout in accordance with State and County requirements. Where required, the County inspection office will be notified.

Surface Restoration

Restoration will be conducted in accordance with temporary entry permit.

Anticipated Duration

CPT explorations will be conducted to depths ranging from about 175 to 200 feet below ground surface and will take about 1 day to complete depending on site access and subsurface conditions.

Typical Properties for a Track-Mounted CPT Rig						
Vehicle	Weight (lbs)	Length (feet)	Width (feet)	Height (feet)	Required Overhead (feet)	Work Area Required
Track-mounted CPT Rig	42,000 [1]	20	9	14	17	12 feet wide by 45 feet long
(1) For reference, a fully loaded tandem trailer tomato haul truck weighs approximately 60,000 lbs						

DCA
DELTA CONVEYANCE **DESIGN**
& CONSTRUCTION AUTHORITY

Truck-Mounted Rotary Drill Rig

Soil borings will be performed at various locations within the Delta Conveyance project area. Soil borings will be performed using a truck-mounted rotary wash drill rig similar to those shown in Images 1, 2, and 3. Samples are taken using a variety of sampling tools in the drill hole as drilling progresses. For drill holes that extend fairly deep, the drilling operation switches to rotary wash drilling to maintain hole stability by introducing drilling mud. Drilling mud includes a mixture of potable water, drilling polymers, and/or bentonite clay.

Image 1. Truck-Mounted Rotary Drill Rig

Image 1. Truck-Mounted Rotary Drill Rigs

Image 3. Mud-Rotary Wash Drilling

DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Truck-Mounted Rotary Drill Rig

Field Procedure

After acquiring permits and performing public and private utility locates, the crew will advance a hand auger to a depth of 5 feet to reduce the possibility of striking a buried utility line. If the area to be tested is paved, a hole will be cored. The drill rig will then be aligned over the exploration location and outriggers will be extended to stabilize the rig. Wood blocks will be placed under the outriggers to distribute the load and limit ground disturbance, as required. If the ground is too soft, mats will be used, or a track-mounted rotary drill rig will be deployed.

At the start of the boring (at ground surface), hollow stem augers are turned into the ground. The augers work by digging while simultaneously turning and lifting the soil cuttings to the surface. Each auger flight is five feet in length. After a flight of augers is drilled into the ground, a second auger is bolted onto the prior auger. Augers are added for the upper approximately 10 to 25 feet. As the drilling progresses, soil samples are collected continuously from the borehole. The soil samples are collected in hollow samplers that are pounded into the ground by a mechanized hammer attached to the drill rig or by coring samples using the rotary head.

After having drilled down through the upper soils, the drilling is converted to mud-rotary by either removing the hollow stem augers or setting casing. Steel casing is then lowered or driven into the boring to the bottom of the borehole. A drill rod with a bit is then lowered through the casing to begin drilling. As the drilling continues deeper, mud and cuttings flow up to the surface, where the soil cuttings are separated from the drilling fluid and the cuttings are placed into 55-gallon steel drums.

After collecting soil samples and drilling to the planned total depth of the boring, downhole geophysics will be completed in selected drill holes. These geophysical tests are conducted by lowering an instrument attached to a cable and measuring various properties of the soils. After collecting the geophysical information, the borehole will be backfilled as described below.

Borehole Abandonment

Boreholes will be backfilled with grout in accordance with State and County requirements. Where required, the County inspection office will be notified.

Surface Restoration

Restoration will be conducted in accordance with temporary entry permit.

Anticipated Duration

Explorations will be conducted to depths ranging from about 50 to 200 feet below ground surface and will take about 1 or 2 weeks to complete depending on site access and subsurface conditions.

DCA
DELTA CONVEYANCE DESIGN
& CONSTRUCTION AUTHORITY

Truck-Mounted Rotary Drill Rig

Typical Properties for a Truck-Mounted Rotary Drill Rig						
Vehicle	Weight (lbs)	Length (feet)	Width (feet)	Height (feet)	Required Overhead (feet)	Work Area Required
2 Axle Rotary Truck-Mounted Drill Rig	32,000 [1]	30	8	11		
Water Truck	44,000 [1]	35	8	10	35	12 feet wide by 70 feet long
Liftgate Truck	25,000 [1]	25	5	8		

(1) For reference, a fully loaded tandem trailer tomato haul truck weighs approximately 60,000 lbs

Track-Mounted Rotary Drill Rig

Soil borings will be performed at various locations within the Delta Conveyance project area. Soil borings are performed using a track-mounted drill rig similar to those shown in Images 1 and 2. The track-mounted drill rigs are equipped with both hollow-stem augers and rotary wash drilling equipment. Samples are taken using a variety of methods in the drill hole as drilling progresses. For drill holes that extend fairly deep, the drilling operation switches to rotary wash drilling to maintain hole stability by introducing drilling mud. Drilling mud includes a mixture of potable water, drilling polymers, and/or bentonite clay.

Image 1. Track-Mounted Rotary Wash Drill Rig

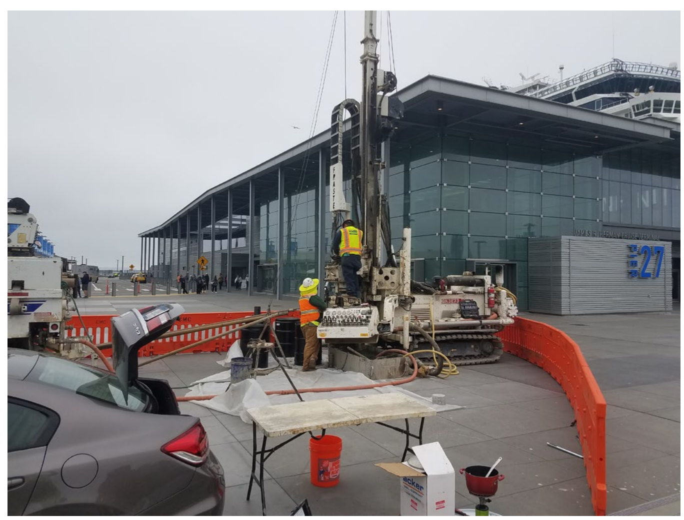


Image 2. Track-Mounted Rotary Wash Drilling

DCA
DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Track-Mounted Rotary Drill Rig

Field Procedure
After acquiring permits and performing public and private utility locates, the crew will advance a hand auger to a depth of 5 feet to reduce the possibility of striking a buried utility line. If the area to be tested is paved, a hole will be cored. The drill rig will then be aligned over the exploration location and outriggers will be extended to stabilize the rig. Wood blocks will be placed under the outriggers to distribute the load and limit ground disturbance, as required.

At the start of the boring (at ground surface), hollow stem augers are turned into the ground. The augers work by digging while simultaneously turning and lifting the soil cuttings to the surface. Each auger flight is five feet in length. After a flight of augers is drilled into the ground, a second auger is bolted onto the prior auger. Augers are added for the upper approximately 10 to 25 feet. As the drilling progresses, soil samples are collected continuously from the borehole. The soil samples are collected in hollow samplers that are pounded into the ground by a mechanized hammer attached to the drill rig or by coring samples using the rotary head.

After having drilled down through the upper soils, the drilling is converted to mud-rotary by either removing the hollow stem augers or setting casing. Steel casing is then lowered or driven into the boring to the bottom of the borehole. A drill rod with a bit is then lowered through the casing to begin drilling. As the drilling continues deeper, mud and cuttings flow up to the surface, where the soil cuttings are separated from the drilling fluid and the cuttings are placed into 55-gallon steel drums.

After collecting soil samples and drilling to the planned total depth of the boring, downhole geophysics will be completed in selected drill holes. These geophysical tests are conducted by lowering an instrument attached to a cable and measuring various properties of the soils. After collecting the geophysical information, the borehole will be backfilled as described below.

Borehole Abandonment
Boreholes will be backfilled with grout in accordance with State and County requirements. Where required, the County inspection office will be notified.

Surface Restoration
Restoration will be conducted in accordance with temporary entry permit. Track-mounted equipment will be delivered and picked up by tractor trailers.

Anticipated Duration
Explorations will be conducted to depths ranging from about 50 to 200 feet below ground surface and will take about 1 or 2 weeks to complete depending on site access and subsurface conditions.

Track-Mounted Rotary Drill Rig

<table>
<tr><th colspan="7">Typical Properties for a Track-Mounted Rotary Drill Rig</th></tr>
<tr><th>Vehicle</th><th>Weight (lbs)</th><th>Length (feet)</th><th>Width (feet)</th><th>Height (feet)</th><th>Required Overhead (feet)</th><th>Work Area Required</th></tr>
<tr><td>Track-Mounted Drill Rig</td><td>40,000 [1]</td><td>23</td><td>8</td><td>11</td><td>35</td><td rowspan="2">12 feet wide by 70 feet long</td></tr>
<tr><td>Track-Mounted Support Vehicle</td><td>30,000 [1]</td><td>25</td><td>8</td><td>11</td><td>11</td></tr>
<tr><td colspan="7">(1) For reference, a fully loaded tandem trailer tomato haul truck weighs approximately 60,000 lbs</td></tr>
</table>

Delta Conveyance Design & Construction Authority
Technical Memorandum

Subject:	**DCA Boring and CPT Logging Standards and Work Procedures**
Project feature:	Geotechnical
Prepared for:	California Department of Water Resources (DWR), Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	Files
Date/Version:	February 19, 2021/Final Draft
Reference no.:	GDE-GE-Boring and CPT Logging Standards-02192021

The Delta Conveyance Design and Construction Authority Boring and CPT Logging Standards and Work Procedures presents the soil description and classification procedures established for the geotechnical exploration program for the Delta Conveyance Project for the Department of Water Resources.

Contents

Attachments

Tables

Figures

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
Caltrans	California Department of Transportation
C_c	coefficient of curvature
CMT	California Test Method
CPT	Cone Penetrometer Test
CU	Consolidated Undrained
C_u	coefficient of uniformity
c_{vh}	coefficient of consolidation
DCA	Delta Conveyance Design and Construction Authority
DCO	Delta Conveyance Office of the Department of Water Resources
DCP	Delta Conveyance Project
DPT	Data Processing Team
DWR	State of California Department of Water Resources
EDM	Engineering Design Manager
ET	Exploration Team
ER	drill rod energy ratio
Rf	friction ratio
Fs	sleeve friction
GC	Geotechnical Consultant (Fugro USA Land, Inc. Team)
GEP	Geotechnical Exploration Plan
gINT	Geotechnical Integrator Boring Log Software
GIS	Geographic Information System
HCl	Hydrochloric acid
HSSE	Health, Safety, Security, and Environmental
ID	inside diameter
k	hydraulic conductivity
lb	pound
LT	Laboratory Team
mm	millimeter
µm	micrometer
OD	outside diameter
PCPT	Pre-field Coordination and Testing
PID	Photoionization Detector
QA	Quality Assurance
QC	Quality Control

Qc	cone resistance
QMP	Quality Management Plan
Qt	corrected cone resistance
q_u	unconfined compressive strength
SAI	Soil Abrasivity Index
SAT	Soil Abrasion Test
SBT	Soil Behavior Type
SPT	Standard Penetration Test
S_u	undrained shear strength
TEMT	Technical Execution Management Team
tsf	tons per square foot
u	pore pressure
USCS	Unified Soil Classification System
UU	Unconsolidated Undrained

1. Introduction

The Delta Conveyance Design and Construction Authority (DCA) Boring and Cone Penetration Testing (CPT) Logging Standards and Work Procedures (Logging Standards) presents the exploration logging and the soil description and classification procedures established for the geotechnical exploration program for the Delta Conveyance Project (DCP). Exploration documentation and detailed soil descriptions and classifications are an essential part of the information developed to support DCP. This document provides informative, consistent, and precise classification and description guidance on geotechnical data to be collected by the Geotechnical Consultant's (GC's) Exploration Team (ET) and the Data Processing Team (DPT). The information presented is based on the Soil and Rock Logging Manual (DWR, Division of Flood Management, September 2009 Soil & Rock Logging Manual) modified to address project specific needs. The procedures are in general conformance with applicable American Society for Testing and Materials (ASTM) standards and other publications commonly used in the industry. All ASTM standards are with reference to the most recent year of publication.

In addition to soil classification and description, this document contains instructions that describe DPT-specific boring and sample identification practices and designations, minimum material requirements for various laboratory tests, and boring and CPT log presentation format. This document also summarizes the DPT review process and the procedure for assigning laboratory testing by the Laboratory Team (LT).

These Standards should be read in conjunction with the Field Exploration Standards and the Laboratory Standards to ensure complete understanding of related procedures and standards. This document may be updated, when necessary, to reflect changes to the Standards authorized during the duration of the project.

1.1 Purpose and Scope

The purpose of these Standards is to define the DCA's practice for soil description and classification, boring and CPT log presentation, and the DPT workflow process. To that end, these Standards are divided into the following sections:

- Section 1: Introduction
- Section 2: Procedures for exploration logging and soil classification and description;
- Section 3: Data Processing review and workflow
- Section 4: Procedures for soil classification and description using laboratory test results;
- Section 5: Development and presentation of final boring logs; and
- Section 6: Development and presentation of CPT data.

The procedures presented within these Standards will be utilized by GC, DCA, and DCO staff.

1.2 Project Related Documents

The following documents are referenced in this report:

- Exploration and Testing Work Procedures Overview,
- Geotechnical Exploration Plan (GEP),

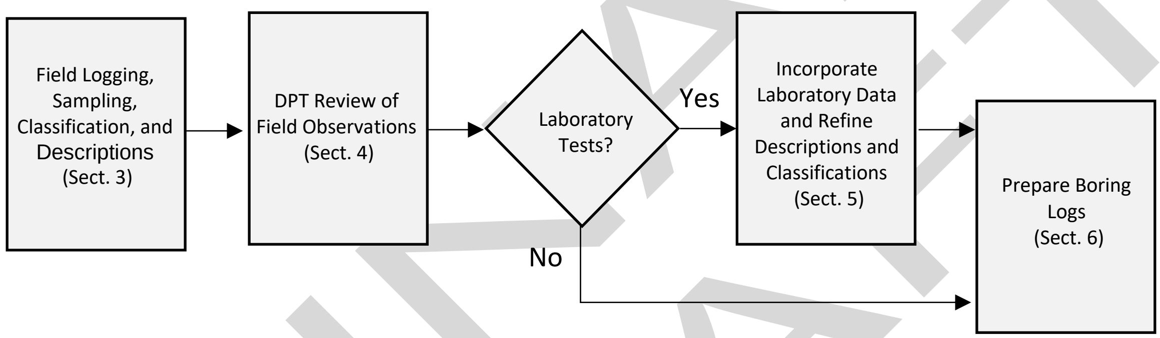
- Pre-field Coordination and Testing Standards (PCPT)
- Field Exploration Standards,
- Laboratory Standards,
- Quality Management Plan (QMP), and
- Health, Safety, Security, and Environmental Management (HSSE) Plan.

DPT and ET members will familiarize themselves with the project-related documents listed above and all associated project requirements.

1.3 Data Processing Team

The GC's DPT is responsible for processing and presenting the data collected from the field explorations. The following is a schematic representation of the process from obtaining subsurface information to the creation of boring logs.

Figure 1-1. Boring Log Process



DPT roles, responsibilities, and tasks are listed below.

- Data Processing Team Leader:
  - Develop documents for program implementation,
  - Provide technical guidance and oversight in program execution,
  - Provide logging standards training to ET, DPT, and others as needed,
  - Coordinate DPT tasks among team members,
  - Establish and implement quality assurance (QA) and quality control (QC) measures for the DPT,
  - Provide feedback to ET and LT, if warranted,
  - Provide weekly progress reports, including task order costs and schedule to the GC Project Manager, and
  - Provide program status and collected information to the GC Team.
- Data Processing Team staff:
  - Participate in DPT training and QC tasks,
  - Review field log data and resolve apparent errors and discrepancies,
  - Review soil samples,

- Perform manual testing, such as torvane and plasticity determination,
- Assess and document suitability and availability of soil samples for desired laboratory testing, and
- Refine boring logs from results of laboratory testing.

1.4 Quality Assurance

Quality assurance (QA) of field exploration activities will be conducted through a review/checking process where field activities conducted are compared against the established procedures outlined in this document. The procedures documented in this memorandum are intended to establish a consistent, systematic approach to all field activities in accordance with industry standards, with a focus on providing high quality field and laboratory data to meet the quality requirements of the DCP Program. In addition to planning for quality and implementing established procedures to ensure quality, periodic audits will be conducted by the Quality Assurance Manager (QAM). The audits will be used to document and improve quality procedures in use and to monitor and identify when measures need to be added to improve upon established procedures to ensure high quality data is delivered.

1.5 Quality Control

Quality control (QC) measures will be employed throughout the duration of the field exploration activities of the DCP to review and check various activity details to ensure providing quality data for the project. For the DPT, training and document review procedures are key. Periodic quality assessments or audits of DPT review staff will be performed by the DPT lead to evaluate the accuracy and completeness of their soil classification review. DPT reviews will also be used to help ensure quality processes in ET and LT technical teams. Persistent errors or deficiencies in field logging will be discussed with the ET lead to promote improvement to the overall logging and deliverable process. Questionable lab testing results will be discussed with the LT to make needed corrections in the laboratory testing process, at designated laboratories, or with individual laboratory testing staff.

Each version of the logs will be labeled with their current status in accordance with the following:

- Rev0 – Uncorrected Field log – paper log as developed in the field,
- Rev1 – Corrected Field Log – gINTed log that incorporates refinements from review of field data and soil samples,
- Rev2 – Final Draft Log – incorporates refinements from laboratory testing data, and
- Rev3 – Final Log – incorporates DCA and DCO edits and comments.

1.5.1 Onboarding

All DPT and ET staff must be on the list of DCA approved personnel and need to have completed DPT-specific training. Documentation of personnel training will be maintained by the DPT Lead.

Personnel new to the DPT and ET must familiarize themselves with this document and the documents listed in the Project Related Documents section and have completed all required training.

To ensure quality and accuracy, individuals involved in DPT review of soil and laboratory testing assignments will meet the following education and experience requirements:

- Licensed professional geologist (PG) or engineer (PE) in the state of California, and

- Have a minimum of 10 years of experience with a focus on geotechnical explorations, soil description/classification and subsurface characterization.
- Have a minimum of 5 years of experience assigning laboratory tests and incorporating laboratory test results into boring logs.

1.5.2 Training

The DPT Lead will provide training for DPT and ET staff, which will include, at a minimum, review and commitment to following the established procedures identified below and described in this document:

- DPT review process, data management, and overall workflow (only DPT personnel),
- Geologic environment and properties of soil units likely to be encountered during exploration,
- Boring and CPT logging and soil classification procedures and methods presented in this document,
- Quality control measures to preserve data and sample integrity,
- Equipment use, calibration and operation, and
- Other applicable task instructions that may arise during the project.

2. Procedures for Exploration Logging and Soil Classification and Description

2.1 Introduction

This section presents the DC procedures for logging borings and CPTs and classifying and describing soil samples in the field based primarily on ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedures). These procedures will also be used by ET staff logging in the field and by the DPT during preliminary review of the soil samples. The procedure for classification of soils based on Unified Soil Classification System, incorporating laboratory test results in accordance with ASTM D2487 is presented in Section 4. Other documents (besides ASTM D2488) that were used to develop these procedures include:

- Engineering Geology Field Manual published by the Bureau of Reclamation, and
- Soil and Rock Logging, Classification, Description, and Presentation Manual (DWR Logging Manual) by California Department of Water Resources, Division of Flood Management (2009).

The classifications and descriptions presented in field logs are to be verified, calibrated, or corrected based on laboratory test results of selected soil samples, as described in Section 5 to develop final boring logs. Processing of primary CPT data is described in Section 6.

2.1.1 Overview of the Logging and Presentation Process

The process of creating a boring log takes place in four steps: (1) field sampling and logging and classification/description, (2) DPT review and editing of field descriptions in the office with collected soil samples, (3) refinement of descriptions and classifications based upon laboratory test results, and (4) preparation of the final boring log. In the final boring log, descriptions presented should be based on laboratory and field tests first, if available, and field logging second.

Prior to field explorations, ET and DPT personnel should have a basic understanding of project features, technical requirements, overview of the geological and geotechnical setting of the areas to be investigated, and the data and parameters that are to be collected for the DCP. Furthermore, the ET field personnel should have an understanding of the exploratory equipment and the operation procedures for drilling and sampling, as documented in the Field Exploration Standards and other field instructions; the site clearance procedures and information to be presented for each exploration in the Field Briefing Packets, as documented in the PCPT Standards; the HSSE Plan; the QMP; and the GEP for applicable information.

The process of recovering, labeling, and accurately describing and classifying samples is a detailed and involved process. Ensuring quality data requires a thorough DPT review of descriptions and collected samples and data once back in the office or laboratory prior to developing a laboratory test program. Next, with laboratory test results in hand, the DPT applies judgment considering both field observations and laboratory test results to describe and classify the soil. One might use only field observations due to the absence of laboratory test data and with the confirmation of field observation tests on index properties (Section 2) or adjusted field observations to reflect laboratory test results (Section 4) to describe a sample. Retesting of soil samples may be required, as needed, to confirm the accuracy of soil sample descriptions and classifications. DPT guidance on log presentation and whether multiple samples are grouped into layers or presenting a sample description at each sample location is discussed in Section 6.

During explorations, ET field personnel should attempt to log soil by grouping soil encountered into soil units. A soil unit is defined as a volume of soil material that has similar engineering and geologic characteristics and that was formed during a given time period under the similar geologic conditions. With this definition, soil properties within a unit can vary somewhat; however, the same general soil classification applies and from the perspective of the evaluation, the materials will behave similarly.

ET field personnel should define the extent and characteristics of soil units considering stratigraphy. It is helpful for ET field personnel to understand the geologic environment and the properties of soil units likely to be encountered prior to beginning the field exploration. While samples provide the most detailed information regarding soil composition, drill rig behavior, fluid circulation and returns, sampler driving resistance, sample recovery, and other factors also provide valuable data for classification.

In logging soil units, it is important to maintain consistent classification of soil between borings and within a boring. This allows the use of laboratory testing from selected samples to be used to evaluate and describe the geologic unit from which they came. This may be difficult on long-duration field exploration programs where the work extends over several days or where multiple individuals are logging soil. It is DCA's policy to edit the boring logs in the laboratory by the DPT to check classification and compare descriptions and samples from separate borings to help ensure that soil units that are encountered in adjacent borings are described and classified consistently.

2.2 General Project and Exploration Information

Some of the most important aspects of field work are properly identifying the location of the project site, location of exploration, drilling tools and methods used, and personnel involved in field work. The following is the minimum required general information for every field boring log.

- Date(s) of work,
- Boring Identification Number (see Table 1-1 in Attachment 1),

- Project and Site Features:
  - Project Name,
  - Location, and
  - County;
- Boring Location and Elevation:
  - Northing and Easting (or Latitude and Longitude), based on California State Plane coordinate system (Note: In the absence of accurate coordinate data, a suitable and verifiable field description may be temporarily used – e.g., distance to fixed object or benchmark, etc.),
  - Latitude and Longitude based on hand-held GPS device should be recorded in the field
  - Elevation, vertical datum;
- Personnel:
  - ET Field Supervisor,
  - Drill Operator/Helper, and
  - Subcontractor;
- Drilling and sampling equipment (verify with Driller):
  - Drill rig:
    - Type,
    - Manufacturer and model;
  - Drilling method (mud rotary, sonic, solid auger, hollow stem auger, etc.);
  - Drilling fluid constituents (bentonite, polymer type, etc.)
  - Drill rod description (type, diameter);
  - Drill bit description or hole diameter;
  - Casing and installation depth;
  - Hammer Type: (type, e.g., safety or automatic trip hammer, diameter):
    - Measured energy efficiency ratio,
    - Manufacturer and model;
  - Type of sampler(s) and size(s), see list in Table 1-3 in Attachment 1;
- Groundwater:
  - Reading Method (observed while drilling, measured in hole, etc.),
  - Date, time, and depth of each reading;
- Wells – see list in Table 1-2 in Attachment1:
  - Depth of screened zone, sand pack, seal material, grout (including per cent bentonite);
  - Marker/cap details;
  - Other pertinent details or items from drilling;
- Instrumentation– see list in Table 1-2 in Attachment 1;

- In-situ tests – see list in Table 1-4 in Attachment 1;
- Total depths, cause of termination (e.g., drilled to depth, refusal, early termination of traffic control, etc.), and abandonment (e.g., grout, dry bentonite chips, piezometers installed, slope inclinometer installed, etc.).

2.3 Assignment of Exploration Designation

The exploration designation for DCP explorations comprises a series of short, alphanumeric text strings representing the project, facility, exploration type, and number in the form of [XX][XXX]-[XXXX]-[XXXX]. An example exploration designation is DCIE3-SCPT-001, which represents the Delta Conveyance Project, East Intake 3, Seismic Cone Penetrometer, exploration number 001. Table 1-1 in Attachment 1 summarizes the naming and numbering protocol.

2.4 Sample Preparation and Identification for Laboratory Testing and Storage

The ET personnel performing the drilling, sampling, preserving, and transporting of soil samples play an important role in the quality of the laboratory test results. In addition to a brief discussion of soil coring discussed below, refer to the Field Explorations Standards, Attachment 6 for specific soil sample handling and storage.

Soil samples retrieved from coring are extruded in the field onto a logging tray (134 mm Geobarrel) or retrieved in clear plastic liners (Geobor-S). Geobarrel samples are logged in the field and portions retained from each distinct stratum within each core run. Portions of the Geobarrel samples retained are sealed in moisture-proof glass jars, labeled, and placed in boxes for storage. Portions of samples not retained are disposed in the field along with drill cuttings. Geobor-S samples recovered in clear plastic liners are logged in the field, visually through the clear liner and at the ends of the liner where the sample is exposed. The liners are then sealed, labeled, and returned to the GDPC for DPT review.

At the GDPC, Geobor-S liners are cut with an electric saw or router along the axis of the liner exposing the soil to allow for DPT review. Portions of the sample may be collected for laboratory testing. Portions of the remainder of the Geobor-S sample are selectively retained, placed in glass jars for storage for additional review and lab testing, if needed. Alternatively, the entire core sample, absent portions removed for laboratory testing, may be retained by wrapping and sealing in plastic wrap, and enclosing the wrapped sample in the split liner, which is resecured with tape for additional review and laboratory testing, if needed.

2.4.1 Sample Identification Designations

Every sample attempt, whether there is recovery or not, is assigned a unique designation. In a boring, samples are numbered chronologically for each sampling method, i.e., the first Standard Penetration Test (SPT) sample attempt from a given boring is given the number S01, the second S02, and so forth. The first Shelby tube would be numbered ST01, the second ST02, and so forth, regardless of its relative position to other samples obtained by different methods. All samples will be labeled with both the boring number and sample number. Table 1-3 in Attachment 1 summarizes the naming and numbering protocol for DCP soil samples.

2.4.2 Recommended Field Sample Size for Various Laboratory Tests

Table 3-3, below, lists recommended sample material amounts to be collected in the field for various laboratory tests to help ensure there is sufficient material for assigning desired laboratory tests. The recommended material amounts are generally more than the ASTM minimum sample size to allow for ancillary laboratory testing. For example, some engineering tests, such as consolidation, may dictate additional index tests, such as Atterberg Limits, for a more complete understanding of soil behavior. A list of laboratory test methods and names are provided in the table in Attachment 3, List of Geotechnical Laboratory Standard Test Methods. Refer to applicable latest ASTM standards and California Dept. of Transportation (Caltrans), California Test Methods (CTM) for the testing standards.

Table 2-1. Recommended Sample Material Amounts

Test Name	Test Method(s)	Material Required	Typical Sample Size/Type
Moisture Content	ASTM D2216	0.5 lb	1/2 Tube
Unit weight	ASTM D7263	1 lb	1 Tube
Specific Gravity	ASTM D854	0.5 lb	1/2 Tube
Grain Size Analysis (Sieve)	ASTM D6913	1 lb	1 Tube
Sedimentation Analysis (Hydrometer)	ASTM D7928	1 lb	1 Tube
Atterberg Limits	ASTM D4318	1 lb	1 Tube
Consolidation • Undisturbed – (2.0” Diameter) – (2.5” Diameter) • Remolded (2.0” Diameter)	ASTM 2435	- - 40 lb	1 Tube 1 Tube 1 Full Canvas Bag
Swell Potential • Undisturbed – (2.0” Diameter) – (2.5” Diameter) • Remolded (2.0” Diameter)	ASTM D4546	- - 40 lb	1 Tube 1 Tube 1 Full Canvas Bag
Collapse Potential • Undisturbed – (2.0” Diameter) – (2.5” Diameter) • Remolded (2.0” Diameter)	ASTM D5333	- - 40 lb	1 Tube 1 Tube 1 Full Canvas Bag
Direct Shear • Undisturbed Remolded	ASTM D3080	- 80 lb	1 Tube 2 Full Canvas Bags

Test Name	Test Method(s)	Material Required	Typical Sample Size/Type
Relative Compaction • Standard Proctor Modified Proctor	ASTM D698 ASTM D1557	40 lb	1 Full Canvas Bag
Permeability • Undisturbed – Falling Head • Remolded – Falling Head Constant Head	ASTM D5084	- 40 lb 40 lb	1 Tube 1 Full Canvas Bag 1 Full Canvas Bag
Unconfined Compression	ASTM D 2166	-	1 Tube or Core
Triaxial CU (3 points) • Undisturbed – (2.0" Diameter) – (2.5" Diameter) – (2.0" Diameter) – (2.5" Diameter) • Remolded – (2.8" Diameter) Triaxial UU (1 point) • Undisturbed – (2.0" Diameter) – (2.5" Diameter) – (2.5" Diameter) – (3.0" Diameter) • Remolded (2.8" Diameter)	ASTM D 4767 ASTM D 2850	- - 40 lb - - 40 lb	3 Tubes – in series 3 Tubes – in series 1 thin-walled Tube 1 thin-walled Tube 1 Full Canvas Bag 1 Tube 1 Tube 1 thin-walled Tube 1 thin-walled Tube 1 Full Canvas Bag
Shrinkage Limit	ASTM D4943	1 lb	1 Tube
Expansion Index	ASTM D4829	40 lb	1 Full Canvas Bag
Sand Equivalent	ASTM D2419	10 lb	1/4 Full Canvas Bag
R-Value	ASTM D2844	80 lb	2 Full Canvas Bags
Corrosion Sulfates Chlorides	CTM 643 CTM 417 CTM 422	10 lb	1/4 Full Canvas Bag
Organic Content	ASTM D2974	1 lb	1 Tube
PH Cation Exchange	EPA 9081	10 lb	1/4 Full Canvas Bag
Soil Abrasion Test (SAT)	Dahl et al. method – 2007 NTNU/SINTEF	10 lb	1/4 Full Canvas Bag

Test Name	Test Method(s)	Material Required	Typical Sample Size/Type
Soil Abrasivity Index (SAI)	Colorado School of Mines (CSM)	40 lb	1 Full Canvas Bag
Miller Number and Slurry Abrasion Response Number	ASTM G75	0.5 lb	1/2 Tube
Pinhole Dispersion • Undisturbed • Disturbed/Remolded	ASTM D4647	 0.5 lb 10 lb	 1/2 Tube 1/4 Full Canvas Bag
X-ray diffraction	XRD.US	0.02 lb	1/50 Tube
Soil age dating	AMS	0.02 lb	1/50 Tube
Resonant Column • Undisturbed – (2.0" Diameter) – (2.5" Diameter) – (2.5" Diameter) – (3.0" Diameter)	ASTM D4015		 3 Tubes – in series 3 Tubes – in series 1 thin-walled Tube 1 thin-walled Tube

Notes:

1. A 12" by 24" canvas bag completely filled contains approximately 40 lb of material.
2. One tube is 2" to 2.5" by 6" and contains approximately 1 lb of material.
3. One thin-walled tube is 2.5" to 3.0" by 3' and contains approximately 15 lb of material.
4. Minimum material weights shown for remolded samples include sufficient material for the development of a moisture density curve.

When calculating the number of triaxial samples that can be obtained from a Shelby tube, use a minimum sample length equal to three times the sample diameter.

2.5 Field Soil Description and Classification Procedures

Soil description and classification procedures presented in this section follow ASTM D2488, DWR Logging Manual (2009), and Engineering Geology Field Manual (US Bureau of Reclamation, 2001). The descriptive sequence presented in the following table shall be used when classifying and describing soils in the field. Items 3 to 10 shall be repeated to describe all the components of the subject soil to provide 100 percent descriptive coverage.

Table 2-2. Soil Classification Descriptive Sequence

Sequence Classification Components	Refer to Section	Required	Recommended	Optional	DPT Review
1. Group Name	2.5.1	✓			
2. Group Symbol	2.5.1	✓			
Sequence Description Components					
3. Percent or proportion of Cobbles and boulders	2.5.7	✓			
4. Percent or proportion of gravel, sand, or fines	2.5.6	✓			
5. Particle Size Range	2.5.8	✓			
6. Particle Angularity (for coarse sand and larger particles)	2.5.9		✓		
7. Particle Shape (for coarse sand and larger particles)	2.5.10		✓		
8. Hardness (for coarse sand and larger particles)	2.5.11		✓		
9. Plasticity (for fine-grained soils)	2.5.12	✓			
10. Dilatancy	2.5.16	✓			
11. Color (in moist condition)	2.5.4	✓			
12. Consistency (for cohesive soils)	2.5.2	✓			
13. Apparent Density (for cohesionless soils)	2.5.3	✓			
14. Moisture	2.5.5	✓			
15. Calcium Carbonate (Reaction with HCl)	2.5.13				✓
16. Structure	2.5.14	✓			
17. Cementation	2.5.15		✓		
18. Description of Cobbles and Boulders	2.5.7	✓			
19. Additional Comments (Fill/Odor)	2.5.17	✓			
20. Geologic or Soil Unit Name	2.5.18			✓	✓

The following is an example of a complete soil sample description using required and optional descriptive components.

> *Well-graded SAND with GRAVEL (SW), about 75% coarse to fine, rounded SAND, about 20% coarse, subrounded to rounded, flat and elongated GRAVEL, about 5% low plasticity fines, brown (7.5YR 5/2), medium dense, wet, weak cementation.*

2.5.1 Group Name and Group Symbol (After ASTM D2488)

This section provides standardized criteria and procedures for describing and classifying soils in the field using visual examination and simple manual tests. The soil is to be classified by assigning to it a group name and symbol. The tables provided in Attachment 2 are to be used for the classification of both fine- and coarse-grained soils and to determine the appropriate group symbol(s) and name to be used. According to ASTM D2488 soil constituents (e.g., sand, clay etc.) will be estimated to nearest 5 percent.

2.5.1.1 Fine-Grained Soils

A soil is considered to be a fine-grained soil if it contains 50 percent or more fines. Particles that pass through a Number 200 sieve are classified to be fine grained. Table 2-1 and 2-2 in Attachment 2 can be used as an aid in determination of soil classification based on soil gradation.

- If the soil is fine-grained, identify the soil as CL, CH, ML, or MH based on plasticity as described in Table 2.11.
- If the soil is estimated to have 15 to 25% sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML". If the percentage of sand is equal to the percentage of gravel, use "with sand."
- If the soil is estimated to have 30% or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML". If the percentage of sand is equal to the percent of gravel, use "sandy."
- Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy. Use the description terms shown in the Tables 2-3 and 2-4 to describe organic soil. Describe odor if applicable.

Table 2-3. Organic Soil

Percent Organic Soil	Description
50 to 100%	"Peat"
15 to 50%	"Organic (Soil Name)"
5 to 15%	"(Soil Name) with organics"

Table 2-4. Fiber Content

Descriptor for Peat or Organic Soil	Description
Fibric	Greater than 67% fibers
Hemic	Between 33% and 67% fibers
Sapric	Less than 33% fibers

After ASTM D4427 and D5715

2.5.1.2 Coarse-Grained Soil

A soil is considered to be a coarse-grained soil if it contains less than 50% fines. Coarse grained particles will not pass through a Number 200 sieve.

- The soil is classified as gravel if the percentage of gravel is estimated to be more than the percentage of sand; refer to Table 2-2 in Attachment 2.
- The soil is classified as sand if the percentage of gravel is estimated to be equal to, or less than, the percentage of sand.
- The soil is a clean gravel or clean sand if the percentage of fines is estimated to be 5% or less.
  - Identify the soil as well-graded gravel, GW, or as well-graded sand, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.
  - Identify the soil as poorly graded gravel, GP, or as poorly graded sand, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).
- If the soil is estimated to contain 15% or more fines, the words “clayey” or “silty” (whichever is more predominant) shall be added to the group name. For example: “silty sand, SM” or “clayey gravel, GC”.
- If the soil is estimated to contain between 5% and 15% fines, give the soil a dual identification using two group symbols.
  - The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a silty or clayey gravel or sand, as appropriate (GC, GM, SC, SM).
  - The group name shall correspond to the first group symbol plus the words “with clay” or “with silt” to indicate the plasticity characteristics of the fines. For example: “well-graded gravel with clay, GW-GC” or “poorly graded sand with silt, SP-SM”.
- If the specimen is predominantly sand or gravel but contains an estimated 15% or more of the other coarse-grained constituent, the words “with gravel” or “with sand” shall be added to the group name. For example: “poorly graded gravel with sand, GP” or “clayey sand with gravel, SC” or “well- graded sand with silt and gravel, SW-SM”
- If the field sample contains cobbles, boulders, or both, follow the procedures listed in section 2.5.7 for percentages by volume and weight.

2.5.1.3 Borderline Symbol and Name

Since field classification is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH. A borderline symbol may be used when:

- The percentage of fines is estimated to be between 45 and 55%. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.
- The percentage of sand and the percentage of gravel are estimated to be about the same. For example: SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.
- The soil could be either well-graded or poorly graded. For example: GW/GP, SW/SP.

- A fine-grained soil has properties that indicate that it is at the boundary between a soil of low plasticity and a soil of high plasticity. For example: CL/ML, CL/CH, MH/ML.

The group name for a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Effort should be made to place the soil into a single group.

2.5.1.4 Dual Symbol

A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC are used to indicate that the soil has been identified as having the properties of a classification in accordance with ASTM Test Method D2488 where two symbols are required. Two symbols are required for coarse-grained soils when the soil has between 5 and 15 % fines. Dual symbol for fine-grained soils (e.g., CL-ML) is not included in ASTM D2488 and will not be used in field logging but the description will be updated by the DPT team based on laboratory test results, if needed.

2.5.2 Consistency (Cohesive Soils)

The preferred procedure for the determination of consistency of cohesive soils is to obtain relatively undisturbed samples and perform field tests with a pocket penetrometer or torvane shear tester (hand-held vane shear device). Every effort should be made to take pocket penetrometer and/or torvane measurements and record consistency according to Table 2-5. However, if no pocket penetrometer or torvane measurement is recorded, then consistency in the field may be recorded based on SPT N-value, blow counts from a split barrel sampler other than SPT, or indentation test, according to Table 2-6. Refer to Section 2.5.3 for discussion regarding energy-corrected blow counts. For the final boring log, consistency will be revised by the DPT team based on laboratory test data, if needed.

Table 2-5. Consistency of Cohesive Soils

Descriptor (after AASHTO 1988)	Pocket Penetrometer Measurement (tsf)	Torvane Measurement (tsf)
Very Soft	< 0.25	< 0.12
Soft	0.25 to 0.50	0.12 to 0.25
Medium Stiff	0.50 to 1.0	0.25 to 0.50
Stiff	1 to 2	0.50 to 1.0
Very Stiff	2 to 4	1.0 to 2.0
Hard	> 4.0	> 2.0

After DWR Logging Manual

Table 2-6. Consistency of Cohesive Soils Based on Indentation Test or Blowcount

Consistency	Identification Procedure	Approximate Properties	
		SPT N (blows/foot)	Split-Barrel Sampler Blow Count (3-in. OD; 2.38-in. ID w/SPT Hammer)
Very Soft	Easily penetrated several inches by thumb	0-1	0-2
Soft	Easily penetrated several inches by thumb	2-4	3-6
Medium Stiff	Penetrated several inches by thumb with moderate effort	5-8	7-13
Stiff	Readily indented by thumb, but penetrated only with great effort	9-15	14-24
Very Stiff	Readily indented by thumb nail	16-30	25-47
Hard	Indented with difficulty by thumb nail	>30	>47

Strengths of silts with medium to high plasticity (Section 2.5.12) should be described by consistency. Likewise, silts with low to no plasticity shall have their strength described by apparent density (Section 2.5.3).

2.5.3 Apparent Density (Granular Soils)

The blow count from an SPT sampler or a split barrel sampler other than SPT constitutes the $N_{measured}$. Field personnel should note apparent density in the field log based on energy-corrected blow counts (SPT N) or energy-corrected equivalent SPT N-values (corrected for split barrel samplers other than SPT) and referred to as N_{field} using the apparent density descriptors shown in the following table. The correction factor for the proposed split-barrel sampler (3-inch OD; 2.38-in. ID) is 0.63, while the energy correction is a ratio of the measured efficiency of the specific hammer in use to the theoretical efficiency of 60 percent. The final logs prepared by the DPT team will account for additional correction factors to revise the apparent density, as needed.

Table 2-7. Apparent Density Descriptors of Granular Soils

Apparent Density	N_{field} (blows/ft)	Split-Barrel Sampler Blow Count (3-in. OD; 2.38-in. ID w/SPT Hammer)
Very loose	0 – 4	0 – 6
Loose	5 – 10	7 – 16
Medium dense	11 – 30	17 – 47
Dense	31 – 50	48 – 79
Very dense	>50	>80

After DWR Manual with addition of Split-Barrel Sampler

2.5.4 Color

The color name from the *Munsell Color System* should be used to describe soil color at the time of drilling and sampling. The color shall be described for moist samples [*Ex: Pale Yellow Brown*]. Color is an important property in identifying organic soils, and it may also be useful in identifying materials of similar geologic origin within a given locality. If the sample contains layers or patches of varying colors, this shall be noted, and all representative colors shall be described. ASTM D1535, *Standard Practice for Specifying Color by the Munsell System*, can be referenced for additional information.

2.5.5 Moisture

Describe the moisture condition as dry, moist, or wet. If the observed moisture of a sample appears to have been influenced by the drilling method (i.e., drilling fluid infiltrating sample), it should be noted on the field log.

Table 2-8. Moisture Descriptors

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

After ASTM D2488

2.5.6 Percent or Proportion of Soils

Use ASTM D2488 to describe the estimated percentage (to the nearest 5 percent) or proportion of gravel, sand, and fines, by weight of the total sample excluding the cobbles and boulders. Adjectives, such as trace, few, little, etc. should be avoided since percentages are being used and their meaning varies depending on the soil classification system used.

2.5.7 Gravel, Cobbles, and Boulders

The presence of gravel, cobbles, boulders, and other oversize materials can have significant impact on construction. Therefore, it is important to document coarse and oversized materials encountered or inferred during geotechnical explorations. Direct identification of gravel, cobbles, and boulders can be difficult with conventional, small diameter borings; therefore, it is important to note other indicators that could suggest the presence of cobbles and boulders. Examples of such indicators include:

- Geological depositional environment.
- Results of previous explorations nearby.
- Evidence of exposed material on site or in nearby stream channel banks.
- Refusal or difficult driving of samplers and related shoe damage, freshly broken rock fragments recovered, or bouncing of the sampler and drill rod string.
- Widely varying blow counts within a particular layer.
- Loss of drilling fluid when using rotary-wash methods.
- Pushing larger materials down in front of the drill bit.
- Very slow or difficult drilling progress.
- Rig chatter.
- The results of nearby large diameter bucket auger holes and/or test pits.

The ASTM procedure for identifying and describing fine-grained and coarse-grained soils is only applicable to material passing the 3-inch sieve (coarse gravel). The sampler used could be as small as 1.4 inches in ID, which prevents the entry of all but fine gravel into the barrel. If the presence of gravel, cobbles, or boulders is identified or inferred during the site exploration, it should be very clearly indicated on the boring logs. It may also be useful to count blows per 1-inch of sampler penetration when materials with a gravel and/or larger material is encountered. This can help identify when the sampler tip is blocked by gravel, resulting in artificially high blow counts following blockage.

When noting the presence of oversize material, the reason for the inference should be given, such as "rig chatter and drill string bouncing potentially indicative of cobbles/boulders or other obstructions." Isolated boulders may be treated as individual units and described as such. Describe cobbles and boulders, if encountered, using the descriptive sequence for rock in Section 2.5 of the DWR Logging Manual.

If encountered in large diameter bucket auger holes and/or test pits, the volume of cobbles and boulders should be estimated and reported as percentage of total volume. Estimation of volume of cobbles and boulders is based upon recovered intersected lengths, drilling chatter, and observations and experience of the driller and ET field representative.

If the sample or layer is estimated to be more than 50% cobbles and/or boulders by volume, the layer should be described as "COBBLES," "BOULDERS," or "COBBLES and BOULDERS," with the soil matrix description following. Examples follow:

If it is estimated that 40% by volume of the material is cobbles, describe the sample in this way:

> *Well-graded SAND with GRAVEL and COBBLES (SW), medium dense, brown to light gray, wet, gravel to 3" in greatest dimension, about 40% cobbles [SEDIMENTARY ROCK (SANDSTONE), hard, intersecting lengths from 5 to 10 inches].*

If it is estimated that 60% by volume of the material was cobbles, describe the layer as:

COBBLES with well-graded SAND with GRAVEL, about 60% cobbles [SEDIMENTARY ROCK (SANDSTONE), fresh, hard, gray, medium sand, rounded to subrounded, intersecting lengths from 8 to 10 inches], matrix consists of well-graded SAND with GRAVEL, medium dense, brown to light gray, wet.

Note that the Group Symbol is not used in the last example, because cobbles and boulders are the predominant material.

2.5.8 Particle Size

Table 2-9. Particle Size Descriptors

Descriptive Term	Size	Familiar Example
Boulder	>12 in (300mm)	Larger than a basketball
Cobble	3 to 12 in (75 to 300 mm)	Larger than a Grapefruit or Orange
Coarse Gravel	¾ to 3 in (19 to 75 mm)	Larger than a Walnut or Grape
Fine Gravel	No.4 to ¾ in (4.75 to 19 mm)	Larger than a Pea
Coarse Sand	No.10 to No.4 (2.00 to 4.75 mm)	Larger than Rock Salt Grain
Medium Sand	No.40 to No.10 (425 µm to 2 mm)	Larger than openings of a Window Screen
Fine Sand	No.200 to No.40 (75 to 425 µm)	Size of a Granulated Sugar Grain

After ASTM D2488

2.5.9 Particle Angularity

Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded as indicated by the criteria in the following table and photo. A range of angularity may be stated, such as subrounded to rounded.

Table 2-10. Particle Angularity Descriptors

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

Figure 2-1. Particle Angularity Examples (after ASTM D2488)

2.5.10 Particle Shape

Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in the table below. Otherwise, do not mention the shape. Indicate the percentage of the particles that have the shape, such as: 20 percent of the gravel particles are flat.

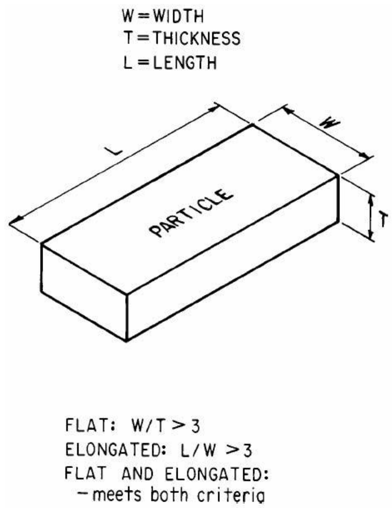
The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Table 2-11. Particle Shape Descriptors

Description	Criteria
Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

After ASTM D2488

Figure 2-2. Particle Shape Example



2.5.11 Hardness (After ASTM D2488)

For sand and gravel, describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

2.5.12 Plasticity (for Fine-Grained Soils)

Describe the plasticity of the material in accordance with the criteria given in the table below.

Table 2-12. Plasticity Descriptors for Fine-Grained Soils

Description	Criteria
Non-plastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

After ASTM D2488

2.5.13 Reaction with Hydrochloric Acid (HCl)

Describe the reaction with dilute hydrochloric acid (HCl) as none, weak, or strong, in accordance with the criteria in the table below. Since calcium carbonate is a common cementing agent, reporting its presence based on the reaction with dilute HCl (typically 10 percent solution) is important.

Table 2-13. Calcium Carbonate Descriptors

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

After ASTM D2488

2.5.14 Structure

Describe the structure of intact soils in accordance with the criteria in the table below.

Table 2-14. Structure Descriptors

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick; note thickness.
Laminated	Alternating layers of varying material or color with the layers less than ¼ inch (6 mm) thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

After ASTM D2488

2.5.15 Cementation

Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in the table below.

Table 2-15. Cementation Descriptors

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

After ASTM D2488

2.5.16 Dilatancy

To perform a dilatancy test, mold the material into a ½-inch diameter ball adding water if necessary, to make it soft. Shake the ball horizontally in the palm, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers and note the reaction in accordance with the criteria in the table below.

Table 2-16. Dilatancy Descriptors

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

After ASTM D2488

2.5.17 Sample Recovery

The sample recovery value, with few exceptions, provides an indication of the success of the drilling and sampling operation in recovering the cored material. Portions of the cored material mass may not be recovered because the fluid used in the drilling operation transports portions of the mass during the coring operation or soil is not completely retained in the sampler. Sample recovery is expressed as a percentage.

$$Recovery = \frac{(Length\ of\ recovered\ soil) \times (100\%)}{Length\ of\ the\ sample\ run}$$

2.5.18 Additional Comments and Information

Additional constituents and soil characteristics not included in the previous categories may be noted. Observations may include:

- Presence of roots or root holes,
- Presence of mica, gypsum, etc.,
- Presence of volcanic ash (tephra),
- Surface coatings on coarse-grained particles,
- Oxide staining,
- Odor,
- Fill Indicators [common fill indicators include glass, brick, clay pipe, dimensioned lumber, concrete debris, asphalt debris, metal, plastics, plaster, etc. Other items that may suggest fill include buried vegetation mats, tree limbs, stumps, etc. The size and distribution of fill indicators may be noted. The limits (depth range) of fill material should be determined and identified at each exploration location], and

- Presence of contaminants based on visual observation or odor. Readings from Photoionization Detector (PID) should be recorded for each sample. Procedures for PID use are included in the Field Exploration Standards.

2.5.19 Unit Name

The soil description for a fill material should be followed by the term "(Fill)", i.e., for a sandy silt with some brick fragments the description would be "SANDY SILT (ML), with brick fragments (Fill)". The size and distribution of fill indicators should be noted. The limits (depth range) of fill material should be determined and identified at each exploration location. Other potential unit names are listed in the table in Attachment 5.

2.5.20 Other Drilling Observations

Other observations, not included in the descriptive sequence, may include:

- Caving or sloughing of bore hole or trench sides,
- Difficulty in augering or excavating, etc.,
- Observations or generic name (e.g., hard pan, fault gouge, etc.),
- Groundwater inflow, elevation(s), and estimated rate(s),
- Drilling pressures,
- Hydraulic sample pressure for push-samples,
- Water fluid pressure and artesian conditions,
- Water loss or loss of drilling fluids,
- Use of casing (type, thickness, depth, method of advance, etc.),
- Delays (nature, duration, timing, cause, etc.),
- Driller's observations,
- Color change,
- Any additives, and
- Grouted (volume, constituents, timing, etc.).

2.6 Photographic Documentation

ET personnel are to take digital photographs to aid in documentation of site conditions, sample conditions, or unusual or unexpected events on site. A log of photographs should be included in the Daily Field Report form. A summary log of photographs should be completed. The summary log should include one or more sentences indicating the approximate number of photographs taken, date and time, and the subject or subjects of the photographs.

Beginning a series of photographs with an overall view of the site, and then zooming in on areas of interest provides perspective on what is being photographed. Photographs of exploration locations and surroundings should be documented before and after completion of explorations.

For close-up photographs of soil samples, include a tape measure or ruler in the photograph to aid the viewer. The boring designation, sample number, and depth should be written on a white marker board to provide a label in the photograph to identify the soil sample.

2.7 Rock Classification Procedures for Borehole Cores

Although encountering rock is not anticipated in the proposed subsurface explorations, cobbles and boulders may be encountered and should be described using rock classification procedures. Refer to Section 2.5 of the DWR Logging Manual for DC rock classification.

3. Data Processing Review and Workflow

3.1 Introduction

Work in the field can be fast-paced and subject to difficulties associated with remote sites and adverse weather. These conditions can lead to errors in labeling, documenting required information, and sample descriptions. The DPT will provide a quality check of basic boring and CPT data, collected soil samples, field descriptions, and summary descriptions to ensure that accurate boring logs are developed in accordance with these Logging Standards and other DCA standards and protocols.

3.1.1 Borings

The DPT quality control review process for borings consists of a series of sequential steps conducted in a controlled environment, such as a warehouse or laboratory, that result in progressive refinements to the boring log, from the uncorrected field log to the final log. These review steps will be documented and tracked per project-developed protocols. For the purposes of lab testing assignments by others, the DPT will record sample quality relative to the suitability for lab testing on the sample inventory and may suggest samples for testing. The DPT review process will include the checking of data entry accuracy.

Sound engineering design is based on appropriately and accurately characterizing ground conditions. As such, the DPT review process is an integral step in developing boring logs that meet the quality standards required to achieve the engineering objectives of this project and to ensure that the logs best represent subsurface conditions.

3.1.2 CPTs

The CPT is an in-situ test for evaluating geotechnical engineering properties and delineating soil stratigraphy. Refer to the Field Exploration Standards for field procedure to conduct CPTs, including seismic CPTs and dissipations tests.

The stratigraphic interpretation, referred to as the soil behavior type, is based on empirical correlations to measured cone resistance, sleeve friction, and pore pressure data recorded by the CPT. It is not always possible to clearly identify a soil type based solely on cone resistance, sleeve friction, and pore pressure. Correlation to adjacent borings and estimation of overburden stress and pore pressure are important steps in the engineering process to develop a final CPT log. The DPT will review the field CPT logs, update and revise the log based on groundwater level, overburden stress, and pore pressure measurements. DPT will also review the data from SCPT and dissipation tests. The details of the field data and its review and revision process are presented in Sections 2 and 4.

3.2 Boring Log and Soil Sample Review

3.2.1 Soil Sample Check-In, Handling, and Storage

Samples will be transported daily from the field to the designated laboratory or testing facility by the ET. Samples received will be compared to chain of custody records. Samples will be assessed for proper closure or sealing and labeling, logged in sample database, and then stored to preserve sample quality and soil characteristics. Bulk samples, split-spoon and continuous soil core samples and boxes will be stored on shelves. Thin-walled tube samples, such as Shelby tubes, are to be stored vertically in a temperature-controlled room awaiting review and laboratory testing assignment.

Soil samples will remain appropriately stored until they are retrieved for DPT review. During DPT review, samples will be handled and transported with care to minimize disturbance and preserve sample integrity. Once soil review and laboratory testing are complete, samples will be placed in long-term storage in accordance with project specifications.

3.2.2 DPT Data Check

The data check process is to identify and correct absent, inconsistent, or erroneous information. Before performing soil review, basic field data recorded on the raw field log and in notes are checked to ensure accuracy to avoid introducing errors to logs and to maintain accuracy of sample inventory and record database. At a minimum, the DPT will perform the following QC checks:

- Compare collection data on samples received to chain of custody records;
- Ensure that the previously defined minimum required general information are provided;
- Assess accuracy of, and agreement between, sample labeling and field logs; and
- Evaluate completeness of well construction documentation such as materials, symbols, and depths.

If errors or omissions in basic field data are identified, the DPT will make every reasonable effort to resolve these issues. This includes consultation with the ET field supervisor (logger) and the review of the sample inventory and adjacent soil samples within the same boring. A deficiency report may need to be prepared if samples are identified as missing.

3.2.3 DPT QC Soil Review and Boring Log Update

Following sample review and resolution of sample issues, a review of the field soil description notations should be made. Soil samples will be compared to the field logs and description corrections made as needed. The goal of soil review is to improve the accuracy of the soil descriptions and classification, and the grouping of soil into layers that best represent subsurface conditions as they pertain to the engineering objectives of the project. Any characteristic that is not likely to have changed since sampling may be adjusted by this review.

During the review, soil samples are compared to the field logs and the field-assigned descriptions/classifications. This review entails evaluating uniformity and variations in the soil with depth to assess appropriate groupings of soil and performing visual and manual assessments of the soil within these soil layers, in accordance with ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

To aid review, qualitative hand sieving and manual plasticity tests for dry strength, dilatancy, and toughness, will be performed, as needed, to modify the field-assigned description and classification. Features not noted, such as structure, reaction to hydrochloric acid, and the presence of organics or mica should be added. The DPT reviewer should be aware that characteristics, such as oxidation of exposed soil surfaces and hydrocarbon odors from environmental contamination, commonly develop or change over time, and may or may not be present or detected at the time of field sampling.

At a minimum, the DPT will perform quality checks on the following:

- General spelling, description word order, punctuation, and syntax as specified in this Logging Standard;
- Frequency and results of manual tests such as pocket penetrometer and torvane;
- Appropriateness of soil layer assignments and consistency with other borehole logs; and
- Soil description, such as apparent density or consistency, moisture content, and ASTM group name and symbol.

Based on their review, DPT staff will make corrections to the field logs (not copies but the actual field logs). To document the history of the boring log revisions, these corrections should be made by crossing out the erroneous information and writing in the correct information (no erasing or whiteouts). It is important to note that descriptors that are subject to change by time or environment should consult with the logger before making any major adjustment to the field log. A moisture descriptor is one such example, as the moisture content within a sample could change between the time of sample recovery and the time of office review.

An example of a descriptor change could be the Group Name. A field sample may have been identified as “silty sand” using the guidelines of Section 2. However, upon performing the office review, again using Section 2, it is determined that “sand with silt” is more appropriate. In this case the field logs should be changed to “sand with silt”. It is appropriate to check and change any descriptors that are subject to review.

During their review, DPT staff will assess representative samples or portions of a sample that would be candidates for laboratory testing to meet the type and frequency of testing specified in the GEP.

3.2.4 Laboratory Testing Assessment

Laboratory testing may include a variety of types as summarized in Table 2-1. The type and anticipated number of laboratory tests assigned will be in accordance with the GEP.

An assessment of the suitability of soil samples for desired laboratory testing will be performed by the DPT and recorded on the sample inventory. The Technical Execution Management Team (TEMT) will select laboratory tests to be performed and prepare a draft lab testing request and then EDM will review and send to DCO for their review. Once approved, it goes back to the DPT to check and submit to the LT.

Samples or portions of samples will be packaged as needed and shipped to a designated laboratory for testing, except where sample disturbance during shipping is likely to result in poor-quality data. Samples sent off site will be tracked in an exploration spreadsheet. Except where impractical, portions of samples to be submitted for testing should be retained to allow for review once lab testing results are known and the remaining sample size recorded in the exploration database.

3.3 CPT Log Review

The field CPT logs will include graphs of sleeve friction, cone tip resistance, pore pressure, friction ratio as recorded in the field. A Soil Behavior Type (SBT) is calculated based on empirical correlations to measured cone resistance (qc), sleeve friction (fs), and pore pressure (u) data in accordance with correlations proposed by Robertson and others (1986) as shown in Figure 4-1 below, where:

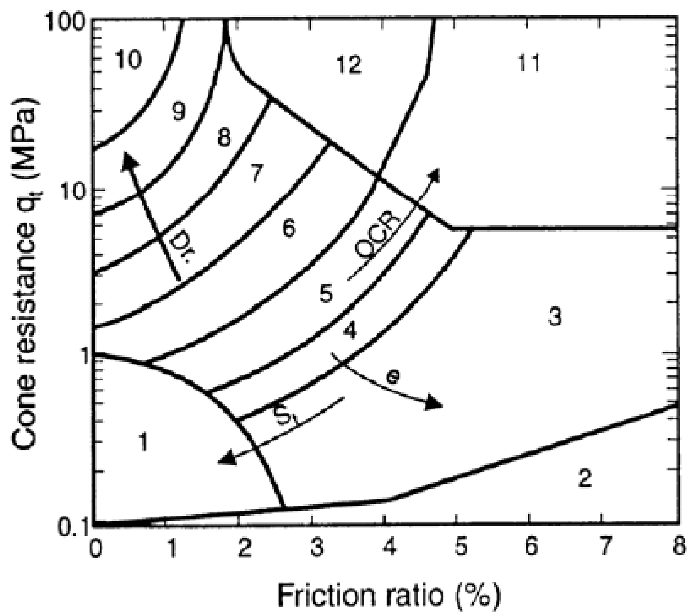
friction ration (Rf) = (fs/qt) x 100% Equation 3-1

corrected cone resistance (qt) = qc + u2(1- a) Equation 3-2

These parameters and the interpreted SBT using uncorrected CPT data will be reported versus depth on the field CPT log. An example of a CPT log generated in the field based solely on the measured parameters and not corrected for overburden stress is included in Attachment 4. In addition to the field plots, the CPT contractor will provide the uncorrected field data in digital format (CSV or XLS).

If additional tests, such as seismic CPTs and pore water dissipation test are performed, the CPT contractor will provide the field data in digital format for the DPT team to process. The processing of CPT field data is described in Section 6.

Figure 3-1. SBT Chart (from Robertson and others, 1986)



Zone	*Soil Behavior Type*
1	*Sensitive fine grained*
2	*Organic material*
3	*Clay*
4	*Silty Clay to clay*
5	*Clayey silt to silty clay*
6	*Sandy silt to clayey silt*
7	*Silty sand to sandy silt*
8	*Sand to silty sand*
9	*Sand*
10	*Gravelly sand to sand*
11	*Very stiff fine grained**
12	*Sand to clayey sand**

** Overconsolidated or cemented*

4. Procedures for Soil Classification and Description Using Laboratory Test Results

4.1 Introduction

In the field and in the DPT review, soils are classified and described using visual-manual methods (ASTM D2488) and basic field-testing tools. These procedures are generally sufficient to classify and describe the soil in qualitative terms. Assigned descriptors can be correlated to some degree to engineering parameters for use in geotechnical design. It is appropriate, however, to more definitively and quantitatively characterize selected soil samples using the results from laboratory testing.

Laboratory test results will be used to revise and supplement DPT-reviewed field classifications and descriptions by comparing numerical test results with visual and manual characteristics observed in the field or during DPT review. Descriptor revisions will be based on these Logging Standards and ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes. The process of quality checking of logs with soil review and laboratory testing can be iterative. Lab test results may suggest the need for additional sample review and additional laboratory testing. The checking process will confirm, using both DPT review and laboratory data, that the soil classification is correct and all required information is present in the revised log, identified as a final draft log.

4.2 Revising Soil Description and Classification Using Laboratory Test Results

Of the listed 22 attributes in the classification and description sequence for soils (see Section 2.5.1), there are 6 attributes that could be revised with laboratory test results. Those are:

- Group Name,
- Group Symbol,
- Consistency,
- Percent or proportion of gravel, sand, or fines, or all three,
- Particle Size Range, and
- Plasticity.

In the field, the *Group Name* and *Group Symbol* are estimated using visual-manual procedures based upon ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).* In using this field method, the user makes judgments on a number of observations (e.g. percent of constituents by weight, whether a soil is well or poorly graded, and whether the soil is a clay or silt or some combination thereof). Laboratory Mechanical Analysis and Atterberg Limits tests permit quantitative classifications of the soil with a single Group Name and Group Symbol, thereby removing judgment and ambiguity from the classification process. Furthermore, the laboratory procedure employs a much more comprehensive listing of possible Group Names, as compared to field methods, as well as finer distinctions based on fine- or coarse-fraction percentages. Tables 2-3 through 2-6 in Attachment 2 are used in laboratory classification and provided for reference.

Consistency is estimated in the field using (if possible) multiple attempts with a pocket penetrometer or torvane. Laboratory triaxial, direct shear, and unconfined compression tests provide less subjective undrained shear strength values that can be correlated to specific consistency descriptors.

In the field, the percent of gravel, sand, and fines and range of particle sizes are estimated using visual method, jar method, or wash test as outlined in ASTM D2488. The laboratory Grain Size Analysis test provides a quantitative distribution of particle sizes in proportion to the total sample weight. One must consider that sample size is important when characterizing soils with gravel or larger sized particles.

Plasticity is estimated in the field in order to determine Group Name and Group Symbol for fine-grained soils and to provide a plasticity descriptor. Laboratory Atterberg Limits, used in conjunction with ASTM D2487, provide a Group Name and Group Symbol. The field-based plasticity descriptor is eliminated, as the plasticity is inherent in the Group Name and Group Symbol.

4.2.1 Examples

The example below illustrates such a case where the initial field soil classification, consistency, and plasticity were changed based upon laboratory test results. The color and moisture were described using the field observations.

Field Description per Section 2:

Sandy Lean Clay (CL), gray, stiff, moist, medium plasticity

The laboratory test results and descriptors based on Section 3 are as follows:

- Triaxial UU results of undrained shear strength (S_u)= 3 tsf; q_u is estimated to be 6 tsf; per Section 2.2.3 this soil is "very stiff."
- Atterberg Limits results of Liquid Limit = 55, Plasticity Index = 30; per Table 2-1 in Attachment 2, the Group Name is "Sandy Fat Clay (CH)."
- Mechanical Analysis results show greater than 50% fines, and ≥ 30% sand retained on the #200 sieve.
- Moisture = 22.3%.

Reported Description Per Sections 2 and 4:

Sandy Fat Clay (CH), gray, very stiff, moist

4.2.2 Soil Classification and Description Descriptive Sequence

The descriptive sequence presented in the following table shall be used when classifying and describing soils. To incorporate laboratory test data in the classification and description sequence, where applicable, refer to the laboratory sections in this section, and noted in the "Lab" column in the table below.

Table 4-1. Soil Classification and Description Descriptive Sequences

Sequence	Classification Components	Refer to Section		Required	Recommended
		Field	Lab		
1	Group Name	2.5.1	4.2.3	✓	
2	Group Symbol	2.5.1	4.2.3	✓	
Sequence Description Components					
3	Percent or proportion of Cobbles and Boulders	2.5.7		✓	
4	Percent or proportion of gravel, sand, or fines	2.5.6	4.2.6	✓	
5	Particle Size Range	2.5.8	4.2.7	✓	
6	Particle Angularity (for coarse sand and larger particles)	2.5.9			✓
7	Particle Shape (for coarse sand and larger particles)	2.5.10			✓
8	Hardness (for gravel and larger particles)	2.5.11			✓
9	Plasticity (for fine-grained soils)	2.5.12	4.2.8	✓	
10	Dilatancy	2.5.16		✓	
11	Munsell Color and color number (in moist condition)	2.5.4		✓	
12	Consistency (for cohesive soils)	2.5.2	4.2.4	✓	
13	Apparent Density (for cohesionless soils)	2.5.3	4.2.5	✓	
14	Moisture	2.5.5		✓	
15	Calcium Carbonate (Reaction with HCl)	2.5.13		✓	
16	Structure	2.5.14		✓	
17	Cementation	2.5.15			✓
18	Description of Cobbles and Boulders	2.5.7		✓	
19	Additional Comments	2.5.17		✓	
20	Geologic or Soil Unit Name	2.5.18			✓

4.2.3 Group Name and Group Symbol

This section presents a procedure for classifying soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index. This method is based upon the ASTM version (D2487) of the Unified Soil Classification System (USCS). The ASTM procedure for classifying and describing fine and coarse-grained soils is only applicable to material passing the 3-inch sieve. If the presence of cobbles or boulders or both is identified during the field investigation, the proportion of cobbles and boulders shall be further defined using the proportional terminology presented in Sections 2.5.7 and 2.5.8.

Dual Symbol – Use of this standard will result in a single classification group symbol and group name except when a soil contains 5 to 12 percent fines or when the plot of the liquid limit and plasticity index values falls into the crosshatched area of the plasticity chart (see Table 2-3 in Attachment 2)). In these two cases, a dual symbol is used, for example, GP-GM, CL-ML.

4.2.3.1 Procedure for Classification of Fine-Grained Soils

Classify the soil as fine-grained if 50 percent or more by dry weight of the test specimen passes the No. 200 sieve using the Atterberg Limits with the chart in Tables 2-3 and 2-4 in Attachment 2.

- In cases where the liquid limit exceeds 110 or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending the “A” line at the indicated slope.

The soil is organic if organic matter is present in sufficient amounts to influence the liquid limit. Typically, organic soils have a dark color and an organic odor when moist and warm and may contain visible organic matter.

4.2.3.2 Procedure for Classification of Coarse-Grained Soils

Classify the soil as coarse-grained if 50 percent or more by dry weight of the test specimen is retained on the No. 200 sieve.

Classify the soil as gravel if more than 50 percent of the coarse fraction [plus No. 200 sieve] is retained on the No. 4 sieve.

Classify the soil as sand if 50 percent or more of the coarse fraction [plus No. 200 sieve] passes the No. 4 sieve.

If 12 percent or less by dry weight of the test specimen passes the No. 200 sieve, plot the cumulative particle-size distribution and compute the coefficient of uniformity, Cu, and coefficient of curvature, Cc, as given in Equations 5-1 and 5-2.

$$C_u = \frac{D_{60}}{D_{10}} \qquad \text{Equation 4-1}$$

$$C_c = \frac{D_{30}^2}{D_{60}D_{10}} \qquad \text{Equation 4-2}$$

Where D_{10}, D_{30}, and D_{60} are the particle-size diameters corresponding to 10, 30, and 60 percent, respectively, passing on the cumulative particle-size distribution curve. It may be necessary to extrapolate the curve to obtain the D_{10} diameter. Using the results obtained and Table 2-6 in Attachment 2, the soil classification can be determined.

4.2.4 Consistency (Cohesive Soils)

Cohesive soil consistency descriptors shall conform to terminology and criteria established in the table below, generally after Bureau of Reclamation standards, and others. Note that the terms to be used have been modified from those contained in both AASHTO and Bureau of Reclamation.

The preferential procedure for the determination of consistency of cohesive soils is to obtain relatively undisturbed samples (Shelby tubes) and perform laboratory triaxial, direct shear, or unconfined compression tests. The results from these tests can be correlated to specific consistency descriptors as presented in the table below. A triaxial unconsolidated undrained (UU) test is recommended for strength determination. This can be converted to an equivalent unconfined compressive strength (q_u) by multiplying the undrained shear strength (Su) value by 2.

Table 4-2. Consistency Descriptors of Cohesive Soils

Descriptor	Unconfined Compressive Strength (tsf)
Very Soft	< 0.25
Soft	0.25 to 0.50
Medium Stiff	0.50 to 1.0
Stiff	1 to 2
Very Stiff	2 to 4
Hard	> 4.0

4.2.5 Apparent Density (Granular Soils)

Apparent density of a coarse-grained (cohesionless) soil will be based on a corrected Standard Penetration Test (SPT) or a corrected equivalent SPT N value, both defined as an N_{60} value. Blow counts and apparent density recorded on the field logs are based on field corrected N-values (N_{field}) which is a summation of the last two blow count totals per six inches corrected for hammer energy and sampler size (for non-SPT samplers), as discussed previously. Blow counts presented on the final logs shall consist of the raw blow counts or refusal ($N_{measured}$), the SPT N value (for SPT samplers and corrected for hammer efficiency), and the corrected SPT N or corrected equivalent SPT N value (N_{60}). Which is adjusted for various correction factors as presented in Manual on Subsurface Investigations (NCHRP, 2019) and shown below:

$$N_{60} = N_{measured} \times C_E C_B C_R C_S \quad \text{Equation 4-3}$$

Where correction factors are hammer energy (C_E), borehole diameter (C_B), rod length and type (C_R), and sampler configuration (C_S).

For samplers or hammers that are not consistent with the SPT standards, equivalent SPT N-values will be calculated but not displayed on the final logs. While equivalent SPT N-values are useful for estimating consistency and apparent density, the actual field blow counts will also be shown on the field boring logs. The formula for calculating the equivalent SPT N-values used in this document are as follows:

$$\text{Equivalent SPT N-Value} = C_{Area} \times C_{Hammer} \times N_{measured} \times (ERi / 60) \quad \text{Equation 4-4}$$

Where:

C_{Area} = sampler area correction factor

$C_{Area} = (OD^2 - ID^2)_{SPT}/(OD^2 - ID^2)_{Used}$

For the Split Barrel Sampler with liners:

$(2.0^2 - 1.375^2)_{SPT}/(3.0^2 - 2.38^2)_{MC} = 0.63$

C_{Hammer} = hammer weight correction factor

$C_{Hammer} = (HW \times DH)_{Used}/(140 \text{ lbs} \times 30'')_{SPT}$

HW = hammer weight in pounds

DH = hammer drop height in inches

$N_{Measured}$ = blow count measured in the field

ER_i = drill rod energy ratio, expressed as a percent based on SPT hammer calibration for each hammer assembly as described in the Field Exploration Standards

All blow counts and N-values should be rounded to the nearest whole number (decimals should not be reported).

If the sampler is driven less than 1.5 ft because of refusal (50 blows for 6 inches or less than 6 inches), the number of blows per each complete 6-inch increment and each partial increment should be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest inch in addition to the number of blows. N-value should be recorded for partial penetration of less than 1.5 feet as shown in Table 4-3 below. Blows for the first 6 inches of penetration should not be used unless the sampler did not penetrate beyond the first 6 inches.

Table 4-3. Partial Penetration Resistance

Recorded Blow Count per 6-inch Increment	Reported Penetration Resistance or N-Value
15-22-50/5”	72/11”
36-50/4”	50/4”
50/4”	50/4”

4.2.6 Percent or Proportion of Gravel, Sand, or Fines

Percentages of gravel, sand, and fines should be reported as percentages based upon grain size analysis (ASTM D6913). Qualitative proportional descriptors (e.g., trace, some, etc.) shall not be used when gradation data is available.

Table 4-4. Gravel, Sand and Fines Size Descriptors

Descriptive Term	Size
Gravel	3 inches to No.4 Sieve
Sand	No.4 to No.200 Sieve
Fines	Passing No.200 Sieve

4.2.7 Particle Size

The USCS soil descriptions can be further refined using the results of the laboratory grain size analysis and the table below.

Table 4-5. Particle Size Descriptors

Descriptive Term	Size
Boulder	>12 in
Cobble	3 to 12 in
Coarse Gravel	¾ to 3 in
Fine Gravel	No.4 to ¾ in
Coarse Sand	No.10 to No.4
Medium Sand	No.40 to No.10
Fine Sand	No.200 to No.40
Clay and Silt	Passing No.200

4.2.8 Plasticity (For Fine-Grained Soils)

Field- or DPT-review estimates of plasticity should not be reported when Atterberg Limits have been performed. PI and LL should be reported in their respective columns on the boring log.

5. Development and Presentation of Final Boring Log

5.1 Introduction

Boring logs produced by the DPT are subject to review and edits by the DCA and DCO to produce the final boring log. As such, the boring logs developed by the process documented above will be considered final draft boring logs. The process of creating final draft boring logs comprises four steps:

- Field sampling and descriptions (Section 2),
- DPT review of field descriptions and data (Section 3),
- Refinement of descriptions and classifications based upon DPT review and laboratory test results (Section 4), and
- Preparation of the final draft boring logs (Sections 5).

This section provides additional details and guidance for incorporating laboratory test data and preparing final draft boring logs.

5.2 Incorporating Laboratory Data and Refining Descriptions and Classifications

When describing a layer, the geo-professional should use the most reliable data available, which could be field-generated data, or a combination of field and laboratory generated data. If laboratory tests are performed, and in the opinion of the geo-professional those test results represent the actual conditions of the soil, then those results should control the classification or description.

Laboratory tests are usually performed on representative samples collected from primary strata samples, especially on contiguous samples within a layer of similar material. One should use professional judgment in conjunction with the firsthand review of results to apply laboratory test data from one sample to the description of contiguous materials within a boring, if the field observations are such that the geo-professional considers the materials to be similar. For example, three contiguous samples were determined to be "medium stiff" using a pocket penetrometer. However, a UU triaxial test on one of those samples indicated that the material was in fact "stiff." In this example, the strength properties of the other two samples need to be reevaluated, as necessary, to affirm their description. Explanation should be given as to the source or basis of reevaluated description. The strength values obtained from pocket penetrometer tests should also be documented in the log for future reference.

The boring logs present the description, both visual and written, of the types of soil encountered during subsurface investigations. The data on the boring logs should be as factual as possible; however, an inherent level of professional interpretation in the presentation of subsurface data cannot be avoided. For example:

- Field description and classification procedures, according to ASTM D2488, require estimation and interpretation.
- Sampling may occur at discrete intervals, yet layer boundaries are drawn between discrete sampling locations based on visual observations of cuttings during boring advancement. There may be uncertainty as to the depth material changes occur.
- Continuity of material types between discrete sampling locations is sometimes difficult to confirm.

Soil descriptions are to be presented in layer presentation format where a single description for a layer may span across more than one sample location for similar material based on field observations and laboratory tests when available. When, in the judgment of the geo-professional, laboratory test results are applicable over a range of contiguous samples, it is appropriate to develop a layer description to reflect the results (laboratory calibrated description). With the laboratory calibrated description, the classification and description used to describe the layer is based upon an integration of both field and laboratory-derived attributes of one or many samples and may present specific descriptors in terms of ranges.

5.2.1 General Rules and Considerations

A number of general rules apply in these methods, and are as follows:

- Reliable laboratory test results shall be used when available to determine the applicable descriptors within the descriptive sequence (e.g., Group Name and Symbol, consistency, gradation properties, plasticity).
- Individual descriptors for contiguous samples with the same descriptions and classifications can be uniformly adjusted based upon the test results of one or more representative samples. Use of more than one test sample is encouraged.
- Line breaks between layers may be dashed or solid. Dashes are reserved for an “inferred” break between soil layers or lithology, a gradational boundary, or if loss in recovery is significant. A solid line should be used if a definitive boundary is observed between two materials.

5.2.2 Example

To demonstrate using the method described in this section to edit the soil classification using laboratory test results, the example below is provided.

In this example, a field investigation is conducted with the following notes:

- The borehole is drilled to a depth of 45 ft.
- Samples are retrieved at regular 5 ft intervals.
- Three general layers are identified during the investigation.
- Layer boundaries are estimated from cuttings while drilling.
- Laboratory testing is performed on three samples, one from each layer.
- Field testing is conducted for some samples.

While out in the field, the ET staff logging a boring applies the field classification and description methods described in Section 2 to come up with appropriate descriptive sequence for each sample. Standard Penetration Test (SPT) field measurements are used to estimate the relative density of cohesionless samples. Pocket Penetrometer (PP) measurements are used to estimate the consistency of cohesive samples. The resulting classification and description based upon field procedures are presented in the first column in the figure above.

One sample from each layer was collected and tested for additional engineering properties.

- A Mechanical Analysis (MA) is performed on the sandy sample taken from a depth of 10 feet. Using the gradation results and the methods described in Section 2, tests indicate that the sample is a "well-graded sand (SW)," not a "poorly graded sand (SP)" as originally determined in the field.
- Atterberg Limits tests are conducted on the clayey sample taken from a depth of 20 feet. Test results show a Liquid Limit (LL) of 53 and a Plasticity Index (PI) of 28. Using the classification and the methods described in Section 5, tests indicate that the sample is a "fat clay (CH)," not a "lean clay (CL)" as originally determined in the field.
- Unconsolidated Undrained (UU) Triaxial tests are conducted on the clayey sample taken from a depth of 20 feet. Test results show an unconfined compressive strength of 1.2 tsf. Using the method described in Section 4 for consistency, the test indicates that the sample is "stiff," not "medium stiff" as originally estimated in the field with the Pocket Penetrometer.

The DPT uses the samples collected to make a determination of the soil unit boundaries and changes within each unit based on his observation of the discrete samples and comparing them with laboratory data. The example above shows that, for instance in the laboratory analysis of the sample taken at a depth of 20 feet, the sample collected at the same location was incorrectly classified as lean clay (CL). The DPT would perform manual plasticity texts to determine if the entire layer should be reclassified or if the revised classification applies to only the sample tested.

5.3 Exploration Log Presentation Format

A boring log is a written record of subsurface materials encountered in a boring and subsurface data collected during drilling and sampling. The final boring log presents field observation and testing results and incorporates edits to those based on subsequent quality review and laboratory testing. A boring log conveys fundamental information upon which subsequent engineering decisions are based; therefore, the boring log format used for a project should be appropriate for presenting observations and data important to the project in an easy-to-understand and clear manner. The boring log format to be used for the DCP is included in Attachment 4.

5.4 Well Completion

Reserved for future use.

6. Development and Presentation of CPT Data

The CPT data and logs from the field will include primary data such as, sleeve friction, cone tip resistance, pore pressure, friction ratio, and Soil Behavior Type (SBT). SBT from the field will be based on Robertson and others (1986). In addition to this set of basic data, CPT data will include data from SCPTs and pore pressure dissipation tests, where performed.

6.1 Processing Primary CPT Data

The GC DPT staff will process field CPT data to create draft CPT logs. The CPT processing workflow is depicted in Figure 6-1.

Raw CPT data files will be imported into computer software for processing and analysis. CPT data will be processed in the office to update the field SBT based on newer correlations proposed by Robertson (2010) that are similar to the stress normalized soil behavior type charts in Robertson (1990). The newer SBT correlations are shown in Figure 6-2 below. Processed data will be imported into gINT 8.0 (Bentley 2010) to create CPT plots. Signature plots generated in gINT software will display graphs of sleeve friction, cone tip resistance, pore pressure, friction ratio and Soil Behavior Type (SBT) versus depth.

If desired by DCA, CPT logs using normalized SBT_n correlations (Robertson, 1990) can be provided. Field parameters are normalized correcting for groundwater level and overburden stress. SBT_n correlations are more reliable than soil behavior types indicated by non-normalized values as long as correct stresses are provided in the computer software for re-interpretation. Correlations of borings to adjacent CPTs should be performed to improve SBT_n interpretation and strata identification.

Figure 6-1. CPT Processing Workflow

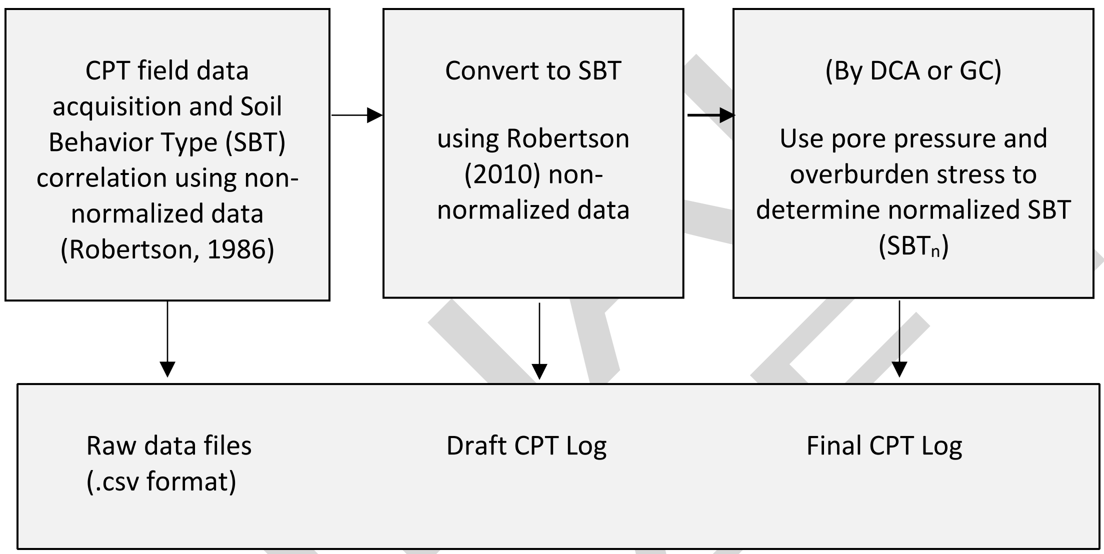
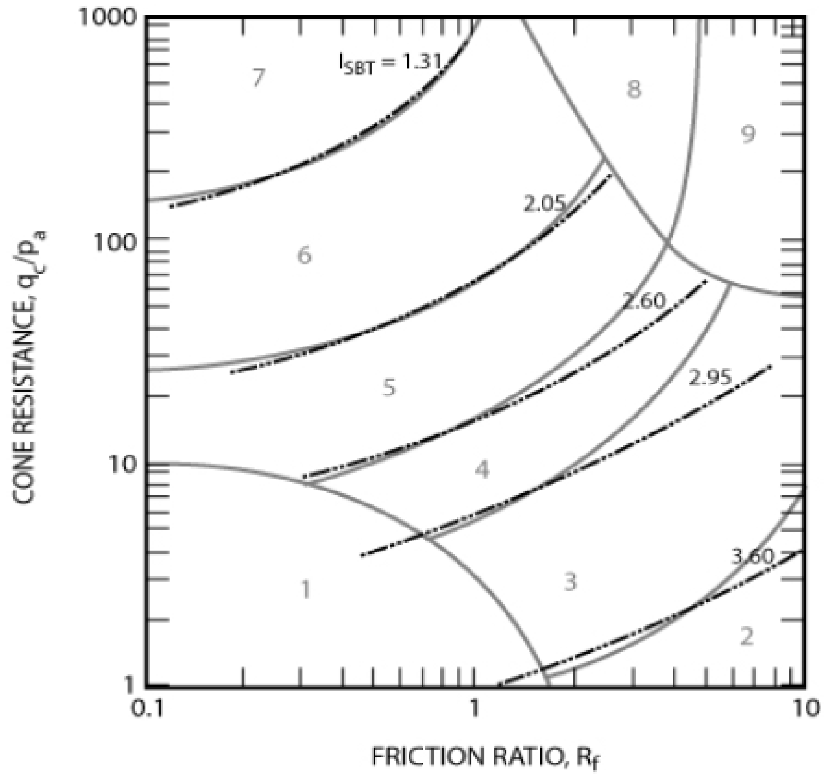


Figure 6-2. Updated Non-Normalized SBT Chart (from Robertson, 2010)



Zone	Soil Behaviour Type (SBT)
1	*Sensitive fine-grained*
2	*Clay - organic soil*
3	*Clays: clay to silty clay*
4	*Silt mixtures: clayey silt & silty clay*
5	*Sand mixtures: silty sand to sandy silt*
6	*Sands: clean sands to silty sands*
7	*Dense sand to gravelly sand*
8	*Stiff sand to clayey sand**
9	*Stiff fine-grained**

* *Overconsolidated or cemented*

6.2 CPT Log Presentation Format

The CPT log format, using non-normalized SBT correlations (Robertson and others, 1986) is included in Attachment 4. Updated SBT correlations data (Robertson, 2010), and at the discretion of DCA, CPT logs using normalized SBT_n correlations will be provided.

The GC can provide additional CPT data presentation using the CPT data tools developed by Fugro. Some examples include CPT plots using published correlations to generate soil unit weight, water content, plasticity index, fines content, undrained shear strength, overconsolidation ratio, in-situ stress ratio, relative density, friction angle, shear wave velocity, soil stiffness and shear modulus, and hydraulic conductivity. CPT-based analyses can also be performed including liquefaction triggering and seismic settlement using inputs provided by DCA. In addition, various parameter plots can be generated easily using the CPT database. Example outputs showing are included in Attachment 4.

6.3 Processing of SCPT Data

Field SCPT data will be imported into computer software for processing and analysis. The output from the software will include plots of seismic wave velocity with depth and also the wave forms at each test depth to show the arrival times. These plots will be attached to corresponding CPT logs where the test was conducted. Example outputs are included in Attachment 4.

6.4 Processing of Pore Water Pressure Dissipation Test

Pore pressure dissipation data, which includes pore pressure measurement with time, will be imported into computer software for processing and analysis. The pore water pressure data will be plotted against log time which can be used to calculate hydraulic conductivity (k) and coefficient of consolidation (c_{vh}), and static ground water condition. Pore pressure dissipation plots will be attached to corresponding CPT logs where the test was conducted. Example outputs are included in Attachment 4.

7. References

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8. Document History and Quality Assurance

Reviewers listed below have completed an internal quality review check and approval process for this deliverable that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

Rev.	Date	Version Description	Approval Names and Roles			
			Prepared by	Internal QC review by	Consistency review by	Approved for submission by
0	08/31/2020	Initial submission	Ted Hopkins /Data Processing Team Leader	Debanik Chaudhuri /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Geotechnical Engineering Manager
1	10/16/2020	Incorporate DCA review comments	Ted Hopkins /Data Processing Team Leader	Debanik Chaudhuri /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Geotechnical Engineering Manager
2	11/20/2020	DCO submission	Ted Hopkins /Data Processing Team Leader	Debanik Chaudhuri /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Geotechnical Engineering Manager
3	02/19/2021	Final Draft	Ted Hopkins /Data Processing Team Leader	Debanik Chaudhuri /TEMT Member	Deron van Hoff /TEMT Lead	Andy Herlache /GC Geotechnical Engineering Manager

This interim document is considered preliminary and was prepared under the responsible charge of Ward Andrew Herlache, Geotechnical Engineering License 2149.

Attachment 1
Subsurface Explorations Naming Convention

Attachment 1. Subsurface Explorations Naming Convention

Table A-1: Naming and Numbering Protocol for DC explorations

Project	Facility		Type		Number	
XX	XXX	-	XXXX	-	XXX	Notes
DC	IE1	-	DH	-	001	East Intake 2, DH-Drill Hole
DC	IE2	-	CPT	-	002	East Intake 3, CPT-Cone Penetrometer Test
DC	IE3	-	SCPT	-	003	East Intake 4, SCPT-Seismic Cone Penetrometer Test
DC	IE4	-	TP	-	…	East Intake 5, TP-Test Pit
DC	IW1	-	SON	-	…	West Intake 1, SON-Sonic Coring
DC	IW2	-	VBC	-	…	West Intake 2, VBC-Vibro Coring
DC	IW3	-	HA	-	…	West Intake 3, HA-Hand Auger
DC	IW4	-	…	-	…	West Intake 4
DC	IF1	-	…	-	…	Intermediate Forebay 1
DC	CA1	-	…	-	…	Central Alternative Alignment No. 1
DC	EA1	-	…	-	…	Eastern Alternative Alignment No. 1
DC	WA1	-	…	-	…	Western Alternative Alignment No. 1
DC	BA1	-	…	-	…	Bethany Alternative Alignment No. 1
DC	SDP	-	…	-	…	South Delta Pumping Plant
DC	BAP	-	…	-	…	Bethany Alternative Pumping Plant
DC	SOF	-	…	-	…	Southern Forebay
DC	SDC	-	…	-	…	South Delta Conveyance
DC	BAC	-	…	-	…	Bethany Alternative Conveyance
DC	BIS	-	…	-	…	Banks Isolation structure
DC	JIS	-	…	-	…	Jones Isolation structure

Table A-2: Naming and Numbering Protocol for DC Wells and Instrumentation

Project	Facility		Type		Sub-Group	
XX	**XXX**	**-**	**XXX**	**-**	**X**	**Notes**
DC	IE1	-	VW	-	A	VW-Vibrating Wire Piezometer, for facility definition see previous table
DC	IE2	-	PN	-	B	PN-Pneumatic Monitoring Well
DC	IE3	-	MW	-	C	MW-Standpipe Monitoring Well
DC	IW1	-	PW	-	…	PW-Production (Pumping) Well
DC	IW2	-	IN	-	…	IN-Inclinometer
DC	IW3	-	EX	-	…	EX-Extensometer

Table A-3: Naming and Numbering Protocol for DC Samples

Method	Number	Sub-Sample		Starting Depth (feet)		Ending Depth (feet)	
XX	**XX**	**X**	**-**	**XXX.X**	**-**	**XXX.X**	**Notes**
S	01	A	-	002.5	-	005.0	S-SPT
S	01	B	-	095.2	-	097.2	S-SPT
B	02	…	-	…	-	…	B-Bag/Grab
ST	…	…	-	…	-	…	ST-Shelby Tube
D	…	…	-	…	-	…	D-Discrete CPT
V	…	…	-	…	-	…	V-Sonic
PB	…	…	-	…	-	…	PB-Pitcher Barrel
PS	…	…	-	…	-	…	PS-Piston Sample
GS	…	…	-	…	-	…	GS-Geobor-S
GB	…	…	-	…	-	…	GB-Geobarrel
SB	…	…	-	…	-	…	SB-Split Barrel Sample (3”)

Examples:

- SPT Soil Sample Number 3, only one sub sample, between 10 feet and 11.5 feet – **S03A-010.0-011.5.**
- Geobarrel Sample Number 2, 3rd sub-sample number between 10 and 14.5 feet –**GB02C-010.0-014.5.**
- Shelby Tube Sample Number 15 between 97 and 100 feet – **ST15A-097.0-100.0.**

Table A-4: Naming and Numbering Protocol for DC In-situ Tests

Method	Number	Sub-Test		Starting Depth (feet)		Ending Depth (feet)	
XX	XX	X	-	XXX.X	-	XXX.X	Notes
PA	01	A	-	002.5	-	005.0	PA-Packer Test
PM	02	B	-	095.2	-	097.2	PM-Pressuremeter
VS	…	…	-	…	-	…	VS-Downhole Shear Wave Velocity
FV	…	…	-	…	-	…	FV-Field Vane Shear
PP	…	…	-	…	-	…	PP-Pore Pressure Dissipation (CPT)
TV	…	…	-	…	-	…	TV-Optical Televiewer Log
AV	…	…	-	…	-	…	AV-Acoustic Televiewer Log
GG	…	…	-	…	-	…	GG-Gamma-Gamma Log
CA	…	…	-	…	-	…	CA-Caliper Log

Attachment 2
Field and Laboratory Soil Classification Tables

Attachment 2. Field and Laboratory Soil Classification Tables

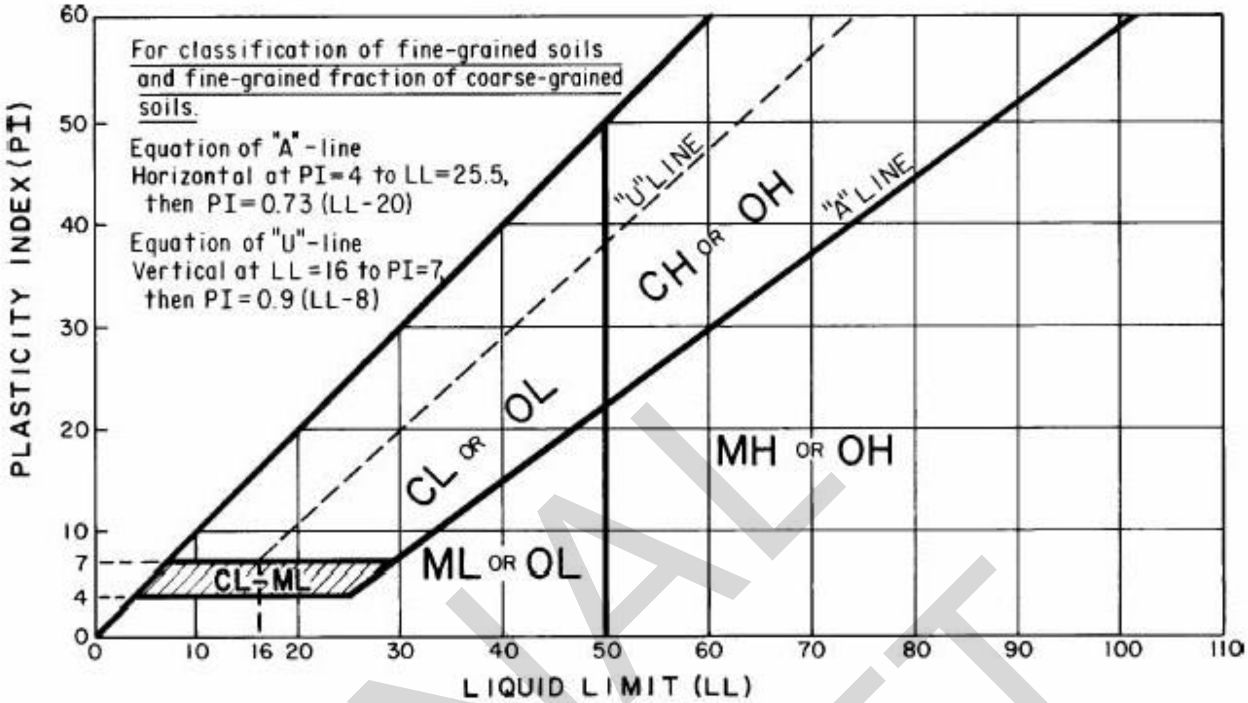
Table B-1: Field Classification Table for Fine Grain Soils

	Fines	Coarseness	Sand or Gravel	Description
	<30% plus No.200	<15% plus No.200		Lean clay
		15-25% plus No.200	% sand > % gravel	Lean clay with sand
			% sand < % gravel	Lean clay with gravel
CL			< 15% gravel	Sandy lean clay
	>30% plus	% sand > % gravel	> 15% gravel	Sandy lean clay with gravel
	No.200		< 15% sand	Gravelly lean clay
		% sand < % gravel	> 15% sand	Gravelly lean clay with sand
	<30% plus	<15% plus No.200		Silt
	No.200		% sand > % gravel	Silt with sand
		15-25% plus No.200	% sand < % gravel	Silt with gravel
ML			< 15% gravel	Sandy silt
	>30% plus	% sand > % gravel	> 15% gravel	Sandy silt with gravel
	No.200		< 15% sand	Gravelly silt
		% sand < % gravel	> 15% sand	Gravelly silt with sand
	<30% plus	<15% plus No.200		Fat clay
	No.200		% sand > % gravel	Fat clay with sand
		15-25% plus No.200	% sand < % gravel	Fat clay with gravel
CH			< 15% gravel	Sandy Fat clay
	>30% plus	% sand > % gravel	> 15% gravel	Sandy Fat clay with gravel
	No.200		< 15% sand	Gravelly Fat clay
		% sand < % gravel	> 15% sand	Gravelly Fat clay with sand
	<30% plus	<15% plus No.200		Elastic silt
	No.200		% sand > % gravel	Elastic silt with sand
		15-25% plus No.200	% sand < % gravel	Elastic silt with gravel
MH		Soil	< 15% gravel	Sandy elastic silt
	>30% plus	% sand > % gravel	> 15% gravel	Sandy elastic silt with gravel
	No.200		< 15% sand	Gravelly elastic silt
		% sand < % gravel	> 15% sand	Gravelly elastic silt with sand
	<30% plus	<15% plus No.200		Organic soil
	No.200		% sand > % gravel	Organic soil with sand
		15-25% plus No.200	% sand < % gravel	Organic soil with gravel
OL/ OH	>30% plus No.200	% sand > % gravel	< 15% gravel	Sandy organic soil
			> 15% gravel	Sandy organic soil with gravel
		% sand < % gravel	< 15% sand	Gravelly organic soil
			> 15% sand	Gravelly organic soil with sand

Table B-2: Field Classification Table for Coarse Grain Soils

	Fines	Grade	Type of Fines	Group Symbol	Sand/ Gravel	Group Name
Gravel	≤ 5%	Well		GW	< 15% sand	**Well-graded gravel**
					≥ 15% sand	**Well-graded gravel with sand**
		Poorly		GP	< 15% sand	**Poorly graded gravel**
					≥ 15% sand	**Poorly graded gravel with sand**
	10%	Well	ML or MH	GW-GM	< 15% sand	**Well-graded gravel with silt**
					≥ 15% sand	**Well-graded gravel with silt and sand**
			CL or CH	GW-GC	< 15% sand	**Well-graded gravel with clay**
					≥ 15% sand	**Well-graded gravel with clay and sand**
		Poorly	ML or MH	GP-GM	< 15% sand	**Poorly graded gravel with silt**
					≥ 15% sand	**Poorly graded gravel with silt and sand**
			CL or CH	GP-GC	< 15% sand	**Poorly graded gravel with clay**
					≥ 15% sand	**Poorly graded gravel with clay and sand**
	≥ 15%		ML or MH	GM	< 15% sand	**Silty gravel**
					≥ 15% sand	**Silty gravel with sand**
			CL or CH	GC	< 15% sand	**Clayey gravel**
					≥ 15% sand	**Clayey gravel with sand**
Sand	≤ 5%	Well		SW	< 15% gravel	**Well-graded sand**
					≥ 15% gravel	**Well-graded sand with gravel**
		Poorly		SP	< 15% gravel	**Poorly graded sand**
					≥ 15% gravel	**Poorly graded sand with gravel**
	10%	Well	ML or MH	SW-SM	< 15% gravel	**Well-graded sand with silt**
					≥ 15% gravel	**Well-graded sand with silt and gravel**
			CL or CH	SW-SC	< 15% gravel	**Well-graded sand with clay**
					≥ 15% gravel	**Well-graded sand with clay and gravel**
		Poorly	ML or MH	SP-SM	< 15% gravel	**Poorly graded sand with silt**
					≥ 15% gravel	**Poorly graded sand with silt and gravel**
			CL or CH	SP-SC	< 15% gravel	**Poorly graded sand with clay**
					≥ 15% gravel	**Poorly graded sand with clay and gravel**
	≥ 15%		ML or MH	SM	< 15% gravel	**Silty sand**
					≥ 15% gravel	**Silty sand with gravel**
			CL or CH	SC	< 15% gravel	**Clayey sand**
					≥ 15% gravel	**Clayey sand with gravel**

Table B-3: Laboratory Classification of Fine Grain Soils



From ASTM 2487

Table B-4: Laboratory Classification of Soils

Liquid Limit	Organic	Plasticity Index	Group Symbol	Fines	Coarseness		Group Name
LL<50	Inorganic	PI>7 and plots on or above "A"-line	CL	<30% plus No.200	<15% plus No.200		Lean clay
					15-29% plus No.200	% sand ≥ % gravel	Lean clay with sand
						% sand < % gravel	Lean clay with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy lean clay
						≥ 15% gravel	Sandy lean clay with gravel
					% sand < % gravel	< 15% sand	Gravelly lean clay
						≥ 15% sand	Gravelly lean clay with sand
		4≤PI≤7 and plots on or above "A"-line	CL-ML	<30% plus No.200	<15% plus No.200		Silty clay
					15-29% plus No.200	% sand ≥ % gravel	Silty clay with sand
						% sand < % gravel	Silty clay with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy silty clay
						≥ 15% gravel	Sandy silty clay with gravel
					% sand < % gravel	< 15% sand	Gravelly silty clay
						≥ 15% sand	Gravelly silty clay with sand
		PI<4 or plots below "A"-line	ML	<30% plus No.200	<15% plus No.200		Silt
					15-29% plus No.200	% sand ≥ % gravel	Silt with sand
						% sand < % gravel	Silt with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy silt
						≥ 15% gravel	Sandy silt with gravel
					% sand < % gravel	< 15% sand	Gravelly silt
						≥ 15% sand	Gravelly silt with sand
	Organic	PI≥4 and plots on or above "A"-line	OL	<30% plus No.200	<15% plus No.200		Organic clay
					15-29% plus No.200	% sand ≥ % gravel	Organic clay with sand
						% sand < % gravel	Organic clay with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy organic clay
						≥ 15% gravel	Sandy organic clay with gravel
					% sand < % gravel	< 15% sand	Gravelly organic clay
						≥ 15% sand	Gravelly organic clay with sand
		PI<4 or plots below "A"-line		<30% plus No.200	<15% plus No.200		Organic silt
					15-29% plus No.200	% sand ≥ % gravel	Organic silt with sand
						% sand < % gravel	Organic silt with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy organic silt
						≥ 15% gravel	Sandy organic silt with gravel
					% sand < % gravel	< 15% sand	Gravelly organic silt
						≥ 15% sand	Gravelly organic silt with sand

From ASTM 2487

Table B-5: Laboratory Classification of Soils

Liquid Limit	Organic	Plasticity Index	Group Symbol	Fines	Coarseness		Description
LL≥50	Inorganic	Plots on or above "A"-line	CH	<30% plus No.200	<15% plus No.200		Fat clay
					15-29% plus No.200	% sand ≥ % gravel	Fat clay with sand
						% sand < % gravel	Fat clay with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy Fat clay
						≥ 15% gravel	Sandy Fat clay with gravel
					% sand < % gravel	< 15% sand	Gravelly Fat clay
						≥ 15% sand	Gravelly Fat clay with sand
		Plots below "A"-line	MH	<30% plus No.200	<15% plus No.200		Elastic silt
					15-29% plus No.200	% sand ≥ % gravel	Elastic silt with sand
						% sand < % gravel	Elastic silt with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy elastic silt
						≥ 15% gravel	Sandy elastic silt with gravel
					% sand < % gravel	< 15% sand	Gravelly elastic silt
						≥ 15% sand	Gravelly elastic silt with sand
	Organic	Plots on or above "A"-line	OH	<30% plus No.200	<15% plus No.200		Organic clay
					15-29% plus No.200	% sand ≥ % gravel	Organic clay with sand
						% sand < % gravel	Organic clay with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy organic clay
						≥ 15% gravel	Sandy organic clay with gravel
					% sand < % gravel	< 15% sand	Gravelly organic clay
						≥ 15% sand	Gravelly organic clay with sand
		Plots below "A"-line		<30% plus No.200	<15% plus No.200		Organic silt
					15-29% plus No.200	% sand ≥ % gravel	Organic silt with sand
						% sand < % gravel	Organic silt with gravel
				≥30% plus No.200	% sand ≥ % gravel	< 15% gravel	Sandy organic silt
						≥ 15% gravel	Sandy organic silt with gravel
					% sand < % gravel	< 15% sand	Gravelly organic silt
						≥ 15% sand	Gravelly organic silt with sand

From ASTM 2487

Table B-6: Laboratory Classification of Soils

	Fines	Grade	Type of Fines	Group Symbol	Sand/ Gravel	Group Name
Gravel	≤ 5%	Cu≥4 1≤Cc≤ 3		GW	< 15% sand	Well-graded gravel
					≥ 15% sand	Well-graded gravel with sand
		Cu<4 1>Cc> 3		GP	< 15% sand	Poorly graded gravel
					≥ 15% sand	Poorly graded gravel with sand
	5-12%	Cu≥4 1≤Cc≤ 3	ML or MH	GW-GM	< 15% sand	Well-graded gravel with silt
					≥ 15% sand	Well-graded gravel with silt and sand
			CL, CH or CL-ML	GW-GC	< 15% sand	Well-graded gravel with clay (or silty clay)
					≥ 15% sand	Well-graded gravel with clay and sand (or silty clay and sand)
		Cu<4 1>Cc> 3	ML or MH	GP-GM	< 15% sand	Poorly graded gravel with silt
					≥ 15% sand	Poorly graded gravel with silt and sand
			CL, CH or CL-ML	GP-GC	< 15% sand	Poorly graded gravel with clay (or silty clay)
					≥ 15% sand	Poorly graded gravel with clay and sand (or silty clay and sand)
	> 12%		ML or MH	GM	< 15% sand	Silty gravel
					≥ 15% sand	Silty gravel with sand
			CL or CH	GC	< 15% sand	Clayey gravel
					≥ 15% sand	Clayey gravel with sand
			CL-ML	GC-GM	< 15% sand	Silty, clayey gravel
					≥ 15% sand	Silty, clayey gravel with sand
Sand	≤ 5%	Cu≥6 1≤Cc≤ 3		SW	< 15% gravel	Well-graded sand
					≥ 15% gravel	Well-graded sand with gravel
		Cu<6 1>Cc> 3		SP	< 15% gravel	Poorly graded sand
					≥ 15% gravel	Poorly graded sand with gravel
	5-12%	Cu≥6 1≤Cc≤ 3	ML or MH	SW-SM	< 15% gravel	Well-graded sand with silt
					≥ 15% gravel	Well-graded sand with silt and gravel
			CL, CH or CL-ML	SW-SC	< 15% gravel	Well-graded sand with clay
					≥ 15% gravel	Well-graded sand with clay and gravel
		Cu<6 1>Cc> 3	ML or MH	SP-SM	< 15% gravel	Poorly graded sand with silt
					≥ 15% gravel	Poorly graded sand with silt and gravel
			CL, CH or CL-ML	SP-SC	< 15% gravel	Poorly graded sand with clay
					≥ 15% gravel	Poorly graded sand with clay and gravel
	> 12%		ML or MH	SM	< 15% gravel	Silty sand
					≥ 15% gravel	Silty sand with gravel
			CL or CH	SC	< 15% gravel	Clayey sand
					≥ 15% gravel	Clayey sand with gravel
			CL-ML	SC-SM	< 15% gravel	Silty, clayey sand
					≥ 15% gravel	Silty, clayey sand with gravel

From ASTM 2487

Attachment 3
List of Geotechnical Laboratory Standard Test Methods

Attachment 3. List of Geotechnical Laboratory and Field Standards and Test Methods

Test Standard	Test Description	Note
AMS	Soil Age Dating using Accelerator Mass Spectrometry	Lab must be ICO accredited
ASTM D1535-14	Specifying colors by the Munsell system	
ASTM D1557	Modified Proctor	
ASTM D1586-18	Standard penetration test (SPT) and split-barrel sampling	
ASTM D1587-15	Thin-walled tube sampling	
ASTM D2166	Unconfined Compression	
ASTM D2216	Water Content	Method A or B dependent on soil type
ASTM D2419-14	Sand Equivalent Value	
ASTM D2435	Consolidation	
ASTM D2487-17e1	Classification of soils for engineering purposes (unified soil classification system)	
ASTM D2488-17e1	Description and identification of soils (visual-manual procedure)	
ASTM D2844	Resistance R-Value of Soil	
ASTM D2850	Unconsolidated Undrained Triaxial Compression (TXUU)	
ASTM D2974	Organic Content	Method A
~~ASTM D3080~~	Direct Shear (Consolidated Drained)	Standard withdrawn in 2020 and not replaced.
ASTM D3550-17	Thick wall, ring-lined, split barrel, drive sampling of soils	
ASTM D4015	Resonant Column	
ASTM D4186	Consolidation, Constant Rate of Strain (CRS)	
ASTM D4220-14	Preserving and transporting samples	
ASTM D4318	Atterberg Limits (LL, PL, PI)	Method A, Wet Preparation
ASTM D4546-14e1	One-dimensional swell or collapse of soils	
ASTM D4647-13(2020)	Pinhole Dispersion	

Test Standard	Test Description	Note
ASTM D4767	Consolidated Undrained Triaxial Compression (TXCU)	
ASTM D4829-19	Expansion Index	
ASTM D5084	Hydraulic Conductivity	Select method suitable for material, Method C is common
ASTM D5731-16	Point Load	
ASTM D6066-11	Normalized penetration resistance of sands	
ASTM D6467	Torsional Shear	
ASTM D6528	Direct Simple Shear (Consolidated Undrained)	
ASTM D6913	Grain Size Analysis (Sieve)	
ASTM D698	Standard Proctor	
ASTM D7263	Unit Weight	Direct measurement by Method B
ASTM D7608	Torsional Shear (Fully Softened)	
ASTM D7928	Hydrometer Analysis (Sedimentation)	
ASTM D8296	Cyclic Direct Simple Shear (Consolidated Undrained)	Load or displacement controlled
ASTM D854	Specific Gravity	
ASTM G75-07	Miller Number & Slurry Abrasion Response Number	
CTM 417	Sulfate content	
CTM 422	Chloride content	
CTM 643	Resistivity and pH	
CSM	Soil Abrasivity Index	
EPA 9801	Cation exchange	
NTNU (SAT)	Soil Abrasion Test	
XRD.US	X-Ray Diffraction	

Attachment 4
Boring Log and CPT Format

Attachment 4. Boring Log and CPT Format

Example gINT boring log showing format.

DCA

Project: Delta Conveyance Feature: California WaterFix / Bouldin Island County: San Joaquin	**DRILL HOLE LOG** **DCA-DH-048** **Sheet 1 of 9**
Coordinates: North 2,224,933.36 East 6,261,080.06 Datum: Survey Method: Ground Survey GPS: Latitude Longitude	Delta Conveyance Design & Construction Authority California Department of Water Resources

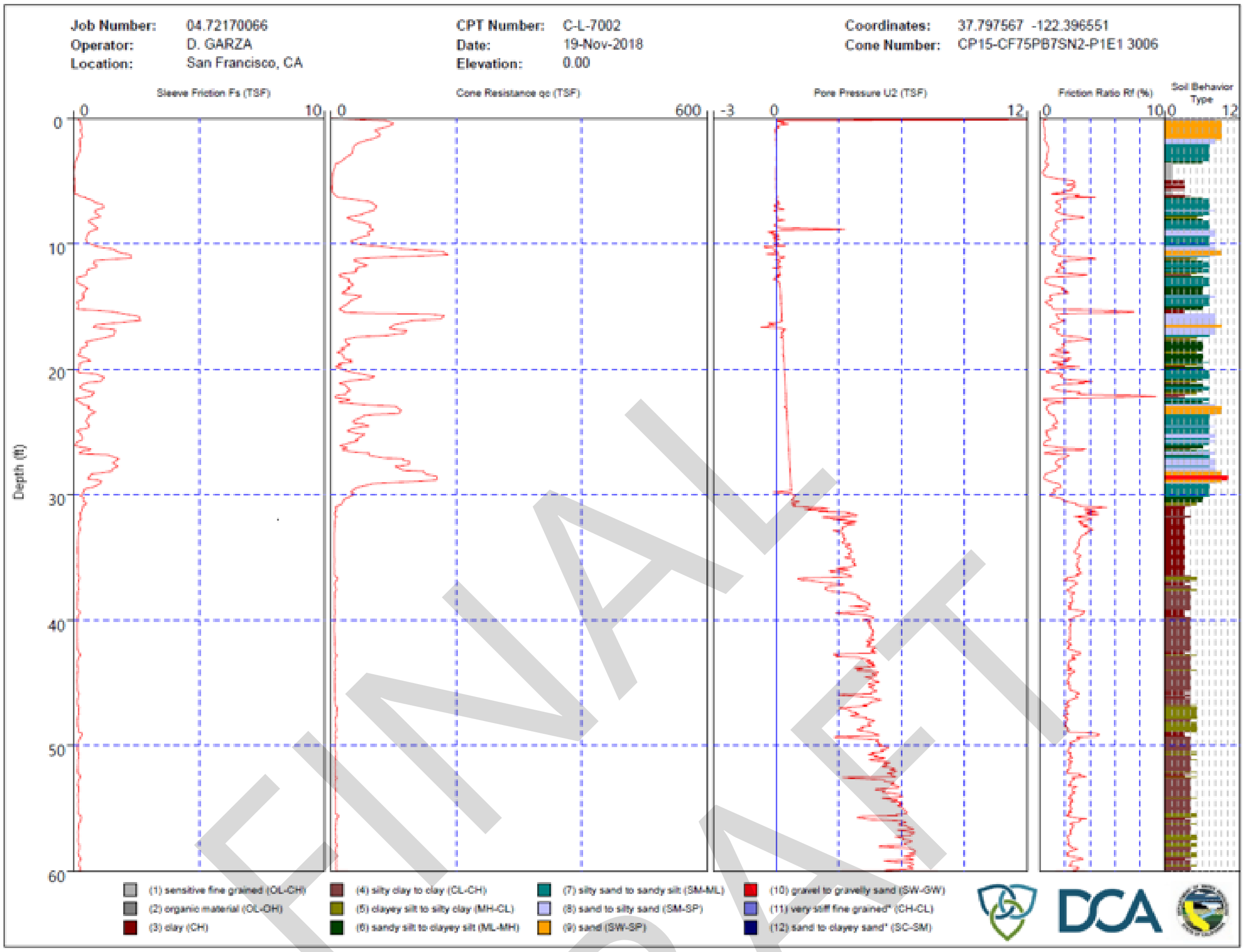
DATE/TIME STARTED **9/17/12** DATE/TIME COMPLETED **9/21/12**	GROUND ELEVATION (NAVD88) **-13.00 ft** ELEVATION BASIS **Ground Survey**	TOTAL DEPTH OF BORING **217.0 ft**
DRILLING CONTRACTOR **Gregg Drilling & Testing, Inc.**	DRILLER'S NAME **Luis Torres** HELPER'S NAME **Rick Ryon**	TOTAL DEPTH OF FILL **0 ft**
DRILLING METHOD **0 - 5 ft: HA, 5 - 10 ft: HSA, 10 - 217 ft: RD**	DRILL RIG MAKE AND MODEL **Mobile B-53, D-3**	CONSULTANT COMPANY **DWR/URS**
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) **9 O.D. HSA bit/ 5-3/4 O.D. punch core bit**	DRILLING ROD TYPE AND DIAMETER **8 HSA & 4.5 O.D. HWT & 2.5 NWJ**	FIELD LOGGER **N. Hightower/M. Palmer**
☒ VERTICAL ☐ INCLINED	CASING TYPE, DIAMETER, INSTALLATION DEPTH **6.5 steel casing to 18.5'**	FIELD LOG REVIEWER **D. Pieczynski**
SAMPLER TYPE(S) **SPT, 3 Shelby, 2 i.d. MCAL, 134mm Punchcore**	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP **Automatic, 140 lbs / 30-inch drop**	HAMMER EFFICIENCY **75%**
BOREHOLE BACKFILL OR COMPLETION **Tremie backfilled with 95% cement, 5% bentonite by wt.**	GROUNDWATER READING: DURING DRILLING **9 ft**	AFTER DRILLING (DATE-TIME)

Elevation, feet	Depth, feet	Graphic Log	CLASSIFICATION AND DESCRIPTION	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N_{60}(ASTM)	PP or TV, tsf	Retained Sample	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS / INSTALLATION NOTES
	0		HOLOCENE PEAT, 0.0 to 6.0'														Hand Auger 0-5'
	1	OL															
-15	2		0.0 to 2.5' ORGANIC SILT, (OL): About 50% nonplastic fines; about 30% organics, fibrous organics; about 20% fine sand; brown, dry; no reaction with HCl.	Hand Auger	BULK	15					☒						**B01A-002.0-002.5 (2.0' to 2.5')**
	3																
	4	PT	2.5 to 5.6' PEAT, (PT): About 60% hemic organics, slightly altered organic fibers, recognizable, grass-like fibers; brown turbid water expressed when squeezed; about 40% fines; very soft, dark brown, dry; no reaction with HCl; low density. From 4.0', Moist.								☒						**B01B-004.0-004.5 (4.0' to 4.5')**
	5				SPT	47	0 0 3	3	4		☒						Switched to Hollow-Stem Auger **S01A-005.0-005.6 (5.0' to 5.6')**
-20	7		5.6 to 12.4' CLAYEY SAND, (SC): About 85% fine sand; about 15% low to medium plasticity fines; very loose, greenish gray, moist; no reaction with HCl; trace mica; trace organic fibers; possibly SM. HOLOCENE BASIN, 6.0 to 12.0'	Auger	DCORE	66					☒						**P01A-006.5-007.0 (6.5' to 7.0')**
	9 ▽	SC															Water level at 9.0', matches adjacent water level in drainage ditch
	10		From 9.0', Wet. From 10.8', About 75% fine sand; about 25% low plasticity fines.		SPT	100	1 2 1	3	3		☒						Switched to Mud Rotary, pushed 10' of casing **S02A-010.0-011.5 (10.0' to 11.5')**
	11.5					100					☒						**P02A-011.5-012.0 (11.5' to 12.0')**
-25	12		MODESTO FM, 12.0 to 75.0'		SPT	93	2 1 2	3	3		☒						**S03A-012.4-013.4 (12.4' to 13.4')**
	13	SP-SM									☒						**P03A-013.5-013.8 (13.5' to 13.8')**
	14		12.4 to 14.9' Poorly Graded SAND with Silt, (SP-SM): About 90% fine sand; about 10% nonplastic fines; very loose, greenish gray, wet; no reaction with HCl; trace mica; gradational upper contact. From 13.7', Very dense cemented sand, no HCl reaction, siliceous cement?; highly indurated, had to break with rock hammer.	Rotary	PCORE	83				>4.5P	☒						**P03B-014.0-014.5 (14.0' to 14.5')** Driller had to stop drilling, too hard. Down pressure over 1500 psi, switched to shorter punch core shoe **P03C-015.5-016.0 (15.5' to 16.0')**
-30	17	s(CL)	14.9 to 19.0' SANDY LEAN CLAY, s(CL): About 60% medium plasticity fines with very high dry strength, no dilatancy, medium toughness; about 40% fine to medium sand; hard, greenish gray, moist; abundant calcium carbonate stringers with strong HCl reaction.		SPT	40	12 19 21	40	55		☒						**S04A-017.0-017.6 (17.0' to 17.6')** Too hard for Shelby, no Pitcher set up on-site
	19	SM			PCORE	40											
	20																

Draft 3 After All Lab Data Added 4/2/2013

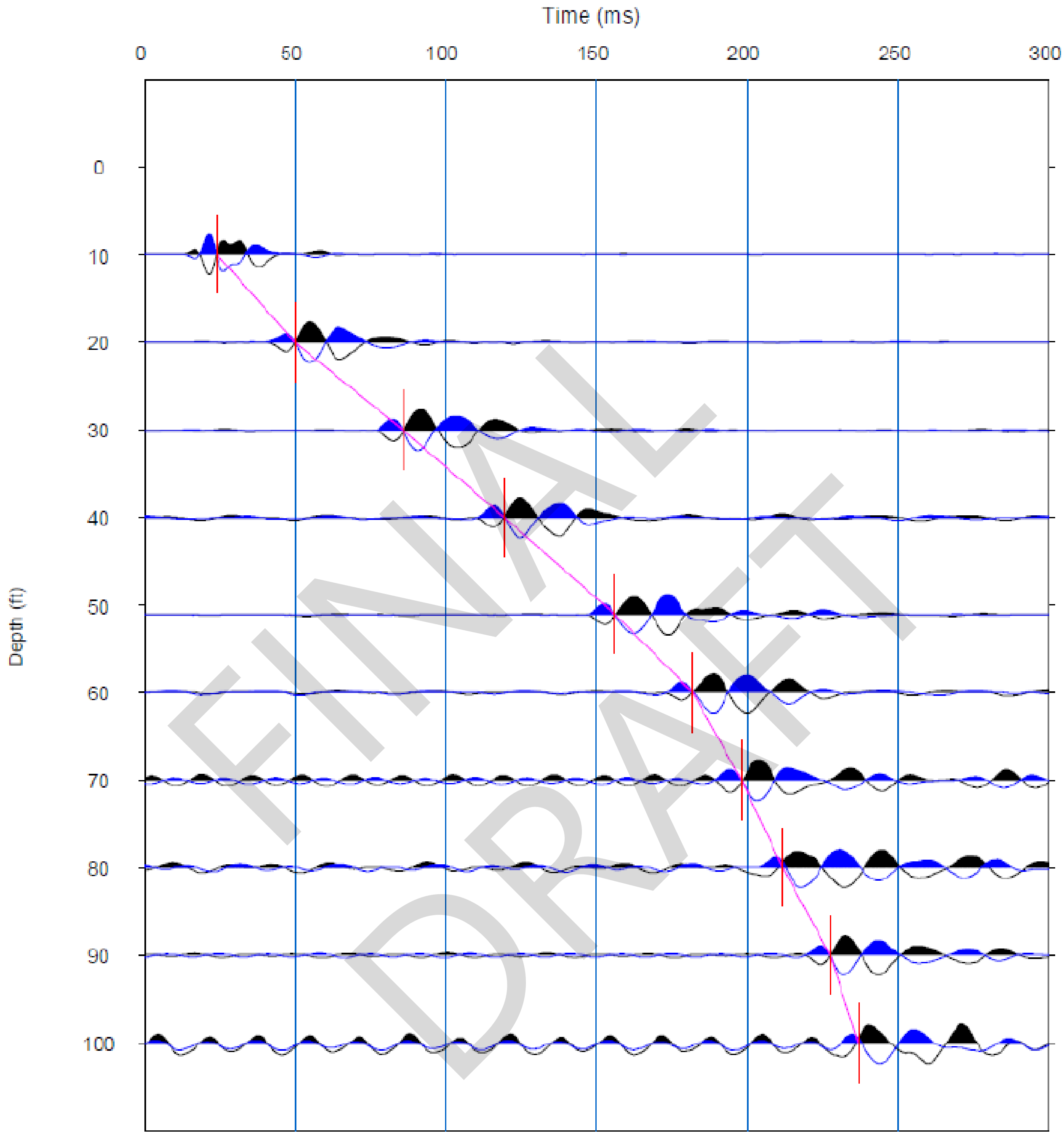
DCDCA SOIL AND LAB: HISTORIC_DELTA_CONVEYANCE.GPJ; DCDCA LIBRARY 2020_04_24.GLB; 10/30/20

Example of raw CPT log generated in the field.

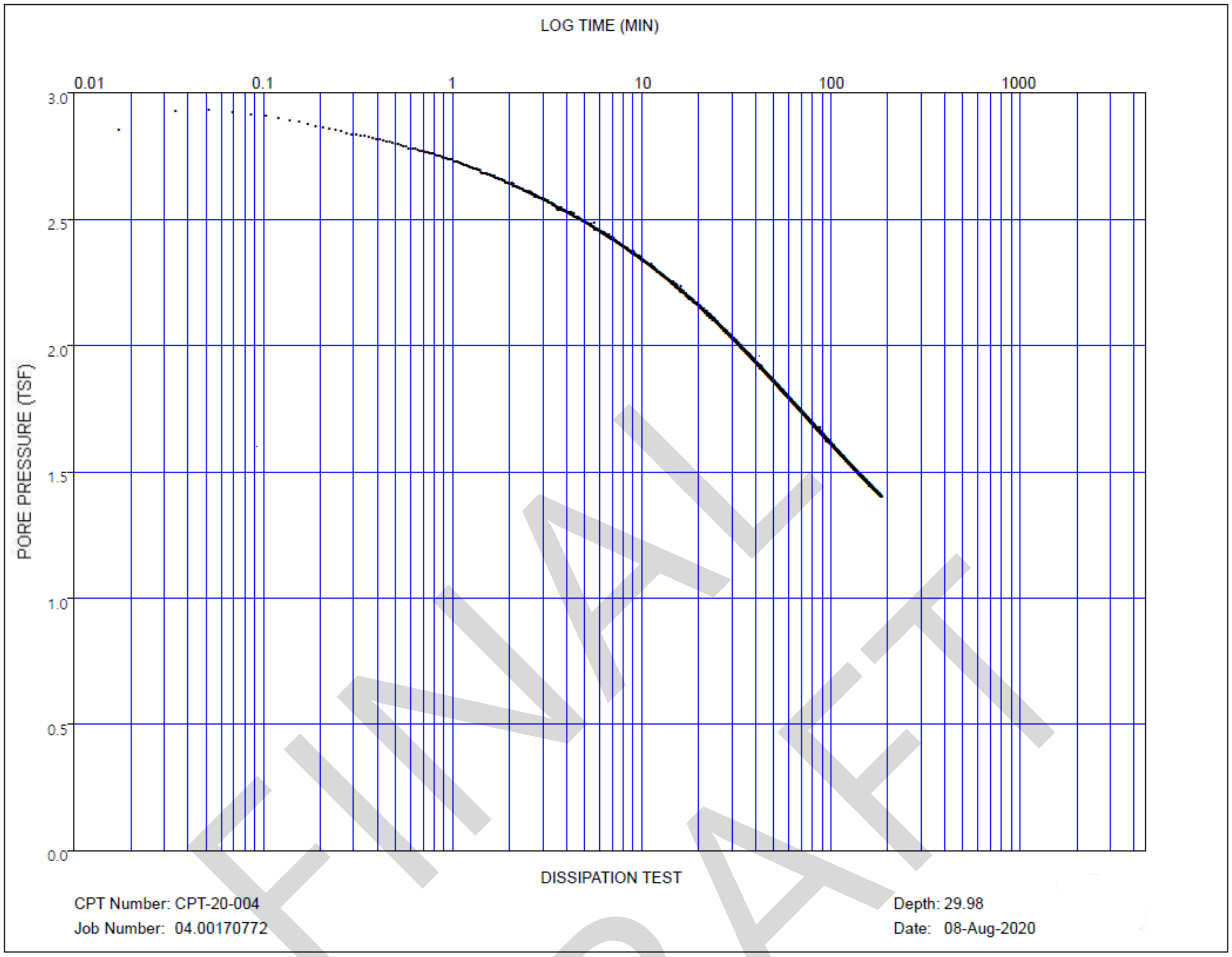


Example of shear wave velocity data.

Example of shear wave waveform data.



Example of pore pressure dissipation data



Attachment 5
Geologic Unit Nomenclature

Placeholder for future addition of Table of Geologic Units

Subject:	**Laboratory Standards**
Project feature:	Geotechnical
Prepared for:	California Department of Water Resources (DWR)/Delta Conveyance Office (DCO)
Prepared by:	Delta Conveyance Design and Construction Authority (DCA)
Copies to:	Files
Date/Version:	February 19, 2021/Final Draft
Reference no.:	GDE-GE-Laboratory Standards-02192021

This document presents minimum requirements of laboratories performing testing for the Delta Conveyance Project (DCP).

Contents

Attachments

Acronyms and Abbreviations

AASHTO	American Association of State Highway Transportation Officials
AAP	AASHTO Accreditation Program
A2LA	American Association for Laboratory Accreditation
CVP	Central Valley Project
DCA	Delta Conveyance Design and Construction Authority
DCO	Delta Conveyance Office of the Department of Water Resources
DCP	Delta Conveyance Project
DPT	Data Processing Team
DWR	Department of Water Resources
ELAP	Environmental Laboratory Accreditation Program
ET	Exploration Team
GC	Geotechnical Consultant
GDPC	Geotechnical Data Processing Center
IAS	International Accreditation Service
LT	Laboratory Team
SWP	State Water Project
QAM	Quality Assurance Manager

1. Introduction

This document presents minimum requirements of laboratories performing testing for the Delta Conveyance Project (DCP). This document may be updated as necessary to reflect additional tasks and laboratory methods authorized during the duration of the project.

1.1 Purpose and Scope

The purpose of these standards is to outline laboratory procedures for analysis of soil samples for the Delta Conveyance Project.

1.2 Project Related Documents

The following documents are referenced in this report:

- Geotechnical Exploration Plan,
- Field Exploration Standards,
- DCA Boring and CPT Logging Standards and Work Procedures, and
- Quality Management Plan (QMP).

Laboratory team members will familiarize themselves with the project related documents listed above and all associated project requirements.

1.3 Laboratory Team

The Laboratory Team (LT) is responsible for performance of laboratory testing as assigned by the DCA through the Data Processing Team (DPT). Roles and responsibilities of the GC Laboratory Team include the following:

- Laboratory Team Leader
  - Coordinate the laboratory testing program activities with team members, including subcontracted laboratories,
  - Develop documents for program implementation,
  - Provide technical guidance and oversight in program execution,
  - Provide weekly progress reports, including task order costs and schedule to the GC Project Manager,
  - Provide program status and collected information to the GC Team,
  - Perform contract and subcontract administration and monitoring, and
  - Maintain list of accreditations of all laboratories.
- Sample Runner
  - Deliver samples to the assigned laboratories,
  - Collect remainder of tested samples and untested samples and return them to the GDPC,
  - Deliver samples to DWR Storage Facility after testing is completed, and

– Package samples for shipping to out-of-area laboratories.

1.4 Confidentiality and Public Relations

All laboratory data collected for the DCP is to be kept confidential. Laboratory personnel should not comment on results of testing or share project information unless authorized by the DCA.

2. Health and Safety

Each laboratory shall maintain an Injury Illness Prevention Plan and Chemical Hygiene Program as applicable to their scope of laboratory testing services. Laboratory personnel shall be trained to their plan.

Samples for geotechnical testing are assumed to not be contaminated. If contamination is anticipated based on field observations, sample location history, or results of analytical testing, special handling methods commensurate to the type and level of contamination may need to be employed.

3. Laboratory Quality Management

3.1 Approved Laboratories

Laboratories performing testing for the DCP shall be approved by the GC based on accreditation, capacity, capability, cost, and risk of sample disturbance. Laboratory facilities are to be maintained in a clean and organized manner conducive to the performance of testing consistent with specified standard procedures and the industry standard of care.

3.2 Accreditation or Agency Approval

Laboratories performing testing for the DCP shall maintain current accreditation or agency approval for the services they perform. Evidence of accreditation or agency approval shall be reviewed and documented by the Laboratory Team Leader.

Laboratories performing soil classification, index testing and routine strength testing shall demonstrate compliance to the requirements of ASTM D3740 – Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction. Acceptable accrediting bodies include AASHTO (AAP), A2LA, and IAS.

Laboratories performing environmental testing of soil samples shall have and maintain current certification by the California State Environmental Laboratory Accreditation Program (ELAP) for the tests which they are requested to perform.

Laboratory staff shall have current verified competency for each test standard they perform. The verification may be documented by means of external certification or an in-house competency verification program. In-house competency verifications shall include documentation of satisfactory performance of each test procedure a technician is authorized to perform. Verifications must be performed at a maximum frequency of 24 months for technicians and 36 months for supervisors.

3.3 Calibration and Control of Measuring and Test Equipment

Equipment used by laboratories shall be calibrated in accordance with manufacturer's instructions and/or a frequency specified by the laboratory's quality management system. Evidence of compliance will be reviewed and documented by the Laboratory Team Leader to confirm that testing equipment in use for the DCP Program is considered "fit for service".

Calibrations shall be traceable to one of more of the following:

- National Institute of Standard and Technology (NIST),
- U.S. Environmental Protection Agency, and
- A Primary Standards Laboratory.

Calibration certificates should be maintained and made available to the QAM or LT Leader if requested. Calibration certificates shall contain the following information, at a minimum:

- The calibration laboratory location,
- The certificate's unique identifier,
- The name and address of the facility for which the calibration was performed,
- The serial number or other unique identifier of the device calibrated,
- The name of the person who performed the calibration,
- The date of the calibration,
- Identification of laboratory measuring and test equipment standards used,
- Notation of deviations or out-of-tolerance conditions,
- The calibration results data (as-found and as-left), where applicable,
- The date indicating when the next calibration check is due,
- The signature/title of an authorized certificate approver, and
- A statement attesting to traceability to national or international standards.

4. Laboratory Samples

4.1 Geotechnical Sample Receiving and Storage

Geotechnical soil samples will be received from the DPT after an initial review of the soil boring logs and upon assignment of laboratory testing. After the appropriate laboratory is selected to complete the tests, samples will be packaged and transported in accordance with ASTM D4220. Samples may be transported by the LT Sample Runner or shipped to the testing laboratory, depending on distance to the laboratory from the GDPC, quantity of samples to be transported, and other factors identified at the time of transport.

Samples that are assigned testing will be logged in a tracking spreadsheet indicating the laboratory to complete the test, the exploration identification number, the sample identification number, the tests to be completed, and the status of the test. Upon completion of the tests, samples will be returned to the

GDPC and stored with the remainder of the samples for a specific exploration. This information will also be noted in the tracking spreadsheet.

Geotechnical field samples will be preserved in accordance with the following standards:

- ASTM D1587, Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes;
- ASTM D4220, Standard Practices for Preserving and Transporting Soil Samples; and
- Prior to initiating a laboratory test, samples shall be stored and conditioned consistent with the requirements of the requested testing. This includes, but is not limited to, protection against loss of water content, drying at various temperatures, or conditioning at a specified temperature and/or humidity range.

4.2 Environmental Sample Receiving and Storage

Environmental samples will be received under chain of custody and will be immediately placed in refrigerated storage. Special care should be taken to notify the testing laboratory either 24 hours before environmental samples are collected or as soon as possible (generally within 24 hours of being placed under refrigerated storage) to arrange for sample pickup and ensure the samples do not surpass their maximum hold time before testing. Samples with extremely short hold times may be collected by the testing laboratory directly from the exploration site.

4.3 Test Instructions

Geotechnical and environmental samples will be submitted to laboratories under chain of custody and will identify the LT Leader as the contact for questions about the test instructions. Parameters necessary for testing, such as confining stress or normal loads, shall be included with the test instructions. The field classification shall also be provided to the laboratory so that technicians may confirm that the material received is the material intended for testing.

If a condition is identified that may affect the outcome of testing, the DPT Lead should be contacted for instructions prior to proceeding. For geotechnical testing conditions include the presence of features not described in the field notes (e.g., sand lenses, changes in soil type, or oversize particles), poor sample quality (e.g., limited recovery, or voids). For environmental testing this includes samples received beyond the maximum hold time, and samples exposed to temperatures outside the recommended range. Samples that are returned to the GDPC untested or with testing modifications will be noted in the laboratory tracking spreadsheet.

4.4 Sample Control

Each laboratory's sample control process shall be clearly defined in their quality management system manual. Each sample, or sample portion, shall be controlled throughout the testing process such that each sample remains uniquely identified.

4.5 Sample Disposal

After the completion of testing, materials that have been altered and cannot be retested may be disposed of in accordance with the laboratory's sample disposal procedure. Samples, or portions of samples, that remain intact and/or in their received moisture condition shall be returned to the Geotechnical Data Processing Center (GDPC) after the laboratory testing program is complete.

5. Laboratory Test Reports

5.1 Report Content

The reporting requirements of the assigned test standard will be followed in preparing the written results for testing. As applicable, the following information shall be included and/or traceable to the test report:

- Name and address of the laboratory where the test was performed,
- Identification of the report and the date issued,
- Identification of the project,
- Description and identification of the test sample,
- Date of receipt of the test sample,
- Date(s) the test was performed,
- Identification of the standard test method used and a notation of deviations from the standard, and
- Test results required by the standard.

5.2 Report Deliverables

Results of laboratory testing shall be submitted in electronic format. Geotechnical index and classification tests and environmental tests shall be summarized in an Excel table so that values may be imported into a gINT file format by the LT. Photographs of samples shall be reported for standard test methods which require either a sketch or photograph of the sample before and/or after test.

6. Document History and Quality Assurance

Reviewers listed below have completed an internal quality review check and approval process for this deliverable that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

			Approval Names and Roles			
Rev.	Date	Version Description	Prepared by	Internal QC review by	Consistency review by	Approved for submission by
0	08/31/2020	Initial submission	Chris Pollack /Laboratory Team Leader	James Wetenkamp /Exploration Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache GC Geotechnical Engineering Manager
1	10/16/2020	Incorporate DCA review comments	Chris Pollack /Laboratory Team Leader	James Wetenkamp /Exploration Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache GC Geotechnical Engineering Manager
2	11/20/2020	DCO Submission	Chris Pollack /Laboratory Team Leader	James Wetenkamp /Exploration Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache GC Geotechnical Engineering Manager
3	02/19/2021	Final Draft	Chris Pollack /Laboratory Team Leader	James Wetenkamp /Exploration Team Leader	Deron van Hoff /TEMT Lead	Andy Herlache GC Geotechnical Engineering Manager
This interim document is considered preliminary and was prepared under the responsible charge of Ward Andrew Herlache, Geotechnical Engineering License 2149.						

Attachment 1. List of Geotechnical Laboratory Standard Test Methods

Test Description	Test Standard (current version)	Note
Unit Weight	ASTM D7263	Direct measurement by Method B
Water Content	ASTM D2216	Method A or B dependent on soil type
Soil Finer than No. 200 (Wash)	ASTM D1140	
Grain Size Analysis (Sieve)	ASTM D6913	
Hydrometer Analysis (Sedimentation)	ASTM D7928	
Atterberg Limits (LL, PL, PI)	ASTM D4318	Method A, Wet Preparation
Specific Gravity	ASTM D854	
Unconfined Compression	ASTM D2166	
Unconsolidated Undrained Triaxial Compression (TXUU)	ASTM D2850	
Consolidated Undrained Triaxial Compression (TXCU)	ASTM D4767	
Consolidated Drained Triaxial Compression	ASTM D7181	
Cyclic Triaxial	ASTM D5311/D3999	
Direct Shear (Consolidated Drained)	ASTM D3080	
Direct Simple Shear (Consolidated Undrained)	ASTM D6528	
Cyclic Direct Simple Shear (Consolidated Undrained)	ASTM D8296	Load or displacement controlled
Consolidation	ASTM D2435	
Consolidation, Constant Rate of Strain (CRS)	ASTM D4186	
Resonant Column	ASTM D4015	
Carbonate Content of Soils, Rapid Determination	ASTM D4374	
One-Dimensional Swell or Settlement Potential	ASTM D4546	
Expansion Index	ASTM D4829	
Thermal Conductivity	ASTM D5334	
Double Hydrometer	ASTM D4221	
Pinhole Test for Dispersive Soils	ASTM D4647	
Crumb Test for Dispersive Soils	ASTM D6572	
Torsional Shear	ASTM D6467	
Torsional Shear (Fully Softened)	ASTM D7608	
Hydraulic Conductivity	ASTM D5084	Select method suitable for material, Method C is common

Organic Content	ASTM D2974	Method A
Resistance R-Value of Soil	ASTM D2844	
Standard Proctor	ASTM D698	
Modified Proctor	ASTM D1557	
Minimum and Maximum Relative Density	ASTM D4254 and D4253	
Soil Abrasivity	NTNU SAT	
Soluble Sulfate	CT417	
Minimum Resistivity	CT643	
pH	CT532	
Chloride Content	CT422	
Rock Point Load	ASTM D5731	
Rock Slake Durability	ASTM D4644	
Rock Triaxial Compression	ASTM D7012	Method A
Rock Triaxial Compression w/Modulus of Rupture	ASTM D7012	Method B
Rock Unconfined Compression	ASTM D7012	Method C
Rock Unconfined Compression w/Modulus of Rupture	ASTM D7012	Method D
Rock Splitting Tensile	ASTM D3967	

*CT = California Test

Attachment 2. List of Environmental Laboratory Standard Test Methods

Test Description	Test Standard	Note
Polyaromatic Hydrocarbons	SW8270SIM	
Butylins	Krone Method	
Ammonia	SM4500NH3	
Nitrate/Nitrite	SM4500NO3	
Metals	ICP/MS	
Soluble Metals	STLC SW6020	Using deionized water (Di-WET)
Mercury	SW7471	
Soluble Mercury	STLC SW7470	
Methyl Mercury	EPA Method 1630	
Hexavalent Chromium	SW7196	
Total Petroleum Hydrocarbons	Modified SW8015	
Chlorinated Pesticides	SW8081	
Polychlorinated Biphenyls	SW8082	
Herbicides	SW8151	
Semi-volatile Organics	SW8270/SW8270 SIM	
Total Organic Carbon	Walkley-Black	
Agronomic Planting Suitability Properties Including Boron		
Salinity as Chloride (Cl-)		

Attachment 3. Example Laboratory Test Assignment

Sheet _____ of _____

DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Project No.: __________

Date Submitted: __________

Submitted By: __________

Technical Contact: __________

LABORATORY TESTING PROGRAM - GEOTECHNICAL

Borehole / Test Pit	Sample	Depth, ft.	Sample Type	WATER CONTENT	UNIT WEIGHT	GRAIN SIZE ANALYSIS	HYDROMETER ANALYSIS	ATTERBERG LIMITS	SPECIFIC GRAVITY	UNCONFINED COMPRESSION	TXUU	TXCU	DIRECT SHEAR	DIRECT SIMPLE SHEAR	CYCLIC DIRECT SIMPLE SHEAR	CONSOLIDATION	CONSOLIDATION, CRS	RESONANT COLUMN	TORSIONAL SHEAR	TORSIONAL SHEAR, FS	HYDRAULIC CONDUCTIVITY	ORGANIC CONTENT	RESISTANCE R-VALUE	STANDARD PROCTOR	MODIFIED PROCTOR	SOIL ABRASIVITY	Remarks
Quantity of Tests																											

Test requested   Test in progress   Test complete

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Attachment 4. Example Environmental Chain of Custody Form

DCA — Delta Conveyance Design & Construction Authority

Page ________ of ________

Project No.	Project Name	Receiving Lab:
L.P. No. (PO No.)	Samplers: (Signature/Number)	Instructions/Remarks

#	Date MM/DD/YY	Sample I.D. Time HH-MM-SS	Sample I.D.	Matrix	No. of Containers	Type of Containers	Analysis											Instructions/Remarks
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		

Relinquished By:	Date/Time	Received By:	Instructions/Remarks	Send Results To:
Relinquished By:	Date/Time	Received By:		
Relinquished By:	Date/Time	Received By:		

Rev. 8/25/2020

CHAIN-OF-CUSTODY

Attachment 5. Example Laboratory Report Template

gINT FILE: C:\users\tmckenney\onedrive - Kleinfelder\desktop\gint Stuff\dt And Libraries Archives\klf Gint 2021\development Project Files\klf_gint_2021.gpj
gINT TEMPLATE: C:KLF_STANDARD_GINT_LIBRARY_2021.GLB [_KLF_LAB SUMMARY TABLE - SOIL]

PROJECT NUMBER: 2021_FieldNet.TEST

OFFICE FILTER: KLF ITS
PLOTTED: 08/25/2020 02:47 PM BY: TMcKenney

Exploration ID	Depth (ft.)	Sample Description	Water Content (%)	Dry Unit Wt. (pcf)	Sieve Analysis (%)			Atterberg Limits			Additional Tests
					Passing 3/4"	Passing #4	Passing #200	Liquid Limit	Plastic Limit	Plasticity Index	

PROJECT NO.: 2021_FieldNet.TEST

DRAWN BY:

CHECKED BY:

DATE:

LABORATORY TEST RESULT SUMMARY

KLF Exploration Plan
550 West C Street, Ste 1201
San Diego, CA 92101

TABLE

C-1

DRAFT