

Final Construction Quality Assurance Project Plan (CQAPP) Reach A, Phase I

**Clark Fork River Operable Unit
Milltown Reservoir / Clark Fork River NPL Site
Deer Lodge County, Montana**

Prepared for:

**Montana Department of Environmental Quality
Remediation Division**

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Appendix A – CFRSSI Standard Operating Procedures

1.0 INTRODUCTION

This Construction Quality Assurance Plan (CQAP) details construction Quality Assurance (QA) procedures and responsibilities for Remedial Action (RA) of the Clark Fork River Operable Unit (CFROU) Milltown Reservoir/Clark Fork River Superfund Site (CFR), Reach A, Phase 1. The CFROU is located along the Clark Fork River in southwestern Montana.

DEQ as lead agency will oversee, manage, coordinate, design, and implement the Remedial Action for the Clark Fork Site, in consultation with the Environmental Protection Agency (EPA). DEQ will coordinate with the NRDP for the implementation and integration of Restoration components into the Work.

The Clark Fork River Operable Unit ("CFROU" or "Clark Fork Site") is part of the Milltown Reservoir/Clark Fork River Superfund Site. Heavy metals originating from historic mining activities, milling and smelting processes associated with the Anaconda Company operations in Butte and Anaconda have accumulated on the Clark Fork River stream banks and floodplain over a period of at least 100 years. The primary sources of contamination are tailings and contaminated sediments mixed with soils in the stream banks and floodplains, which erode during high flow events and enter the river and other surface waters. In addition to erosion, heavy metals are leached from the contaminated sediments and tailings directly into the groundwater and eventually to surface water. These contaminant transport pathways result in impacts to terrestrial and aquatic life along the Clark Fork River as described in the Record of Decision (ROD) for the site (EPA, 2004).

The Clark Fork Site is located within four counties, Deer Lodge, Powell, Granite, and Missoula Counties. The upstream boundary of the Site is located at the confluence of the old Silver Bow Creek channel with the reconstructed lower Mill-Willow bypass just downstream of the Warm Springs Ponds. The original channel of the river upstream of this point was obliterated when the Warm Springs Ponds were built. The downstream boundary is the maximum high pool reservoir level (elevation 3265.5, NAVD 88) of the former Milltown Reservoir (eliminated by the removal of the Milltown Dam), just east of Missoula, Montana.

Phase 1 covers the initial 1.6 river miles of Reach A (Figure 1) between the junction with the original channel and the north boundary on land transferred from Atlantic Richfield Company to the State of Montana. The property is located in Section 18, Township 5 North, Range 9 West, and is shown on the Drawings, Sheet C1. Access to the site is via Morel Road east of the community of Warm Springs.

The Phase 1 area consists of the river and its floodplain. There is no development on the site and only one road traverses the area. The floodplain contains slickens (barren areas of tailings) and thick layers of tailings / impacted soils which only support plant growth to varying degrees. Contractor shall excavate contaminated tailings / impacted soils from banks and floodplain in the Phase 1 area; transport these materials to and place them in the B2.12 cell at Opportunity Ponds (owned by Atlantic Richfield Co.); backfill excavations in the floodplain with clean fill and reconstruct portions of the streambanks using bioengineering techniques. All Work will be conducted in accordance with the Drawings, Special Provisions and Technical Specifications as described in the Reach A, Phase 1 Remedial Action Project DEQ Contract 413002. Planting other than in streambanks shall be performed by others in coordination with Contractor.

1.1 Purpose and Objectives

DEQ, as Lead Agency, is implementing and directly oversees the remedial construction (i.e., referred to as the “Work”) under a Remedial Action Work Plan (RAWP). The RAWP takes the form of a construction bid package which will result in a remedial construction contract. Under this remedial construction contract, DEQ is designated the “Owner” of the Project. [DEQ’s Project Officer for the Clark Fork Site is vested with the authority of a Remedial Project Manager (RPM) and an On Scene Coordinator (OSC) as those terms are defined by the National Contingency Plan (NCP)]. The “Engineer” (acting either directly or through its staff of resident project representatives) is DEQ’s primary representative on the site and oversees the details of the Work. The “Contractor” procured through the state procurement process is responsible for “Quality Control” to ensure that construction complies with the requirements of the Contract Documents. Contractor will submit a Construction Quality Control Plan to Engineer for review and approval prior to the start of construction. DEQ’s Engineer will perform Quality Assurance in the form of construction oversight and additional testing as necessary to ensure that the remedial construction contract performed by Contractor meets the requirements for the Work.

This Construction Quality Assurance Plan (“CQAP”) outlines the Quality Assurance (“QA”) procedures by which Engineer determines the Work meets the requirements for this Project.

The specific objectives of the CQAP are:

- Define the QA Team organization and responsibilities.
- Define the interaction between the QA program and Contractor’s QC plan.
- Describe project communication, documentation, and record keeping protocols; on-site communications, progress meetings, and preparation of progress reports and construction files.
- Detail the role of the QA Team in reviewing and approving certification and calibration submittals; verifying construction grade and alignment; conducting verification testing, sampling, and analyses; and monitoring during RA construction activities. These QA efforts are in addition to the contractor QC program testing and analyses.
- Define independent testing to be conducted by the QA Team.

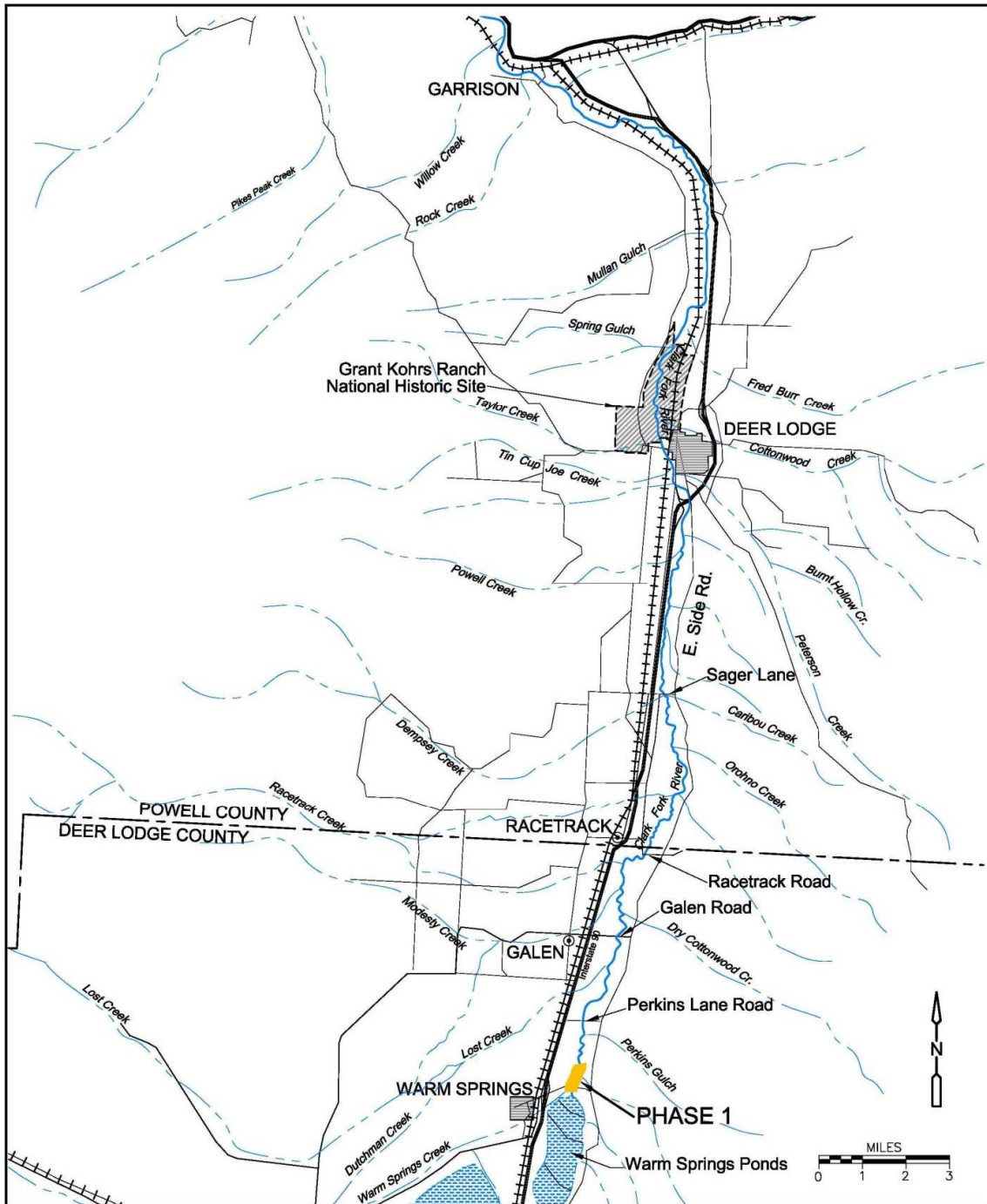


Figure 1: Reach A of the Clark Fork River Operable Unit

2.0 QUALITY ASSURANCE ORGANIZATION AND RESPONSIBILITIES

2.1 QA Organization

Engineer is designated as the leader of the Quality Assurance (“QA”) Team. The QA Team will be comprised of engineers, surveyors, scientists and technicians qualified and experienced in work similar to the CFR Reach A, Phase 1 Remedial Action. Specific personnel assignments will be established prior to the commencement of remedial construction. The QA Team Leader is the main point of contact for the QA Team. The QA Team will conduct both office and field work to verify that remedial construction is accomplished as specified. The QA Team will operate construction field activities from an on-site trailer or other field office. Laboratory analysis and testing will be accomplished in DEQ-contracted facilities. Figure 2 shows the organization of quality assurance for RA of the CFR Reach A, Phase 1.

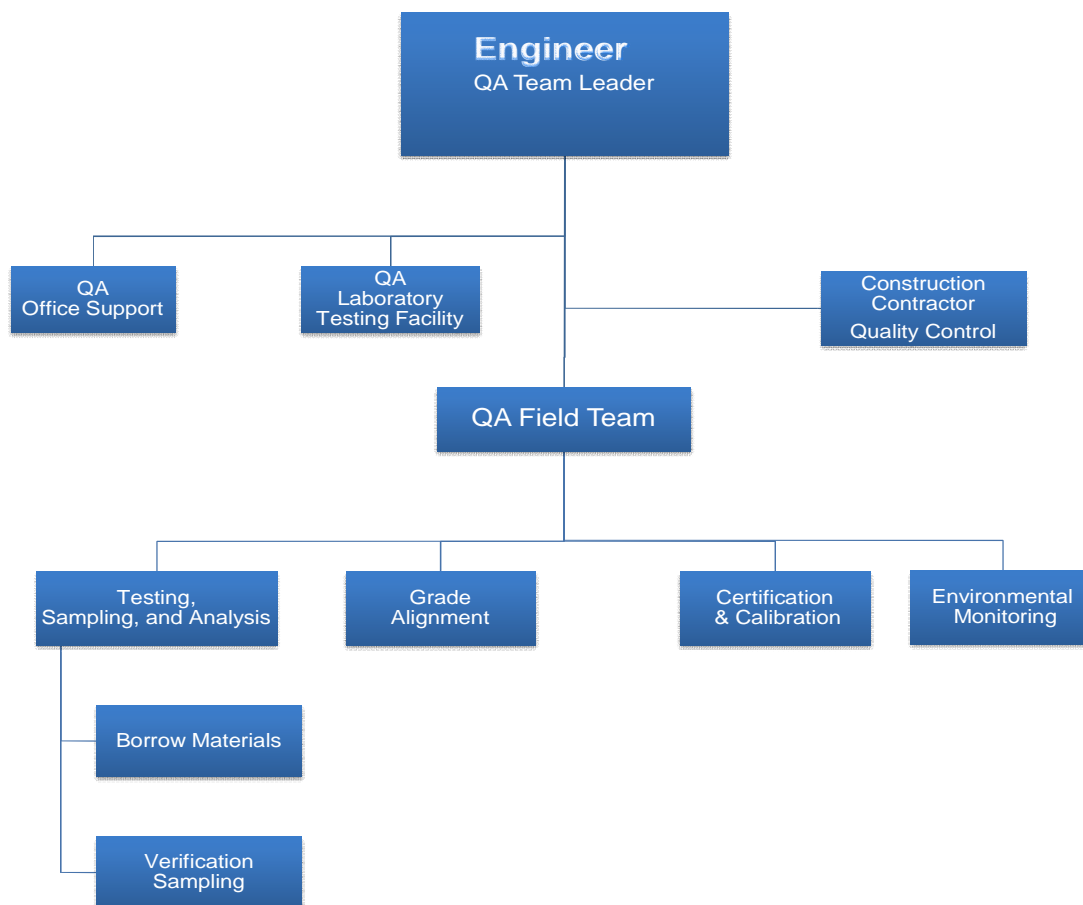


Figure 2: Organization of Quality Assurance for RA of the CFR Reach A, Phase I

2.2 QA Team Responsibilities

In general, the QA Team will be responsible during remedial construction activities for:

- Promoting and implementing remedial construction QA reporting, record keeping, meetings, and inspections;
- Reviewing and approving submittals for material certifications, equipment calibration and various construction plans;
- Conducting verification field tests, sampling, and material analyses;
- Observing and monitoring surface water quality, air quality, verifying removal of tailings/impacted soils; and
- Verifying that the remedial construction complies in all other ways with the Contract Documents; as outlined in the Drawings, Special Provisions and Technical Specifications.

2.3 Control of Work

Neither the Engineer nor other members of the QA Team may direct Contractor's work. Contractor is an independent contractor. Any changes to the remedial construction contract will be approved by Contractor, Engineer and DEQ, in accordance with the terms and conditions of the Contract Documents, and utilizing mechanisms such as a work change directive or a change order.

3.0 PROJECT COMMUNICATION

3.1 Reporting

Engineer (with input from QA Team) will prepare and submit to DEQ a Monthly Progress Report. These reports will present summaries of the important information relating to the monthly remedial construction activities gathered from the various records described below in Section 3.2. The Monthly Progress Report will include, if necessary, any proposed or field-approved modifications and justifications to the Work, this CQAP, the Drawings, the Special Provisions, Technical Specifications, or Site-Specific Health and Safety Plans, Contractor's Erosion Control Plan or other submittals. Engineer will obtain from Contractor updated information on construction activities, including percent completion and any scheduling modifications. The Monthly Progress Report will include Contractor collected information as well as a summary of the laboratory analytical results.

3.2 Record Keeping

Members of the QA Team will perform various record keeping duties under the supervision of Engineer. The QA Team is responsible for maintaining a complete and accurate record of all significant observations and inspections of all field or laboratory testing. These records will be kept on-site for review. The record keeping activities of the QA Team will include the following:

- *Daily Project Logs* -- All field members of the QA Team will keep daily project logs which will be reviewed by Engineer. Logs will be submitted to Engineer on a weekly basis. Log entries will document significant activities, abnormal observations, weather, deviations from the Drawings, Special Provisions and Technical Specifications or other standard procedures, health and safety meetings, important information and summaries regarding field sampling, measurements, observations or testing, equipment calibration and operation results, any photographs taken and topics/results of any significant meetings or discussions. Recording on the logs will generally be in accordance with the methods and procedures specified in Clark Fork River Superfund Site Investigation (CFRSSI) Standard Operating Procedure (SOP) G-4 (ARCO, 1992).
- *Photographs* -- Construction photographs, videos and associated logs will be recorded on a periodic basis to visually document significant construction activities and to provide visual reference material.
- *QA Testing Documents* -- Instrument calibration forms, field and laboratory measurement and sampling forms, sample logs, documentation forms, sample analysis requests, chain-of-custody forms, and any other documents related to QA testing will be kept on-site.
- *Other Documentation* -- Other documentation required, but not limited to, includes shop drawings, material compliance certifications, Material Safety Data Sheets (MSDS) forms, health and safety and construction meeting summaries, inspection records, relevant construction files, material samples and manufacturer's recommended installation or operating instructions.

All records collected by the QA Team will be saved in an electronic database developed by the QA Team.

3.3 Construction Meetings

A series of meetings will be conducted during the implementation of each phase of the remedial construction contract. The meetings and inspections mentioned in this section are in addition to the daily construction oversight inspections to be conducted by the QA Team. The following are inspections and meetings anticipated for each phase of RA construction:

- *Pre-construction Meeting* – The pre-construction meeting is a requirement of the remedial construction contract. Its primary purpose is to develop a working relationship between the parties to the Work, the requirements of the Contract Documents, schedules for the submittal of documents, applications for payment and proposed schedule(s) for the remedial construction. Engineer (and other members of the QA team) and DEQ will initiate and conduct the pre-construction meeting with Contractor personnel prior to the start of Reach A, Phase 1 remedial construction. The goals of the meeting includes familiarizing all parties with the requirements of the project; safety concerns and hazards; relevant land access issues and verifying that the details of the design specified in the Drawings, Special Provisions and Technical Specifications are understood. EPA and NRDP will be invited to the pre-construction meeting.
- *Weekly Progress Meetings* -- Weekly progress meetings will be conducted by Engineer (and other members of the QA team) and DEQ with Contractor to inform participants to the remedial contract of scheduling changes, overall progress of remedial construction and any other relevant construction issues, as necessary. EPA and NRDP will be invited to the weekly progress meetings.
- *Monthly Progress Meetings* – Monthly progress meeting will be conducted to inform all parties and stakeholders of overall remedial progress implementation. EPA, NRDP and other members of the QA team and DRT will be invited to the Monthly Progress Meetings.
- *Final Inspection and Meeting* -- This meeting will be conducted by Engineer and DEQ in accordance with the Supplementary Conditions to identify the completion or resolution of any outstanding issues at the point of completion of remedial construction. EPA and NRDP will be invited to the final inspection and meeting.

Following completion of construction activities, a QA Construction Summary will be prepared and will include the results of the construction monitoring and testing. The summary will contain descriptions of the quality assurance activities, summary of results, any notable events that have occurred and supporting data (i.e., construction logs, supporting photos, laboratory result, etc.) The QA Construction Summary will be submitted to DEQ as part of the construction completion report.

4.0 CONSTRUCTION QUALITY ASSURANCE ACTIVITIES

4.1 Certification and Calibration

Certain specialized materials have been specified in the Drawings, Special Provisions and Technical Specifications. It is imperative that the correct materials are used during remedial construction to maintain the functionality of the design. It will be the responsibility of the Engineer (with input from other members of the QA Team) to review and approve all certifications required as specified in the Special Provisions. Equipment used in special construction or material testing are to be calibrated on a regular basis. The Engineer (and other members of the QA Team) will have the responsibility to ensure that calibration is completed and documented. Table 1 lists the materials and equipment anticipated for certification and calibration submittal and review.

Table 1: Material and Equipment Certification Requirements for Remedial Action of CFR, Reach A, Phase I

Material/Equipment	Specific Certifications Required
Rock and Sand Material	Point Bar Material Channel Bed Material Floodplain/Bank Toe Material Alluvial Backfill Material Vegetative Backfill Material
Geotextiles	Filter Fabric Erosion Control Mat
Streambank Materials	Coir Fabric Streambank Seed Tubeling Plants Cuttings
Pipe	Culverts Drain Pipes
Revegetation	Seed Compost Plantings Fungal Inoculant
Dewatering Pumps	Pump Capacity and Lift Design

4.2 Construction QA Activities

Construction QA activities will be conducted both on- and off-site by Engineer (and other members of the QA Team). Engineer shall be responsible for ensuring the Work is implemented in compliance with all the Contract Documents including the requirements of the Drawings, Special Provisions and Technical Specifications, Contractor Quality Control Plan, Health and Safety Plan, Erosion Control Plan, and other submittals required by the Contract Documents. Key QA activities are to: 1) Execute QA activities in accordance with the Contract Documents, and 2) Confirm terms of Contractor's CQC Plan and/or manufacturer's recommendations are met including:

- Review and approve of all Contractor submittals;
- Verify aggregate and manufactured material certifications;

- Verify aggregate materials' and manufactured products' on-going validation;
- Review and approve material testing results including gradations and layer thickness;
- Verify that the remedial construction complies in all other ways with the approved Drawings, Special Provisions and Technical Specifications.
- Measure pay items;
- Oversee the observation of site functions such as Best Management Practices (BMPs), site housekeeping, traffic control, access, weed control, road maintenance, project boundary, clear/grub, staging area, stream diversion, road reclamation, and site cleanup;
- Track construction progress against project schedule;
- Review laboratory sample results, compare to specifications, and determine if specifications have been achieved;
- Prepare daily and weekly project progress reports;
- Assist in preparation for the monthly progress meetings;
- Preparation of QA Construction Summary; and,
- Preparation for and participation in Final Inspection and Meeting.

Engineer (and other members of the QA Team) shall review Contractor's testing equipment calibration documentation and qualifications of Contractor's testing operator prior to any material testing. Construction Surveying, Grade Staking, and Verification Surveyor will provide the initial construction surveying. Engineer will furnish all primary control and establish control coordinates for locating the principal components of the project with a suitable number of benchmarks adjacent to the project. A limited number of benchmarks will be provided. In general, the bulk of construction survey will be provided to Contractor by Surveyor in the form of a Digital Terrain Model consisting of three dimensional surfaces for principal components. The DTM shall be constructed in any format supported by AutoCAD.

Surveyor will perform all quantity calculation surveys using the methods described in the Special Provisions. Copies of the survey notes and Engineer's calculations will be supplied to Contractor upon request for submittal of pay requests for the measured item. Contractor will note any discrepancies between Engineer's calculation and Contractor's calculation within 10 days of receipt. Any discrepancies will be worked out to both parties' satisfaction or if the discrepancies cannot be reconciled, will be resolved through the Dispute Resolution provisions of the Contract Documents.

Surveyor/Engineer shall provide requested survey information to Contractor so he can implement his own survey needs according to his ways and means. Contractor shall be responsible for the preservation of all primary and other control coordinate stakes and or maintaining and replacing all construction stakes as needed for construction.

The following sections of this plan describe the anticipated features of the remedial construction which will need to be surveyed. Table 2 lists the tolerances for each component of construction for the Work.

Table 2: Construction Grade and Alignment Tolerances for Remedial Action of CFR Reach A, Phase I

Remediation Component		Tolerance (Feet)
Groundwater Dewatering Trenches	Horizontal Alignment	±1.0
	Vertical Grade	±0.2
Groundwater Dewatering Sediment Ponds	Horizontal Alignment	±1.0
	Vertical Grade	±0.2
Diversion Channel	Horizontal Alignment	±0.5
	Vertical Grade	±0.2
Tailings/Impacted Soils Removal	Horizontal Alignment	±1.0
	Vertical Grade of Base of Tailings / Impacted Soils	±0.2
Mine Waste Relocation Repositories	Horizontal Alignment	±10
	Vertical Grade of Compacted Tailings/ Impacted Soils	±0.5
Reconstructed Channel	Horizontal Alignment	±0.5
	Vertical Grade	±0.2
Streambanks	Horizontal Alignment	±0.5
	Vertical Grade	±0.2
Floodplain Final Grade	Horizontal Alignment	±1.0
	Vertical Grade	±0.2
(may vary locally by 0.5 ft. but average of measurements shall be ±0.2)		

4.2.1 Groundwater Dewatering Trenches and Sediment Ponds

The grade and alignment for the groundwater dewatering trenches and sediment ponds will be surveyed and staked by Surveyor. Off-set staking will be performed to accommodate excavation of the trenches. Control will be obtained from established control points. During excavation, spot elevation checks will be conducted by Engineer (and other members of the QA Team) with GPS survey instruments. Pond dimensions and berm configurations will be spot checked with tape and level measurements.

4.2.2 Tailings Removal

The staked grade of the base of tailings / impacted soils will be spot checked by Surveyor prior to excavation. Locations of the grid points will also be verified. During excavation, spot elevation checks on the base of tailings grade will be conducted with GPS survey measurements. The frequency of the grade checks will be the same as for metals sampling verification as described in Section 4.3.1.1 of this Plan.

4.2.3 Haul Roads

Construction and design of the haul roads are the responsibility of Contractor. Engineer (and other members of the QA Team) will coordinate with Contractor to verify that the roads will be located on or near the alignment shown on the Drawings.

4.2.4 Borrow Areas

The final grade of the borrow areas will be checked and verified by Surveyor to ensure that the grading is approximately as shown on the Drawings, Special Provisions and Technical Specifications. Engineer (and other members of the QA Team) may be need to conduct an initial and final topographic survey of the borrow areas for volume determinations.

4.2.5 Floodplain Reconstruction and Backfill

Engineer (and other members of the QA Team) shall use Digital Terrain Models to verify compliance with the grades and alignments specified for the Work. Additional QA spot elevation checks may be conducted with GPS survey or other survey instruments. The frequency of the grade checks will be the same as for metals sampling verification as described in Section 4.3.1.1 of this Plan.

4.3 Testing, Sampling, and Analyses

During remedial construction activities, QA verification testing, sampling, and analyses will be conducted to maintain construction integrity and fulfill the intent of the design. Testing, sampling, and analyses will be accomplished by Engineer (and other members of the QA Team) in accordance with the provisions of this Plan. The RA construction contractor will be required to conduct QC testing, sampling, and analyses in accordance with the special provisions and technical specifications. The following sections of this plan describe the anticipated features of the RA which will need verification testing, sampling, and analyses. The requirements for this section of the Plan will be specific for each type of construction activity.

4.3.1 Tailings Removal Verification Sampling and Analyses

Removal of tailings will be verified through QA sampling by Engineer and other members of the QA Team). The tailings / impacted soils material removal verification will include the sum of total metals criteria (the sum of arsenic, cadmium, copper, lead, and zinc are greater than 800 mg/kg), verification samples will be collected following tailings removal based on a 250 foot sampling grid throughout the removal boundary. Samples will be collected from surface material following tailings removal. Verification samples will be screened in the field using an x-ray fluorescence (XRF) instrument to confirm the tailings removal goal has been achieved using the sum of total metals criteria. In the event that the removal goal has not been achieved, additional tailings / impacted soils material within the sampled grid will be excavated and the area will be resampled.

In addition to the XRF sample verification, 10 percent of all verification samples will be submitted to an analytical laboratory for metal testing to confirm the XRF sample results.

4.3.1.1 Sampling Protocol

Samples will be collected on a systematic grid established by Surveyor prior to backfilling. Samples will be collected on a 250 feet by 250 feet grid within the removal boundaries. After the tailings / impacted soils material have been removed but before the area is backfilled and regraded to final contours, a single soil sample will be taken at each sampling location at a depth of 0 to 4 inches. All samples shall be collected in accordance with CFRSSI SOP SS-1.

Field quality controls samples will be collected in accordance with Table 3 below as outlined in the Sampling and Analysis Plan (SAP) Soils and Wastes Chemical Characterization for Remedial Design/Remedial Action (CDM, 2009).

Table 3: Field Quality Control

Parameters for Laboratory Analysis, CFR Operable Unit QC Sample	Purpose	Frequency	QA Objective
Verification Sample	Tailings/impacted soils removal verification based on sum of total metals criteria.	Sampled based 250 foot sampling grid.	
Field Duplicate	Evaluate sample and laboratory precision.	1 per every 20 natural samples submitted to laboratory.	Target analytes within 50% RPD for soil.
Matrix Spike / Matrix Spike Duplicate	Evaluate sample and laboratory accuracy and precision.	1 per every 20 natural samples submitted to laboratory.	Target analytes within laboratory-specified target levels.
Equipment Rinsate Blanks	Quantify artifacts introduced during sampling and sample handling, decontamination, transport, from ambient air, in decontamination water supply, or analysis of samples – measure of accuracy and representativeness	1 per every 50 samples submitted to laboratory.	Target analytes not detected
Field Blank	Quantify artifacts introduced during sampling, transport, from ambient air	1 per every 20 samples submitted to laboratory	Target analytes not detected.

4.3.1.2 Sample Analysis

Samples will be analyzed for parameters as presented in 4. 4 displays the parameters and the respective method of analysis. The samples will be submitted to a DEQ contracted analytical laboratory for analysis of saturated paste pH, arsenic, cadmium, copper, lead, and zinc.

Table 4: Parameters for Laboratory Analysis, CFR Operable Unit

Parameter	Test	Method
Total Metals (As, Cu, Cd, Pb, ZN)	ICP-AES	EPA Contract Laboratory Program Statement of Work, Multi-Media, Multi Concentration, Inorganic Analytical Service for Superfund (ILM05.4)
pH	Saturated Paste Extract	USDA Handbook 60, Methods 2, 3a, CFRSSI SOP SS-09 modified ¹

¹ CFRSSI SOP-09 was modified: pH was determined using a minimum of 16-hour equilibration time and vacuum

extraction of the saturated paste extract, rather than a 1:1 soil:water dilution
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4.3.1.3 Data Evaluation

Field duplicate samples will be compared to natural samples and relative percent differences (RPD) will be calculated for each constituent. Although RPD will be documented and data will be flagged based on excessive RPD (greater than 30 percent for samples greater than 5 times the probable quantitation limit), all data will be used to determine compliance with the removal criteria. If RPD flags are encountered in a frequency greater than previously observed during sampling activities, sampling methods will be reevaluated to improve data precision.

Field Blank samples and Rinsate Blank samples will be evaluated to determine whether contamination is being entrained in the sample from the water used to decontaminate sample handling equipment or the field environment (i.e., windy and dusty conditions, sample handling procedures, etc.). Data for corresponding metal results in associated natural samples will be qualified if the corresponding metal concentrations are greater than 5 times the blank result.

4.3.2 Opportunity Ponds Waste Management Area Repository

Contractor will transport excavated tailings / impacted soils material from CFR Reach A, Phase 1 to the Waste Management Area at Opportunity, Montana. The waste material will be placed in the eastern portion of the B2.12 Cell which is approximately 200 acres in area and is surrounded by earthen berms. This location was selected based on access into the area from MT Highway 48 and the need to separate Phase 1 placement activity from other construction activities ongoing within the B2.12 Cell. Tailings / impacted soils material are expected to be placed in maximum two-foot lifts and compacted by running haul traffic uniformly over the waste surface.

The QA Team will inspect the B2.12 Cell to ensure the Phase 1 wastes are placed according to the Contract Documents. Visual observations of the waste material shall be recorded in the project field book.

4.3.3 Borrow Material Testing and Analysis

4.3.3.1 Beck Ranch Borrow Soil

The Beck Ranch Borrow Area is owned by the State of Montana and is located approximately 3 miles south-southwest of Deer Lodge. Clean borrow material for replacement of removed material, except as required in the Contract Documents, will be obtained from the Beck Ranch. Although the borrow material has been previously sampled and tested for suitability, variations in borrow material characteristics within a borrow area are anticipated; therefore, it will be necessary to conduct field QA to verify the suitability of the borrow material. Material testing of the Beck Ranch Borrow Area will be conducted by Engineer (and other members of the QA Team) to verify compliance with Contract Documents. Contractor will not be involved in the borrow suitability sampling or testing. **Table 5** displays the parameters and their respective criteria values.

Table 5: Chemical and Physical Criteria for Vegetative Backfill

Parameter	Value
pH	6.5 to 8.5
Arsenic (As)	<30 ppm
Cadmium (Cd)	<4 ppm
Copper (Cu)	<100 ppm
Lead (Pb)	<100 ppm
Zinc (Zn)	<250 ppm
Texture:	Sandy loam or finer; no clay
Coarse fragments (>2 mm diameter)	< 45% by volume
Maximum size	6 in.
Specific conductance	<4.0 dS/m
No weeds or weed seeds	

Note: ppm – parts per million
dS/m – deciSiemens per meter
mm = millimeters

4.3.3.2 Alluvial Material

Certain specialized materials have been specified in the RD and RA special provisions and technical specifications. It is imperative that the correct materials are used during RA construction to maintain the functionality of the design. It will be the responsibility of Engineer (and other members of QA Team) to verify compliance with Contract Documents. Sample material will be submitted for analysis of saturated paste pH, electrical conductivity, arsenic, cadmium, copper, lead, and zinc as indicated from Table 7 below. Physical criteria will be evaluated for compliance with gradations presented in Table 6.

Table 6: Physical Criteria for Alluvial Material

Size (inches) or Screen Size	Percent Passing			
	Floodplain	Bank Toe	Point Bar	Channel Bed
9		100		
6	100	85-95		100
3	80-95	60-90	100	75-95
2	60-80	40-70	60-90	40-75
1	40-65	35-50	40-70	10-30
0.25	15-35	10-30	30-60	0-10
No. 10	10-25	5-25	10-30	0-5
No. 200	0-10	0-10	0-10	0-2

Table 7: Parameters for Laboratory Analysis Alluvial Material

Parameter	Test	Method
Total Metals (As, Cu, Cd, Pb, ZN)	ICP-AES	EPA Contract Laboratory Program Statement of Work, Multi-Media, Multi Concentration, Inorganic Analytical Service for Superfund (ILM05.4)
pH	Saturated Paste	USAD Handbook 60, Methods 2, 3a, CFRSSI SOP SS-09 modified ¹
Electrical Conductivity	Saturated Paste	ASA Monograph #9, Part 2, Method 10-3.4
¹ CFRSSI SOP-09 will be modified: pH will be determined using a minimum of 16-hour equilibration time and vacuum extraction of the saturated paste extract, rather than a 1:1 soil:water dilution		

4.3.3.3 Sampling Frequency

Borrow materials will be sampled at a minimum frequency of one sample per 5,000 cubic yards (cy) or when visual observation indicates the appearance of the material may not meet the specifications in the Contract Documents. Samples may be collected from soil stock piles prepared for project area delivery or may be collected directly from the removal area. Composite samples shall be compiled from a minimum of 5 sub-samples representatively distributed throughout the anticipated 5,000 cy soil removal area or stockpile. Visual observations of borrow material and sampling shall be recorded in the project field book.

Documentation for each sample shall include the following:

- General visual observations of the borrow material;
- Description of sample location including depth and proximity within excavation site;
- Description of the sub-sample group including individual sub-sample locations and proximity within excavation site;
- Time and date of soil collection; and,
- US Department of Agriculture (USDA) soil texture.

4.3.3.4 Imported Material Suitability Testing and Analysis

All imported material sources other than Beck Ranch Borrow must be approved by Engineer (with input from the QA Team) and tested by Contractor for confirmation that it is in substantial conformance with the Contract Documents.

Engineer (and other members of the QA Team) will be present while import material grab samples are taken from the product pile and will visually inspect all imported material for consistency. Representative samples will be taken by Contractor from the proposed borrow source at a location agreed upon by both Contractor and Engineer (with input from the QA Team). The samples collected shall be representative of the entire import material source and shall be collected from a minimum of three locations within the material source. If substantial variability is noted in the source material or upon visual inspection at the site, additional samples shall be collected which represent the range or change in material. Engineer (and other members of the QA Team) will ensure samples shall be qualitatively described and the description included in the laboratory results for each sample such that the appropriate laboratory data may be applied for comparison of imported material at the site.

Engineer (and other members of the QA Team) will conduct the following procedures for verification of imported material suitability:

- Obtain material submittal;
- Review material testing results;
- Visually inspect the material sources;
- Collect copies of truck tickets to verify source of material and volume; and,
- Collect and analyze samples and perform visual inspections for compliance with contract documents using the criteria and frequency described in 4.3.3.1, 4.3.3.2, and 4.3.3.3 above.

4.3.3.5 Control of Work

Contractor is responsible for directing excavation activities within the Beck Ranch Borrow Area. Typically, Contractor will be allowed to excavate in the manner most efficient for conducting their work. Contractor will be required to alter or modify their excavation practice if unsuitable material is encountered, particularly if soil texture or rock content fall outside acceptability criteria. If unsuitable material is encountered, the following actions will be completed:

- For relatively small quantities of unsuitable material, Contractor will be directed to blend the material with suitable material such that the blended materials meet suitability requirements.
- For larger quantities of unsuitable material that cannot be adequately blended, the unsuitable material will be segregated from suitable material and stockpiled in a reject pile. On completion of the project all reject material will be placed by Contractor within the Beck Ranch Borrow Area and integrated into the borrow pit reclamation.

5.0 ENVIRONMENTAL MONITORING

5.1 Water Quality Monitoring

5.1.1 Stream Water Quality Sampling and Analysis

Engineer (with input from members of the QA Team) shall review and approve the Erosion Control Plan and the BMPs it describes. During construction, Engineer (and other members of the QA Team) will inspect each new work area as construction in that work area begins to ensure the BMPs are in place before excavation begins. BMPs will be inspected weekly by Engineer (and other members of the QA Team) to ensure they are in place and functioning properly. During remedial construction, Engineer (and other members of the QA Team) will monitor Clark Fork River water quality upstream and downstream of remedial construction. The data collected during these monitoring activities will be used to evaluate the effectiveness of, and determine the need for modifications to, engineering controls or BMPs as described in Contractor's Erosion Control Plan. In the event that Contractor's Erosion Control Plan does not result in adequate water quality during remedial construction, Engineer will request changes in BMPs or additional BMPs be installed to correct the problem.

Based on the ARARs for surface water quality and on historical turbidity data for the CFR, a turbidity warning limit is chosen for Phase 1 as described below. This turbidity warning limit may be adjusted as Engineer (with input from the QA Team) determines necessary based on an evaluation of sampling and analysis during baseline sampling (as described below). During construction the turbidity warning limit will be used to gauge the need for additional, extended water quality sampling. The results of such sampling shall be used by DEQ to evaluate whether additional steps are required to mitigate the effect of construction on water quality in the Clark Fork River.

5.1.1.1 Locations and Frequencies

In-stream turbidity and total suspended solids (TSS) monitoring of the Clark Fork River will be monitored by Engineer (and other members of the QA Team) during and before remedial construction at locations upstream and downstream from the Work. Two upstream sites consisting of the USGS gages Warm Springs Creek at Warm Springs and Silver Bow Creek at Warm Springs will be sampled. The downstream point of compliance station will be selected at a location 10 times the river width from the remedial construction boundary. The precise station location will be determined based on safety of ingress/egress from the river and general site access. Before any floodplain construction, Engineer (and other members of the QA Team) will collect baseline turbidity and TSS measurements. Baseline samples will be collected once per day for at least three weeks prior to the beginning of construction. Turbidity and TSS measurements will then be obtained at a frequency of once a day during remedial construction activities. After the first month of construction, the sampling data will be reviewed to determine if the monitoring frequency should be modified for the remaining construction period.

5.1.1.2 Sampling Methods and Procedures

Surface water samples will be collected in accordance with CFRSSI SOP SW-1 for equal width increment samples. Operation of the turbidity instrument will be in accordance with CFRSSI SOP HG-10 and will follow the manufacturer's instructions, including all necessary calibrations. Decontamination of equipment and materials will be performed as specified in CFRSSI SOP G-

8. Also, field measurements and other applicable information will be recorded with permanent ink in the field log book consistent with CFRSSI SOP G-4.

Sample Handling

All surface water samples collected for TSS will be packaged, labeled with sample designation and handled according to the handling procedures described by CFRSSI SOP G-5 and more specifically by CFRSSI SOP HG-4 for aqueous samples. Each sample collected will have a unique identification number that will indicate the site sample location and will be coded as follows:

- The first two numbers will identify the CFR, Reach A Phase identifier (i.e., 01 for Phase 1).
- The next four characters indicate sample location.
 - PC indicates a Point of Compliance location and will be followed by the numeric identifier of the location. Since only one Point of Compliance is anticipated for this plan, the following numeric identifier will always be 01.
 - US indicates an Upstream Location and will be followed by the numeric identifier of the upstream location (i.e., 01 or 02).
- The next three characters indicate the sample number (001, 002, etc.).
- Examples: 01-PC01-005 and 01-US02-004.

Analytical Parameters and Methods

Each surface water sample collected during remedial construction will be analyzed for:

- TSS using EPA Method 160.2 from the reference document, EPA-600/4-79-020, Methods for Chemical Analysis of Water and Wastes; and,
- Turbidity measurements require no analysis. Turbidity measurements are read directly from the instrument in Nephelometric Turbidity Units.

Sample Replication

Replicate samples will be collected and analyzed for TSS measurements only. These will consist of one field replicate sample taken in the same location, with the same procedures, and as near the same time as the original natural sample as possible. One replicate will be collected and submitted to the Laboratory at a frequency of 20 natural samples.

Baseline Sampling

Commencing three weeks prior to the start of construction, surface water quality sampling will be performed, referred to as baseline sampling. Baseline sampling will include measurement of turbidity one time each day at the two upstream locations and the one downstream location.

Additionally, two additional samples will be collected from each sampling location which will be analyzed for TSS, hardness, and the following total and dissolved metals and arsenic, cadmium, copper, zinc, arsenic and lead. Sampling will be conducted and submitted such that the results are obtained and integrated into the water quality monitoring component of the CQAP prior to the initiation of construction.

Turbidity Warning Limits

Turbidity warning limits are pre-established for Phase 1. According to ARARs, the maximum allowable increase above naturally occurring turbidity is 10 nephelometric units (NTU) for a C-2 class stream (i.e., the classification of the CFR at the Project site). Using this information and the historical turbidity data presented, a turbidity level of 10 NTU is established as the “turbidity warning limit”. This warning limit is 80% of 12 NTU (the maximum allowable limit), calculated assuming an average baseline turbidity value of 2 NTU plus the 10 NTU allowable turbidity increase. If the results of baseline sampling for turbidity indicate that turbidity warning limits should be adjusted, DEQ shall adjust these limits to better accomplish the purposes of this monitoring.

Turbidity Monitoring

Engineer (and other members of the QA Team) shall monitor turbidity against the turbidity warning limits during construction. At the start of construction, samples will be taken a minimum of once per day at the upstream and downstream sampling locations according to the protocols and methods described in this document. In addition, dissolved oxygen, pH, conductivity, and temperature will be measured in the field at each station during each turbidity measurement event. Additional sampling will be taken at the discretion of Engineer (with input from other members of the QA Team) to monitor construction activities and changes in the conditions in the Clark Fork River. Groundwater dewatering discharges will also be visually monitored to ensure Contractor is not discharging turbid water.

If the turbidity at the downstream station does not exceed the NTU warning limit, no further action is required unless additional sampling or modifications to Contractor’s BMPs are determined necessary by Engineer.

If the turbidity at the downstream sampling location exceeds the turbidity warning limit, then Engineer shall implement an expanded water quality sampling and analytical procedure. The expanded water quality sampling procedure is discussed in Section 5.1.2 below. This expanded sampling and analytical procedure shall continue until turbidity at the downstream sampling location is once again below the turbidity warning limits or as otherwise directed by DEQ in writing.

5.1.2 Expanded Water Quality Sampling Plan

If the turbidity warning limit is exceeded, regardless of whether turbidity is deemed to have been added by remedial construction activities, expanded water quality sampling and monitoring plan will be initiated. The expanded water quality sampling plan includes collection of daily grab samples at both upstream and downstream sampling locations immediately following the turbidity warning limit exceedance. These grab samples will be analyzed for TSS, hardness, and total recoverable and dissolved arsenic, cadmium, copper, zinc, and lead with a two-day turnaround for the results. The expanded water quality sampling and analysis methods are summarized in Table 7. One replicate will be collected and submitted to the Laboratory at a frequency of 20 natural samples.

Table 8: Expanded Water Quality Sampling

Analyte	Analytical Method	Sample Container and Preservation Method
Total Recoverable Metals (As, Cu, Cd, Pb, Zn)	E200.7/E200.8	250 mL polyethylene bottle, unfiltered and preserved with HNO ₃
Total Dissolved Metals (As, Cu, Cd, Pb, Zn)	E200.7/E200.8	250 mL polyethylene bottle, filtered (0.45micron), and preserved with HNO ₃
Total Suspended Solids (TSS)	A2540 D	500 mL polyethylene bottle, raw sample
Hardness	A2340 B	

If, after evaluation of the data collected during expanded water quality sampling, Engineer (with input from the QA Team) concludes that these exceedences are the result of remedial construction activities, Engineer may require additions or modifications to the BMPs or require other controls to reduce the impacts resulting from construction activity. A stop work order may be issued to stop construction activities if necessary until Contractor implements these modifications or additions to the BMPs or other controls to reduce the impacts resulting from construction activity.

If Engineer determines on the basis of expanded water quality sampling, that no contamination has been added by the remedial construction activities, then additional BMPs or other control evaluations will not be required. The expanded sampling will be discontinued after one set of expanded water quality sampling results are received without an exceedance of TSS or total or dissolved metals concentrations at the downstream monitoring station or as when directed by Engineer.

5.2 Air Quality Monitoring

Remedial actions involving the excavation and removal of earth materials often result in a decrease of local air quality because of increased airborne particulates generated from various construction activities. A dust control plan for haul roads will be implemented as part of Contractor's approved Transportation Plan. Contractor is required to apply water and/or magnesium chloride treatments for dust suppression. Contractor's dust control methods must be sufficient to eliminate visible emissions to the extent practical on-site as determined by Engineer (with input from other members of the QA Team) and eliminate dust migration beyond the limits of Work.

6.0 REFERENCES

ARCO. September 1992. Clark Fork River Superfund Site Investigations, Standard Operating Procedures (SOP). Compiled by Canonie Environmental Services, Inc.

CDM, May 2009. Final Sample and Analysis Plan Soils and Wastes Chemical Characterization for Remedial Design/Remedial Action.

DEQ. August 18, 2005. Construction Dewatering General Permit (CDGP) Authorization to Discharge Under the Montana Pollutant Discharge Elimination System.

DEQ. March 16, 2007. General Permit for Storm Water Discharges Associated with Construction Activity.

EPA. December 2004. Milltown Reservoir Sediments Operable Unit Record of Decision.
Schafer and Associates. 1991. Final report for the Clark Fork River Demonstration Project, Warm Springs, Montana. Submitted to the Office of the Governor, Capitol Station, Helena, MT.

Tetra Tech. 2011. Draft Final Sampling and Analysis Plan (SAP) Addendum, Reach A, Phases 15 and 16, Grant-Kohrs National Historic Site. Helena, Montana. June, 2011.

USGS. 2004. Water-Quality, Bed-Sediment, and Biological Data [October 2002 through September 2003] and Statistical Summaries of Data for Stream in the Upper Clark Fork Basin, Montana. Open File Report 2004-1340.

APPENDIX A
CFRSSI STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE SS-1
SAMPLE COLLECTION FROM SOIL BORINGS,
EXCAVATIONS, AND HAND DUG PITS
SOP SS-1

SOIL BORING PROCEDURES

The following procedures are designed to be used during the operation of auger type drill rigs during soil sampling operations. The procedures listed below may be modified in the field by the agreement of the lead site sampler and drill operators based on field and site conditions after appropriate annotations have been made in the appropriate bound field logbook. All utilities (gas and electric, telephone, sewer, etc.) will be located by the utilities (in some instances a utilities locator may be necessary) prior to drilling or excavating.

1. Locate the site as directed in the site-specific Sampling and Analysis Plan (SAP).
2. Drillers prepare rig for operation. This includes but is not limited to decontamination of the drill rig tools and sampling equipment, leveling the rig, preparing the downhole tool, preparing the auger "flights", and establishing the drill over the location.
3. Mount the split tube sampler to the drive stem.
4. Prior to using the split spoon sampler, sample the surface increment to a depth in accordance with the site-specific SAP.

STANDARD OPERATING PROCEDURE SW-1

FIELD SAMPLING OF STREAMS SOP SW-1

This sampling procedure shall be used to collect aqueous samples from stream channels, drainage ditches, and springs or seeps. The samples collected will be composite or grab samples depending on the sample site.

Sampling Procedure

1. Wearing protective clothing and using equipment specified in the site-specific Health and Safety Plan, rinse a clean 1- or 2-liter plastic bottle or decontaminated sampling beaker three times with stream water.
2. Rinse a decontaminated sampling bucket or container three times with stream water.
3. Rinse a set of clean sample bottles (for unfiltered samples) three times with stream water. See Standard Operating Procedure (SOP) HG-4 for correct sample bottle size and composition.

NOTE: If sampling for organics, do not rinse sample bottles with source water before filling.

4. If channel width is less than 5 feet across, collect grab sample from the center of the channel. If channel width is greater than 5 feet, divide channel into 5-foot sections

and collect a sample at the center of each section. Combine samples from each section to obtain a channel-integrated composite sample.

5. Invert the sample container and lower to the approximate midpoint of depth between the stream bed and the water surface. After reaching mid-depth, point the bottle mouth upstream and begin sampling. Take care not to collect any stream bed solids. If collecting a grab sample, fill a sample bottle, and add the required preservatives according to SOP HG-4. Secure the bottle cap tightly, then skip to step No. 10. If collecting a composite sample, pour full container into the bucket and take another sample from the next section of the stream. Collect an adequate amount of water for your sampling needs.

NOTE: If needed, a pond sampler may be used to collect samples as far as 15 feet from the edge of the ditch or channel. See SOP HG-5 for proper use of the pond sampler.

6. For suspended or total analyses use a churn splitter to homogenize the sample. Use the sampling container to fill a set or sets of sample bottles (unfiltered samples).
7. Dipping from the bucket, filter the required amount of sample according to SOP SW-5. Churn splitting is not required for dissolved analyses.
8. Add preservatives to metals samples according to SOP HG-4. Secure the sample bottle cap tightly.
9. Empty the bucket and repeat steps 3 through 7 for each required field replicate.

10. Label the sample bottles with an appropriate sample tag. Label the tag carefully and clearly, addressing all the categories or parameters. Be sure to record the information in the bound field logbook and to complete the chain-of-custody documents.
11. Collect sample field parameters according to procedures in SOP HG-8 and SOP HG-7.
12. Properly clean and decontaminate the sampling equipment prior to reuse or storage, according to SOP G-8.

As a final note, it is very important to make certain that the samples collected are representative of the source at the time the samples are collected and, that the integrity of the samples collected is not compromised by contamination, misidentification, or improper sample handling or preservation.

STANDARD OPERATING PROCEDURES SS-9
FIELD LABORATORY DETERMINATION OF SOIL pH
SOP SS-9

MATERIALS REQUIRED

1. Orion pH meter [refer to Standard Operating Procedure (SOP) HG-8 for calibration and operating procedures]
2. pH probes and pH-4, pH-7, and pH-10 buffer solutions
3. Hard plastic spoons (teaspoon size, two minimum)
4. Glass stirring rods (two minimum)
5. 50-milliliter (ml) sample beaker (or disposable cup) with lid. Quantity depends on number of samples
6. Deionized/distilled (DI/DS) water (two liters minimum)
7. 0.01 M CaCl_2 (1.47 grams $\text{CaCl}_2 \times 2 \text{ H}_2\text{O}$ /liter = 2 liters minimum)
8. Paper towels

FIELD LABORATORY PROCEDURES

1. Place approximately 1 teaspoon (about 10 grams) of soil sample in sample beaker.
2. Add about 20 ml of 0.01 M CaCl_2 into beaker.
3. Stir with glass rod to make slurry. (Clean glass rod with DI/DS water prior to preparing another soil sample.)
4. Attach lid to beaker and shake vigorously.
5. Let beaker stand until sediment has settled. (This will take about 5 minutes for sandy samples to 30 minutes for clayey samples.)
6. Calibrate pH meter according to procedures outlined in SOP HG-8.
7. Immerse clean pH probe in the "clean" solution. Gently move the probe up and down without disturbing the sediment.
8. Record pH value of solution in field log book when stabilized.
9. Decontaminated pH probe and continue on to next sample.

Reference:

Manual on Soil Sampling and Methods of Analyses, 2nd edition, 1978, prepared by Subcommittee (of Canada Soil Survey Committee) on Method of Analysis, J. A. McKeague, Ed.

STANDARD OPERATING PROCEDURE SS-10

**LYSIMETER INSTALLATION AND SAMPLING
SOP SS-10**

STANDARD OPERATING PROCEDURE SS-10
LYSIMETER INSTALLATION AND SAMPLING
SOP SS-10

FIELD PROCEDURES

Coring the Borehole

In rock-free uniform soils at shallow depths, a 2" screw or bucket auger will be used for coring the borehole. If the soil is rocky or coarse materials are encountered, utilization of a larger diameter bucket auger is recommended to advance the borehole.

Installation

Core the borehole to the desired depth, pour in enough crushed 200 mesh pure silica-sand or almost talcum powder consistency or silica flour to a depth which will be slightly above the edge of the cup of the lysimeter. Insert soil water sampler and pour another layer of the 200 mesh silica-sand or silica flour at least six inches deep around the cup of the soil water sampler. Backfill the borehole with soil free of pebbles and rocks, tamping continuously with a metal rod to insure against surface water channeling down between the soil and body tube of the soil water sampler. Continue backfilling the borehole and tamping the soil to within six inches of the surface or a reasonable height above the soil water sampler and add bentonite as a plug to further isolate the lysimeter cup and guard against possible channeling down the borehole. Backfill the remainder of the borehole to the surface.

Sample Collection

After the soil water sampler has been installed in the field, the following accessory items are required to collect a soil water sample: Vacuum test hand pump, stopper assembly and tubing with pinch clamps and glass bottles with rubber stoppers. To collect the sample, the pinch clamp of the stopper assembly (previously installed on the soil water sampler) is opened. the serrated tube fitting on the end of the vacuum dial gauge adapter is inserted into the neoprene tube of the stopper assembly. The vacuum hand pump is then stroked until a vacuum of perhaps 60 centibars (18" of mercury) is created within the sampler, as read out on the vacuum dial gauge.

The pinch clamp is then closed securely to seal the sampler under vacuum. The hand pump is then removed. The sampler is then allowed to set for a period of time (dependent upon the hydraulic conditions of the material being sampled).

In general, vacuums of 50 to 85 centibars (15" to 25" of mercury) are normally applied to the soil water sampler. To remove the soil water sample from the sampler: a sample assembly is usually made up consisting of a small diameter plastic tube, a two-hole rubber stopper, a flask or bottle; the pinch clamp on the sampler is opened and the small diameter tube is inserted into the end of the neoprene tube on the stopper assembly and pushed down until it reaches the bottom of the sampler. The vacuum hand pump is then connected to the other hole in the stopper. Stroking the hand pump creates a vacuum within the bottle or flask which in turn sucks the sample up from the bottom of the sampler and into the collection bottle or flask. Subsequent samples are collected by again creating a vacuum within the sampler and following the steps as outlined above.

STANDARD OPERATING PROCEDURE HG-4

**PRESERVATION AND HANDLING
OF AQUEOUS SAMPLES
SOP HG-4**

STANDARD OPERATING PROCEDURE HG-4

**PRESERVATION AND HANDLING
OF AQUEOUS SAMPLES
SOP HG-4**

This Standard Operating Procedure (SOP) describes the techniques and quality control measures used to collect, preserve and handle water containing the analytes listed below. Table HG-4.1 and Figures HG-4-1 and HG-4-2 summarize the information in this SOP. See SOPs SW-1, GW-1, and SS-1 for the respective sampling procedures for surface water, ground water, and soils/solids.

1. Acidity and alkalinity,
2. Bicarbonate/carbonate,
3. Chloride,
4. Fluoride,
5. Hardness,
6. Metals - Total and Acid Soluble (aluminum, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, strontium, and zinc),
7. Metals - Dissolved,

8. Nitrate,
9. Pesticides and polychlorinated biphenyls (PCBs),
10. Silica - Dissolved,
11. Semivolatile organic compounds,
12. Solids [total dissolved solids (TDS), total suspended solids (TSS)],
13. Sulfate,
14. Total organic carbon in water, and
15. Volatile organic compounds.

ACIDITY AND ALKALINITY

Apparatus and Materials

1. Polyethylene or borosilicate glass (pyrex or equivalent) bottles. (See Figure HG-4-1).

Preservation and Handling

1. Fill sample bottles completely, leaving no headspace, then cap tightly.

2. Store samples at 4 °C.
3. All samples should be analyzed within 14 days of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the samples.
2. Dissolved gases contributing to acidity or alkalinity, such as carbon dioxide, hydrogen sulfide, or ammonia, may be lost or gained during sampling or storage. To prevent this, sample bottles should be filled completely, leaving no headspace, then capped tightly.

BICARBONATE/CARBONATE

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).

Preservation and Handling

1. Completely fill the sample bottle, leaving no headspace, and cap tightly.
2. Store sample at 4°C until analyzed.
3. All samples should be analyzed within 14 days of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. Carbon dioxide may be lost or gained during sampling and storage. To prevent this, sample bottles must be filled completely, leaving no headspace, then capped tightly.

CHLORIDE

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).

Preservation and Handling

1. Store samples at 4°C.
2. All samples must be analyzed within 28 days of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.

FLUORIDE

Apparatus and Materials

1. Polyethylene bottles. (See Figure HG-4-1).

Preservation and Handling

1. Polyethylene bottles are required for collecting and storing samples for fluoride analysis.
2. All samples must be analyzed within 28 days of collection.
3. Store samples at 4°C.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. Only polyethylene bottles may be used.

HARDNESS

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).

Preservation and Handling

1. Acidify with nitric acid to pH 2 or lower; store samples at 4°C.
2. Samples should be analyzed within six months of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. Serious errors may be introduced during sampling and storage by failure to remove residues of previous samples from the sample container. Therefore, all containers and sampling equipment should be thoroughly cleaned before use, in accordance with SOP HG-3 for inorganic sampling containers and SOP G-8 for inorganic sampling equipment.
3. Prepare a "test bottle" at each sampling location to ensure proper acidification.

METALS - TOTAL AND ACID SOLUBLE

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).
2. 0.1 Normal nitric acid.
3. Distilled/deionized (DS/DI) water.

Preservation and Handling

1. Collect the unfiltered water sample.
2. Acidify the sample with dilute nitric acid (1 to 1) to a pH of 2 or less. Normally, 3 milliliters (ml) of dilute nitric acid per liter should be sufficient to preserve the samples. The acid will keep the metals in solution and minimize their adsorption on the container wall. Note that for acid soluble metals, the sample must be acidified to a pH of 1.75 ± 0.1 .
3. Store samples at 4°C until analyzed.
4. All samples should be analyzed within 6 months of collection. An exception is mercury (Hg) analysis, which must be completed within 28 days.
5. Samples for acid soluble metals must be filtered within 16 hours after preservation.
6. Prepare a "test bottle" at each sampling location to ensure proper acidification.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. Serious errors may be introduced during sampling and storage by failure to remove residues of previous samples from the sample container. Therefore, follow the

described rinsing procedure in SOP HG-3 for all inorganic containers and in SOP G-8 for the inorganic sampling equipment.

3. If the sample is to also be analyzed for dissolved and acid soluble metals, collect a large enough grab sample to complete all the required volumes.

METALS - DISSOLVED

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1)
2. Filtering apparatus with 0.45 micron filter(s)
3. 0.1 Normal nitric acid
4. DS/DI water

Preservation and Handling

1. Precondition the filter and filtering apparatus by rinsing with at least 50 ml of DS/DI water. Collect a rinseate sample; see Quality Control section, item No. 1.
2. Pour sample water through the filtering apparatus and rinse the sample bottle(s) three times with filtered sample water before collecting the sample.

3. Pour sample water through the filtering apparatus and collect the filtrate in the sample bottle. This is the "dissolved" metals sample.
4. Acidify the filtrate sample with dilute nitric acid (1 to 1) to a pH 2 or less. Normally, 3 ml of dilute nitric acid per liter of filtrate sample is appropriate. The acid will keep the metals in solution and minimize their adsorption on the container wall.
5. Store all samples at 4°C until analyzed.
6. All samples should be analyzed within 6 months of collection. An exception is mercury analysis, which must be completed within 28 days.

Quality Control

1. Before filtering the water sample through the filtering apparatus, rinse the apparatus with DS/DI water and collect the rinseate for analysis of dissolved metals (acidify with dilute nitric (HNO_3) acid to a pH of 2 or less, as above).
2. Pre-rinse the sample bottle(s) three times with a portion of filtered sample water before collecting the sample.
3. Send in an "unused" filter in DS/DI water and acidified (as above) for metals analysis to determine external sample contamination.

NITRATE

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).

Preservation and Handling

1. Store samples at 4°C.
2. All samples should be analyzed within 28 days of collection.
3. Acidify the sample with sulfuric acid (H_2SO_4) to a pH of 2 or less; store samples at 4°C.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. Prepare a "test bottle" at each location to ensure proper acidification.

PESTICIDES AND PCBs

Apparatus and Materials

Sampling equipment needed for discrete and composite sampling. Sample containers are as indicated on Figure HG-4-2.

1. Discrete Sampling

- Grab sample bottle - Threaded amber glass, 1 liter or 1 quart volume. French or Boston Round design is required. The container must be washed and rinsed with an organic-free solvent (e.g., methanol or hexane) before use to minimize interferences.
- Bottle caps - Threaded, screw on, and lined with Teflon.

2. Composite Sampling

Compositing equipment for time-integrated or space-integrated samples must incorporate glass sample containers for collecting a minimum of 250 ml. For automatic time-integrated sampling, sample containers must be kept refrigerated during sampling. For manual space-integrated samples, samples must be refrigerated immediately after collection. Polyvinyl chloride tubing with plasticizers should not be used in the system. Silicone rubber tubing, polyethylene tubing, or polypropylene tubing are possible alternatives.

Preservation and Handling

1. Grab samples must be collected in amber glass containers. Composite samples should be collected in refrigerated amber glass containers. Automatic sampling equipment must be free of Tygon and other potential sources of contamination.
2. The samples must be iced or refrigerated from the time of collection until extraction.
3. All samples must be extracted within seven days and completely analyzed within 30 days of collection.

Quality Control

1. Do not pre-rinse the vials before sampling.
2. Standard quality assurance practices should be used with this method.

SEMIVOLATILE ORGANIC COMPOUNDS

Apparatus and Materials

1. Threaded amber glass bottles, one 4-liter size, or as indicated on Figure HG-4-2, French or Boston Round design is required.
2. Bottle caps - threaded, screw on, and lined with Teflon.

Preservation and Handling

1. Fill bottle completely, leaving no headspace, then cap tightly.

Quality Control

1. Do not pre-rinse the vials before sampling.
2. Sample must be maintained at 4°C, $\pm 2^\circ\text{C}$ and protected from light.
3. Sample bottles must be filled completely, leaving no headspace, and capped tightly.
4. Extraction of water samples shall be completed within five days, and analysis of extracts must be completed within 40 days following extraction.

SILICA - DISSOLVED

Apparatus and Materials

1. Polyethylene bottles. (See Figure HG-4-1).

Preservation and Handling

1. Collect samples in bottles of polyethylene plastic only; do not use glassware for any sample handling.

2. Store samples at 4°C.
3. All samples must be analyzed within 28 days of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. If samples are stored in glass, silica may leach into the sample and raise concentrations; therefore, do not use glassware.

SOLIDS (TDS, TSS)

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).

Preservation and Handling

1. Store samples at 4°C.
2. Samples must be analyzed within the following times, according to the analysis to be conducted:
 - Dissolved 7 days
 - Suspended 7 days

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the sample water before collecting the sample.
2. Sample should be analyzed as soon as possible after collection for best results.
3. Exclude nonrepresentative particles such as leaves, sticks, or large solids.
4. Glass bottles are desirable. Plastic bottles are satisfactory, provided that the material in suspension in the sample does not adhere to the walls of the containers. Store samples that are likely to contain iron or manganese so that oxygen will not come into contact with the water. Analyze these samples promptly to minimize the possibility of chemical or physical change during storage.

SULFATE

Apparatus and Materials

1. Polyethylene or glass bottles. (See Figure HG-4-1).

Preservation and Handling

1. Store samples at 4°C.
2. All samples must be analyzed within 28 days of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the water sample before collecting the sample.
2. In the presence of organic matter, certain bacteria may reduce sulfate to sulfide. To avoid this, samples will be stored at, or below, 4°C.

TOTAL ORGANIC CARBON IN WATER

Apparatus and Materials

1. Glass bottles, with Teflon-lined caps (see Figure HG-4-2).
2. Concentrated, reagent-grade H_2SO_4 .

Preservation and Handling

1. Acidify samples with concentrated H_2SO_4 to a pH of 2 or less.
2. Store samples at 4°C.
3. All samples should be analyzed within 28 days of collection.

Quality Control

1. Pre-rinse the sample bottle(s) three times with a portion of the water sample before collecting the sample.
2. Avoid exposure of the sample to light and atmosphere; minimize storage time.
3. Prepare a "test bottle" at each sampling location to ensure proper acidification.

VOLATILE ORGANIC COMPOUNDS

Apparatus and Materials

1. Forty-ml amber glass vials with Teflon-faced, silicone screw caps (see Figure HG-4-2).
2. Hydrochloric acid (HCl).

Preservation and Handling

1. Use three vials per sample.
2. Add HCL to sample vials before adding water samples. Sample will be preserved with HCl, to pH range 1.4 to 2.8, to minimize sample degradation by microbial action.

3. Fill sample vial completely, leaving no headspace, then cap tightly.
4. Sample must be maintained at 4°C, and protected from light.

Quality Control

1. Do not pre-rinse the vials before sampling.
2. Sample vials must be filled completely, leaving no headspace, and capped tightly.
3. Analysis must be completed within 10 days.
4. Prepare a "test vial" at each sampling location to determine the proper volume of HCl to add to the vials before sampling to ensure proper acidification.

TABLE HG 4.1
RECOMMENDED SAMPLING AND PRESERVATION PROCEDURES FOR
WATER AND WASTEWATER

<u>Parameter</u>	<u>Collection Technique</u>	<u>Container</u> ^(a)	<u>Preservation</u>	<u>Holding Time</u> ^(b)	<u>Minimum Required Volume (ml)</u>	<u>Reference Method</u> ^(c)
Acidity	Grab or composite	P, G	Cool, 4°C	14 days	100	EPA Method 305.1
Alkalinity	Grab or composite	P, G	Cool, 4°C	14 days	100	EPA Method 310.1
Bicarbonate	Grab only	P, G	Determine on-site	No holding	100	EPA Method 310.1
Carbonate	Grab only	P, G	Determine on-site	No holding	100	EPA Method 310.1
Chloride	Grab or composite	P, G	Cool, 4°C	28 days	100	EPA SW-846, Method 9250 or Method 325.3
Fluoride	Grab or composite	P	Cool, 4°C	28 days	50	EPA Method 340.2
Hardness	Grab or composite	P, G	Cool, 4°C, HNO ₃ to pH < 2	6 months	100	EPA Method 130.2

RECOMMENDED SAMPLING AND PRESERVATION PROCEDURES FOR WATER AND WASTEWATER (Continued)

<u>Parameter</u>	<u>Collection Technique</u>	<u>Container</u> ^(a)	<u>Preservation</u>	<u>Holding Time</u> ^(b)	<u>Minimum Required Volume</u> ^(c) <u>(ml)</u>	<u>Reference Method</u> ^(c)
Metals						
Dissolved	Grab or composite	P, G	Filter on-site, HNO ₃ to pH <2 Cool, 4°C	6 months, except Hg is 28 days	200	EPA CLP SOW 787
Acid Soluble	Grab or composite	P, G	HNO ₃ to pH 1.75 ± 0.1 Cool, 4°C Filter after 16 hrs.	6 months, except Hg is 28 days	200	EPA CLP SOW 787
Total	Grab or composite	P, G	HNO ₃ to pH <2, Cool, 4°C	6 months, except Hg is 28 days	200	EPA CLP SOW 787
Nitrate-N	Grab or composite	P, G	Cool, 4°C, H ₂ SO ₄ to pH <2	28 days	100	EPA Method 352.1
CLP Pesticides and PCBs	Grab or composite	G, amber, Teflon-lined cap	Cool, 4°C	7 days until extraction, 30 days after extraction	4,000	EPA CLP SOW 288
CLP Semivolatile Organic Compounds	Grab or composite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 30 days after extraction	4,000	EPA CLP SOW 288
Silica, Dissolved	Grab or composite	P	Cool, 4°C	28 days	50	
Solids						
Dissolved	Grab or composite	P, G	Cool, 4°C	7 days	100	EPA Method 160.1

HC-4.20

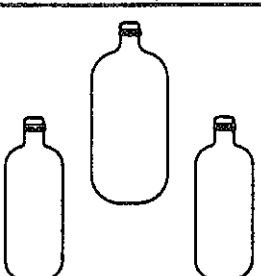
TABLE HG 4.1

CFRSS SOP
April 2, 1992
Revision 1RECOMMENDED SAMPLING AND PRESERVATION PROCEDURES FOR
WATER AND WASTEWATER
(Continued)

<u>Parameter</u>	<u>Collection Technique</u>	<u>Container^(a)</u>	<u>Preservation</u>	<u>Holding Time^(b)</u>	<u>Minimum Required Volume (ml)</u>	<u>Reference Method^(c)</u>
Solids						
Suspended	Grab or composite	P, G	Cool, 4°C	7 days	100	EPA Methods 160.2
Sulfate	Grab or composite	P, G	Cool, 4°C	28 days	50	EPA SW-846 Method 9038
TOC	Grab or composite	G, Teflon-lined cap	Cool, 4°C H ₂ SO ₄ to pH <2	28 days	25	EPA Method 415.1
CLP Volatile Organic Compounds	Grab only	G, Teflon-faced silicone cap	Cool, 4°C HCL to pH 1.4 to 2.8	14 days	3 x 40	EPA CLP SOW 288

Source: "Characterization of Hazardous Waste Sites," A Method Manual EPA-600/4-84-076.




^a P = Polyethylene, G = Glass^b The holding times are those listed in Technical Additions to Methods for Chemical Analysis of Water and Wastes, EPA-600/4-82-005 and Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, EPA-600/4-82-056.^c Reference Methods were taken from the Clark Fork River Superfund Site Investigations, Quality Assurance Project Plan, February 1992.

WATER SAMPLE	REQUIRED VOLUME	CONTAINER TYPE
INORGANIC ANALYSIS	1 LITER 	1 x 1-LITER GLASS OR POLYETHYLENE BOTTLE OR 2 x 500 ML GLASS OR POLYETHYLENE BOTTLE

SUMMARY OF INORGANIC SAMPLE CONTAINERS

PREPARED FOR

ARCO
ANACONDA, MONTANA

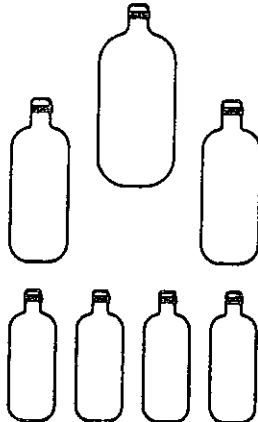

	4-2-92	ISSUED FOR CLARK FORK RIVER SUPERFUND SITE STANDARD OPERATING PROCEDURES	WLH	DEM	MMW
	4-16-91	ISSUED FOR SOP UPDATE SIMPLIFIED DRAWING	M.B.H.	S. dup.	R.S.P.
	8-8-90	ISSUED FOR CLIENT/AGENCY REVIEW	R.H.	M.M.W.	R.S.P.
No.	DATE	ISSUE / REVISION	OWN.	BY CK'D BY	AP'D BY

DATE: 6-16-90
SCALE: NTS

FIGURE HG-4-1

DRAWING NUMBER
89-121-A41

DRAWING
NUMBER 89-121-A42

WATER SAMPLE	REQUIRED VOLUME	CONTAINER TYPE
ORGANIC ANALYSIS	1 GALLON 	1 x 4-LITER AMBER GLASS BOTTLES OR 2 x 80-OZ. AMBER GLASS BOTTLES OR 4 x 1-LITER AMBER GLASS BOTTLES
VOLATILE ANALYSIS	120 ML 	3 x 40-ML GLASS VIALS

SUMMARY OF ORGANIC
SAMPLE CONTAINERS

PREPARED FOR

ARCO
ANACONDA, MONTANA

4-2-92	ISSUED FOR CLARK FORK RIVER SUPERFUND SITE STANDARD OPERATING PROCEDURES	WLH	DEM	MMW
4-16-91	ISSUED FOR SOP UPDATE - CHANGED REQUIRED VOLUME FOR VOLATILE ANALYSIS, SIMPLIFIED DRAWING	M.B.H.	S. JUP.	R.S.P.
8-8-90	ISSUED FOR CLIENT/AGENCY REVIEW	R.H.	M.M.W.	R.S.P.
No.	DATE	ISSUE / REVISION		OWN. BY CK'D BY AP'D BY

DATE: 5-16-90
SCALE: N.T.S.

FIGURE HG-4-2

DRAWING NUMBER
89-121-A42

STANDARD OPERATING PROCEDURE HG-10

**FIELD TURBIDITY MEASUREMENT
SOP HG-10**

STANDARD OPERATING PROCEDURE HG-10

FIELD TURBIDITY MEASUREMENT SOP HG-10

OBJECTIVE

The turbidity of the water pumped during well development will be measured using a portable turbidimeter. The general sampling information will be recorded in the bound logbook or the well development data form, as appropriate. The turbidity measurements data will include, at a minimum, the well number, date and time, volume of water pumped, and the Nephelometric Turbidity Units (NTU) reading.

EQUIPMENT DESCRIPTION

The Hach Model 168000 PortaLab™ Turbidimeter (Hach Turbidimeter) is a hand-held instrument that measures turbidity directly in NTU on a precalibrated meter scale. Ranges of measurement are 0-1, 0-10, and 0-100 NTU.

The Hach Turbidimeter is accurate to ± 5 percent full scale and is reproducible to ± 1 percent full scale. The instrument has a 0.01 resolution on the 0-1.0 range. The meter is powered by a rechargeable battery pack that provides about 10 hours of service when fully charged.

Calibration of the PortaLab™ Turbidimeter is based on formazin, the accepted primary standard of turbidity measurement.

CALIBRATION PROCEDURES

The Hach Model 16800 PortaLab™ Turbidimeter includes three calibration "standard" cells, one for each measurement range.

1. Select the appropriate measurement range.
2. Insert the appropriate calibration standard cell, for the range selected, into the cell holder and close the cover.
3. Press the TEST button and adjust the meter to standard value by turning the "Adjust" knob.
4. Remove the "standard" and the meter is ready to use.

MEASUREMENT PROCEDURE

1. Insert the sample in cell holder and cover.
2. Select the appropriate range.
3. Press the TEST button and read a sample turbidity on the meter scale.
4. An accurate test can be completed in less than one minute.

Maintenance of this instrument is limited to cleaning the sampling cells and charging the battery pack.

STANDARD OPERATING PROCEDURE G-4

**FIELD LOGBOOK/PHOTOGRAPHS
SOP G-4**

STANDARD OPERATING PROCEDURE G-4

FIELD LOGBOOK/PHOTOGRAPHS SOP G-4

FIELD LOGBOOK

A separate field logbook will be used for each field task. Each logbook shall have a unique document control number. The logbooks will be bound and have consecutively numbered pages. The information recorded in these logbooks shall be written in indelible ink. The author will initial and date entries at the end of each day, and a line shall be drawn through the remainder of the page. All corrections will consist of a single line-out deletion in indelible ink, followed by the author's initials and the date. No bound field logbooks will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. These bound logbooks, at a minimum, shall include the following entries:

1. A purpose and description of the proposed field task,
2. Time and date fieldwork started,
3. Location and description of the work area, including sketches if possible, map references and photographs, and sketches of well construction details, soils, pits, etc.,
4. Names and titles of field personnel,
5. Name, address, and phone number of any field contacts,

6. Meteorological conditions at the beginning of fieldwork and any ensuing changes in these conditions,
7. Details of the fieldwork performed and field data sheets used (including document control numbers), with special attention to any deviations from the task-specific Sampling and Analysis Plan (SAP) or Standard Operating Procedures (SOPs),
8. All field measurements made,
9. Any field laboratory analytical results, and
10. Personnel and equipment decontamination procedures.

For any field sampling work, at a minimum, the following entries should be made:

1. Sample location and number,
2. Sample type (eg, ground water) and amount collected,
3. Date and time of sample collection,
4. Split samples taken by other parties. Note the type of sample, sample location, time/date, name of person, person's company, any other pertinent information,
5. Sampling method, particularly any deviations from the SOP,

6. Suspected waste composition, including an estimate of the hazard level as being low or medium,
7. Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample (eg, filters and preserving reagents), and
8. Sample preservation, handling, packaging, labeling, shipping information (eg., weight), the shipping agent, and the laboratory where the samples will be sent.

After each day of fieldwork, all the bound logbooks will be locked up in a location accessible to the Quality Assurance Manager, such as the field office filing cabinet.

PHOTOGRAPHS

Photographs will be taken of field activities using a camera-lens system with a perspective similar to the naked eye. Photographs should include a measured scale in the picture, when practical. Telephoto or wide-angle shots will not be used, since they cannot be used in enforcement meetings. The following items shall be recorded in the bound field logbook for each photograph taken:

1. The photographer's name, the date, the time of the photograph, and the general direction faced,
2. A brief description of the subject and the fieldwork portrayed in the picture, and
3. Sequential number of the photograph and the roll number on which it is contained.

The slides or prints and associated negatives shall be placed in task files in the field office after the film is developed. Any supporting documentation from the bound field logbooks shall be photocopied and placed in the task files to accompany the particular slides or prints.

Figure G-4-1 provides a suggested photograph label format for attaching to photographs, or for a photograph logbook.

ARCO-PHOTOGRAPH LABELS

PHOTOGRAPH NUMBER: _____
DATE: _____
TIME: _____
DIRECTION: _____
PHOTOGRAPHER: _____
DESCRIPTION: _____

PHOTOGRAPH NUMBER: _____
DATE: _____
TIME: _____
DIRECTION: _____
PHOTOGRAPHER: _____
DESCRIPTION: _____

FIGURE G-4-1

STANDARD OPERATING PROCEDURE G-5

**SAMPLE PACKAGING AND SHIPPING
SOP G-5**

STANDARD OPERATING PROCEDURE G-5

SAMPLE PACKAGING AND SHIPPING SOP G-5

Transportation regulations for shipping hazardous substances and dangerous goods are defined by the Department of Transportation (DOT) in 49 Code of Federal Regulations (CFR) Subchapter C, Part 171 (October 1, 1988); the International Air Transport Association (IATA); and the International Civil Aviation Organization (ICAO). A combination of IATA and ICAO shipment and packaging regulations shall be used. These regulations are the accepted protocols for shipping hazardous substances and dangerous goods by Federal Express and other ground or air carriers.

According to DOT regulations, environmental samples shall be classified as Other Regulated Substances (ORS). ORS are articles, samples, or materials that are suspected, or known, to contain contaminants and/or are capable of posing a risk to health, safety, or property when transported by ground or air.

The materials included under the proper shipping name of ORS must **not** meet any of the definitions for the following classes of material:

1. Class 1: Explosives,
2. Class 2: Gases - compressed, liquified, dissolved under pressure, or deeply refrigerated,
3. Class 3: Flammable liquids,

4. Class 4: Substances susceptible to spontaneous combustion,
5. Class 5: Oxidizing substances,
6. Class 6: Poisonous (toxic and infectious substances),
7. Class 7: Radioactive materials, or
8. Class 8: Corrosives.

ORS generated or handled by ARCO personnel shall be defined as samples, substances, or materials (environmental samples) suspected to contain contaminants.

Samples, substances, or materials from areas other than drums, leachate streams, sludges, noticeably discolored soils or waters, and lagoons shall be defined as ORS or environmental samples. In addition, any samples producing photoionization detector/organic vapor analyzer (PID/OVA) readings slightly above background shall be defined as ORS or environmental samples. Examples of environmental samples include most ground water and soil samples.

The following steps shall be followed when packaging and shipping environmental samples:

1. Collect the sample as stated in appropriate standard operating procedure (SOP).
2. Wipe the exterior of the sample container with appropriate decontamination solution while wearing the necessary personal protective equipment as specified in the site-specific Health and Safety Plan.

3. Attach the identification tag to the sample container. Place sample container in a 2-ml thick (or thicker) zip-lock polyethylene bag, one sample per bag. Position the sample container so the identification tag can be read through the bag, then seal the bag.
4. Place one or more bagged samples into a strong outside water-tight container, such as an ice chest or a DOT-approved fiberboard box.
5. Add ice and/or blue ice if required by the appropriate SOP.
6. Secure containers with noncombustible, absorbent, cushioning material such as vermiculite for stability (styrofoam peanuts are not acceptable).
7. Secure the properly completed chain-of-custody form (see SOP G-7) to the inside of the ice chest lid in a plastic bag. The chain-of-custody form shall list only those samples contained in the ice chest.
8. Tape ice chest drain and ice chest closed using fiberglass tape and seal with several chain-of-custody seals (Figure G-5-1).
9. Complete the air bill and Shipper's Certification for Restricted Articles/Dangerous Goods as shown on Figure G-5-2.
10. Label and address the ice chest as shown on Figures G-5-3 and G-5-4.

DRAWING NUMBER 89-121-A47

Contractor's Name Contractor's Address	Project No.
	Sample Type
	Sample No.
	Preservative
	Remarks
	Sampler Date/Time
	SITE NAME
Tag No. _____	

SAMPLE LABEL

Contractor's Name OFFICIAL SAMPLE SEAL	SAMPLE No.	DATE	SEAL BROKEN BY	DATE
	SIGNATURE			
	PRINT NAME AND TITLE			

CHAIN-OF-CUSTODY SEAL

SAMPLE LABEL AND
CHAIN-OF-CUSTODY SEAL
PREPARED FOR
ARCO
ANACONDA, MONTANA

4-2-92	ISSUED FOR CLARK FORK RIVER SUPERFUND SITE STANDARD OPERATING PROCEDURES	WLH	DEM	MMN					
8-8-90	ISSUED FOR CLIENT/AGENCY REVIEW	M.B.H.	M.M.W.	R.S.P.					
No.	DATE	ISSUE / REVISION			OWN. BY	CHK'D BY	APP'D BY	DATE: 6-4-90	FIGURE G-5-1
								SCALE: N.T.S.	DRAWING NUMBER 89-121-A47

SAMPLE FEDERAL EXPRESS LABEL FOR DANGEROUS GOODS

Sender's Federal Express Account Number 0463-0026-2		Date XX/XX/XX	
From (Your Name) Please Print YOUR NAME		Your Phone Number (Very Important) (XXX)XXX-XXXX	
Company _____		Receiver's Name Please Print RECEIVER'S NAME	
Street Address YOUR ADDRESS		Receiver's Company RECEIVER'S COMPANY	
City YOUR C.Y., YOUR ST.		Receiver's Address (DO NOT USE) RECEIVER'S ADDRESS (DO NOT USE)	
State XXXXX		Receiver's City, State RECEIVER CITY, STATE	
ZIP Required XXXXX		ZIP Required XXXXX	
YOUR BILLING REFERENCE INFORMATION (FIRST 24 CHARACTERS WILL APPEAR ON INVOICE) 7 DIGIT PROJECT BILLING CODE HERE			
IF BUILT FOR PICK-UP, Print FEDEX Address Here _____			
PAYMENT <input checked="" type="checkbox"/> Bill Service <input type="checkbox"/> Bill Receiver's Facility Add. No. <input type="checkbox"/> Bill 3rd Party Facility Add. No. <input type="checkbox"/> Bill Credit Card <input type="checkbox"/> Cash <input type="checkbox"/> Extension Date _____			
SERVICES <input checked="" type="checkbox"/> PRIORITY 1 Overnight Delivery using your Packaging when using ICAO/IATA regulations, please mark appropriate boxes. Do not mark for CFR 48. • Dangerous Goods in our attached Shipper's Declaration <input checked="" type="checkbox"/> • Dangerous Goods Shipper's Declaration not required <input type="checkbox"/> • Cargo Aircraft only <input checked="" type="checkbox"/> <input type="checkbox"/> STANDARD AIR Delivery not later than second business day		DELIVERY AND SPECIAL HANDLING <input type="checkbox"/> HOLD FOR PICK-UP (To be used with PRIORITY 1) <input checked="" type="checkbox"/> DELIVER WEEKDAY <input type="checkbox"/> DELIVER SATURDAY (Late charges) <input checked="" type="checkbox"/> DANGEROUS GOODS (Late charges) <input type="checkbox"/> CONTAINER SURVEILLANCE DELIVER FEES (Late charges) <input type="checkbox"/> DAY AFT • Dangerous Goods Shipper's Declaration not required • 24 hrs. & 48 hrs. _____ <input type="checkbox"/> OTHER _____	
DECLARED VALUE AND LIMIT OF LIABILITY Use of this label constitutes your agreement to the service conditions in our current Service Guide which is available upon request. See back of receiver's copy of this label for further information. We will not be responsible for any claims in excess of \$100 per package, whether the result of fire, theft, damage, delay or non-delivery unless you declare a higher amount in the space below. Do not use for contents \$100 or less. (Do not use for contents \$100 or less.) Federal Express Service Guide (copy) will report to receiver from Federal Express the date of the previous value of the package, as well as the date of loss, damage, theft, delay, or non-delivery. Compensation is limited to the amount of \$100 or the declared value, whichever is less, or the value of the package at the time of loss, damage, theft, delay, or non-delivery.		Received At: 1 <input type="checkbox"/> Regular Stop 2 <input type="checkbox"/> On-Call Stop 3 <input type="checkbox"/> Drop Box 4 <input type="checkbox"/> S.S.C. 5 <input type="checkbox"/> Station FEDEX Corp. Employee No. _____ Date / Time for FEDEX Use _____	

6725546833

APPELL NUMBER

SHIPPER'S CERTIFICATION FOR RESTRICTED ARTICLES/DANGEROUS GOODS

CHECK ONE

☐ 49 CFR☒ IATA/ICAO

(TYPE OR PR)

Other regulated Substances	9 Miscellaneous	ID 8027	*23 JARS IN A* polyethylene cooler *18.75kg	906
These Amts. must be in metric units and must correspond to the amts. (total) specified on the chain of custody				

CARGO AIRCRAFT ONLY

ADDITIONAL HANDLING INFORMATION

TRANSPORT DETAILS	THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR	<input checked="" type="checkbox"/> PASSENGER AIRCRAFT	CARGO AIRCRAFT ONLY	(DELETE-NONAPPLICABLE)
AIRPORT OF DEPARTURE FROM GET INFO. FED. EX.	AIRPORT OF DESTINATION TOWN OF DEST.	SHIPMENT TYPE	<input checked="" type="checkbox"/> NON-RADIOACTIVE	<input checked="" type="checkbox"/> RADIOACTIVE

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS OR TREATMENT.

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT BY AIR ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

NAME AND TITLE OF SHIPPER

YOUR NAME / YOUR TITLE

PLACE AND DATE

LOCATION / DATE

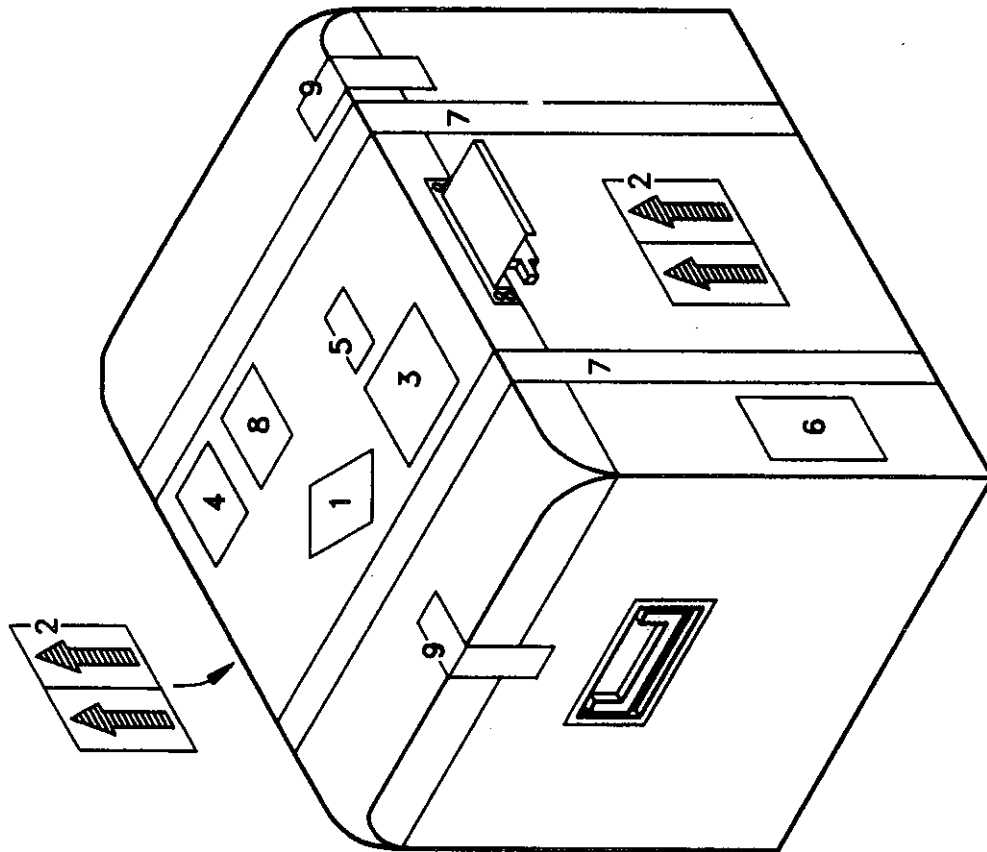
EMERGENCY TELEPHONE NUMBER

YOUR PHONE NUMBER

SIGNATURE OF SHIPPER

YOUR SIGNATURESEE WAR
ON BAG.

DRAWING NUMBER 89-121-A434



LEGEND:

- HAZARD LABEL FOR CLASS 9 - "MISCELLANEOUS DANGEROUS GOODS"
- ORIENTATION LABELS (A MINIMUM OF TWO ARE REQUIRED AFFIXED TO OPPOSITE SIDES OF THE PACKAGE)
- ADDRESSEE'S ADDRESS AND PHONE NUMBER
- SENDER'S ADDRESS AND PHONE NUMBER
- PROPER SHIPPING NAME AND ID No. OTHER REGULATED SUBSTANCES ID 8027
- "DANGER DO NOT LOAD ON PASSENGER AIRCRAFT" LABEL
- TAPE TO SEAL COOLER
- FEDERAL EXPRESS DANGEROUS GOODS AIRBILL
- CHAIN-OF-CUSTODY SEAL

NOTES:

- ADDRESSEE'S ADDRESS AND THE PROPER SHIPPING NAME AND ID No. (OTHER REGULATED SUBSTANCES ID 8027) MUST BE PLACED ADJACENT TO THE LABEL FOR CLASS 9 - MISCELLANEOUS DANGEROUS GOODS.
- SEE FIGURE G-5-4 AND G-5-1 FOR LABEL SPECIFICATIONS.

SHIPPING CONTAINER
LABEL PLACEMENT:
OTHER REGULATED SUBSTANCES
(LOW CONCENTRATIONS)

PREPARED FOR

ARCO

ANACONDA, MONTANA

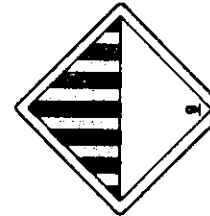
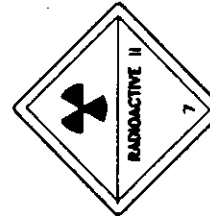
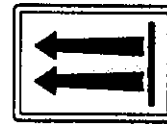
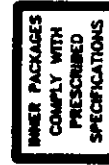
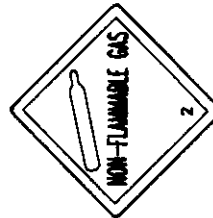
No.	DATE	ISSUE / REVISION	DWN. BY/CK'D BY	DE/IN	MMW
4-2-92					
ISSUED FOR CLARK FORK RIVER SUPERFUND SITE STANDARD OPERATING PROCEDURES					

DATE: 2-25-92	FIGURE G-5-3	DRAWING NUMBER
SCALE: N.T.S.		89-121-A434

DRAWING NUMBER 89-121-A436

LABEL SPECIFICATION TABLE

No.	LABEL DESCRIPTION	MINIMUM SIZE	REMARKS
1	HAZARD LABEL FOR CLASS 2 - "NON-FLAMMABLE GAS"	4" x 4"	-
2	HAZARD LABEL FOR CLASS 2 - "FLAMMABLE GAS"	4" x 4"	-
3	PROPER SHIPPING NAME/UN OR ID LABEL (THIS LABEL IS SPECIFIC FOR "OTHER REGULATED SUBSTANCES", SEE OTHER CLASSIFICATIONS)	-	THE MARKING MUST BE PERMANENT AND LEGIBLE AT A DISTANCE OF THREE FEET
4	"DANGER CARGO AIRCRAFT ONLY" LABEL	4.3" x 5"	-
5	"INNER PACKAGES COMPLY WITH PRESCRIBED SPECIFICATIONS" LABEL	4" x 4"	-
6	ORIENTATION LABELS	-	THE MARKING MUST BE PERMANENT AND LEGIBLE AT A DISTANCE OF THREE FEET
7	HAZARD LABELS FOR CLASS 7 - "RADIOACTIVE II" (IN MOST CASES THESE ARE ALREADY ATTACHED TO THE TOP AND BOTTOM OF THE TROXLER CASE)	4" x 4"	-
8	HAZARD LABEL FOR CLASS 9 - "MISCELLANEOUS DANGEROUS GOODS"	4" x 4"	-
9	"FRAGILE HANDLE WITH CARE" LABEL	-	THE MARKING MUST BE PERMANENT AND LEGIBLE AT A DISTANCE OF THREE FEET



NOTE:

1. THESE LABELS ARE NOT DRAWN TO SCALE.

LABEL SPECIFICATIONS FOR
PACKAGING AND SHIPPING

PREPARED FOR

ARCO

ANACONDA, MONTANA

No. 1	ISSUE / REVISION	RAIL	DEM	APPROV
				DRAWN BY/CHK'D BY/APP'D BY

DATE: 2-26-92
SCALE: N.T.S.

FIGURE G-5-4

IG NUMBER
1-A436

STANDARD OPERATING PROCEDURE G-8
DECONTAMINATION OF EQUIPMENT USED TO
SAMPLE SOIL AND WATER
SOP G-8

STANDARD OPERATING PROCEDURE G-8
DECONTAMINATION OF EQUIPMENT USED TO
SAMPLE SOIL AND WATER
SOP G-8

To prevent potential cross-contamination of samples, all reusable soil and water sampling equipment and pumps shall be decontaminated. The field hydrogeologist or geologist shall set up the area used to decontaminate soil and water sampling equipment in the manner shown on Figure G-8-1. This area will be located approximately 15 feet upwind from the specific sampling area. The personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific Health and Safety Plan.

PROCEDURES USED TO DECONTAMINATE INORGANICALLY CONTAMINATED
SOIL SAMPLING EQUIPMENT

Table G-8.1 lists the equipment that shall be used to decontaminate the soil sampling equipment and the decontamination station where it will be used. The specific procedures for decontaminating inorganic contaminated soil sampling equipment include the following:

1. At Station No. 1, first wash the contaminated equipment in a tub containing tap water to remove the soil material. Follow with a second wash in a tub containing water mixed with a detergent, such as Alconox.
2. Move the equipment to the wash tub in Station No. 2. Rinse the equipment with clean water, wash with 0.1 Normal nitric acid (HNO_3), then rinse with distilled/deionized (DS/DI) water.

3. At Station No. 3, place the clean equipment on plastic sheeting until it is used again.

After decontaminating all the soil sampling equipment, the disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in a trash collection facility. The wash and rinse water from Station Nos. 1 and 2 will be disposed in accordance with the site-specific SAP. At the end of each day, all soil sampling equipment shall be stored in large plastic bags.

PROCEDURES USED TO DECONTAMINATE INORGANICALLY CONTAMINATED WATER SAMPLING EQUIPMENT

Table G-8.2 lists the equipment that shall be used to decontaminate the water sampling equipment and the decontamination stations where it will be used. (To decontaminate pumps, see section **Decontamination of Sampling Pumps** at the end of this SOP.)

The specific procedures for decontaminating inorganic contaminated water sampling equipment include the following:

1. At Station No. 1, wash the contaminated equipment in a tub containing water mixed with a detergent such as Alconox.
2. Move the equipment to the wash tub in Station No. 2. First, rinse the equipment with DS/DI water. Then rinse the equipment with dilute (0.1 Normal) nitric acid and follow with a second rinse using DS/DI water.

3. At Station No. 3, place the clean equipment on plastic sheeting until it is used again.

After decontaminating all the water sampling equipment, the disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in a trash collection facility. The wash and rinse water from Station No. 1 and No. 2 will be disposed in accordance with the site-specific SAP. At the end of each day, all water sampling equipment shall be stored in large plastic bags.

PROCEDURES USED TO DECONTAMINATE ORGANICALLY CONTAMINATED SOIL SAMPLING EQUIPMENT

Table G-8.3 lists the equipment and supplies that shall be used to decontaminate the soil sampling equipment and the decontamination station where it will be used. The specific procedures for decontaminating the organic contaminated soil sampling equipment include the following:

1. At Station No. 1, Tub No. 1, wash and scrub with a detergent such as Alconox, or use a pressurized steam cleaner to remove the soil material. Collect the waste water for disposal in accordance with the site-specific SAP.
2. At Station No. 1, Tub No. 2, double rinse the equipment with DS/DI water.
3. At Station No. 2, rinse the equipment with a spectrographic grade acetone, (a drying agent), followed by a rinse with methylene chloride or hexane.
4. At Station No. 3, lay the equipment on the clean plastic to air dry.

5. Wrap the equipment in clean plastic until reuse.

The solvent waste should be collected in the empty solvent bottles for disposal later, in accordance with the site-specific SAP. The disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in the trash collection containers. The wash and rinse waters from Stations No. 1 and 2 will be disposed in accordance with the site-specific SAP.

PROCEDURES USED TO DECONTAMINATE ORGANICALLY CONTAMINATED WATER SAMPLING EQUIPMENT

Table G-8.4 lists the equipment and supplies that shall be used to decontaminate the water sampling equipment and the decontamination station where it will be used. (To decontaminate pumps, see section **Decontamination of Sampling Pumps** at the end of this SOP.)

The specific procedures for decontaminating the organic contaminated water sampling equipment include the following:

1. At Station No. 1, Tub No. 1, wash and scrub the equipment with a detergent such as Alconox, or use a pressurized steam cleaner to remove the soil material. Collect the waste water for disposal in accordance with the site-specific SAP.
2. At Station No. 1, Tub No. 2, double rinse the equipment with DS/DI water.
3. At Station No. 2, rinse the equipment with a spectrographic grade acetone, (a drying agent), followed by a rinse with methylene chloride or hexane.

4. At Station No. 3, lay the equipment out on the clean plastic to air dry.
5. Wrap the equipment in the clean plastic until reuse.

The solvent waste should be collected in the empty solvent bottles for disposal later in accordance with the site-specific SAP. The disposable gloves and used plastic from Station No. 3, shall be placed in garbage bags and disposed in the trash collection containers. The wash and rinse waters from Stations No. 1 and 2 will be disposed in accordance with the site-specific SAP.

DECONTAMINATION OF SAMPLING PUMPS

When using field decontamination, it is advisable to begin sampling with the well containing the lowest anticipated analyte concentration. Successive samples should be obtained from wells anticipated to have increasing analyte concentrations. Use of dedicated pump equipment is preferable when feasible. Table G-8.5 lists the decontamination equipment required.

When pumps (e.g., submersible or bladder) are submerged below the water surface to collect water samples, they should be cleaned and flushed between uses. This cleaning process consists of an external detergent wash and high-pressure tap water rinse, or steam cleaning, of pump casing, tubing, and cables, followed by a flush of potable water through the pump. This flushing can be accomplished by pouring clean tap water from a carboy into the end of the discharge tube and working it down to the inside of the pump. The procedure should be repeated; then the tubing and inside of the pump should be rinsed with DS/DI water.

Surface pumps (e.g., peristaltic or diaphragm) used for well evacuation need not be cleaned between well locations. However, a new length of polyethylene tubing must be used for each well and discarded after use. The pump and hose should always be placed on clean polyethylene sheeting to avoid contact with the ground surface.

TABLE G-8.1

DECONTAMINATION EQUIPMENT FOR INORGANICALLY
 CONTAMINATED SOIL SAMPLING EQUIPMENT

Equipment List for Decontamination

<u>Item</u>	<u>Quantity</u>
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
0.1 Normal Nitric Acid	a
Hard-bristle brushes	2
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1

Alconox
 Tap water
 Two 3-gallon plastic washtubs
 Scrub brush
 DS/DI water

Station No. 2

3-gallon plastic washtub
 DS/DI water
 0.1 Normal Nitric Acid

Station No. 3

Plastic sheeting or garbage bag

^a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

^b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-8.2
DECONTAMINATION EQUIPMENT FOR INORGANICALLY
CONTAMINATED WATER SAMPLING EQUIPMENT

Equipment List for Decontamination

<u>Item</u>	<u>Quantity</u>
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
0.1 Normal Nitric Acid	a
Hard-bristle brushes	2
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1

Alconox
 Tap water
 Two 3-gallon plastic washtubs
 Scrub brush
 DS/DI water

Station No. 2

3-gallon plastic washtub
 DS/DI water
 0.1 Normal Nitric Acid

Station No. 3

Plastic sheeting or garbage bag

^a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

^b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-8.3
DECONTAMINATION EQUIPMENT FOR ORGANICALLY
CONTAMINATED SOIL SAMPLING EQUIPMENT

Equipment List for Decontamination

<u>Item</u>	<u>Quantity</u>
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
Hard-bristle brushes	2
Acetone, and methylene chloride or Hexane	a
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1

Alconox
 Tap water
 Two 3-gallon plastic washtubs
 Scrub brush
 DS/DI water

Station No. 2

3-gallon plastic washtub
 Acetone, and methylene chloride or hexane

Station No. 3

Plastic sheeting or garbage bag

^a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

^b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-8.4
**DECONTAMINATION EQUIPMENT FOR ORGANICALLY
 CONTAMINATED WATER SAMPLING EQUIPMENT**

<u>Equipment List for Decontamination</u>	
<u>Item</u>	<u>Quantity</u>
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
0.1 Normal nitric acid	a
Hard-bristle brushes	2
Acetone, and methylene chloride or Hexane	a
Plastic sheeting or garbage bags	a
Personal Protective Equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1

Alconox
 Tap water
 Two 3-gallon plastic washtub
 Scrub brush
 Acetone, and methylene chloride or hexane

Station No. 3

Plastic sheeting or garbage bag

^a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

^b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-8.5
DECONTAMINATION EQUIPMENT FOR SAMPLING PUMPS
EQUIPMENT LIST FOR DECONTAMINATION OF SUBMERSIBLE PUMPS

Equipment List for Decontamination of Submersible Pumps

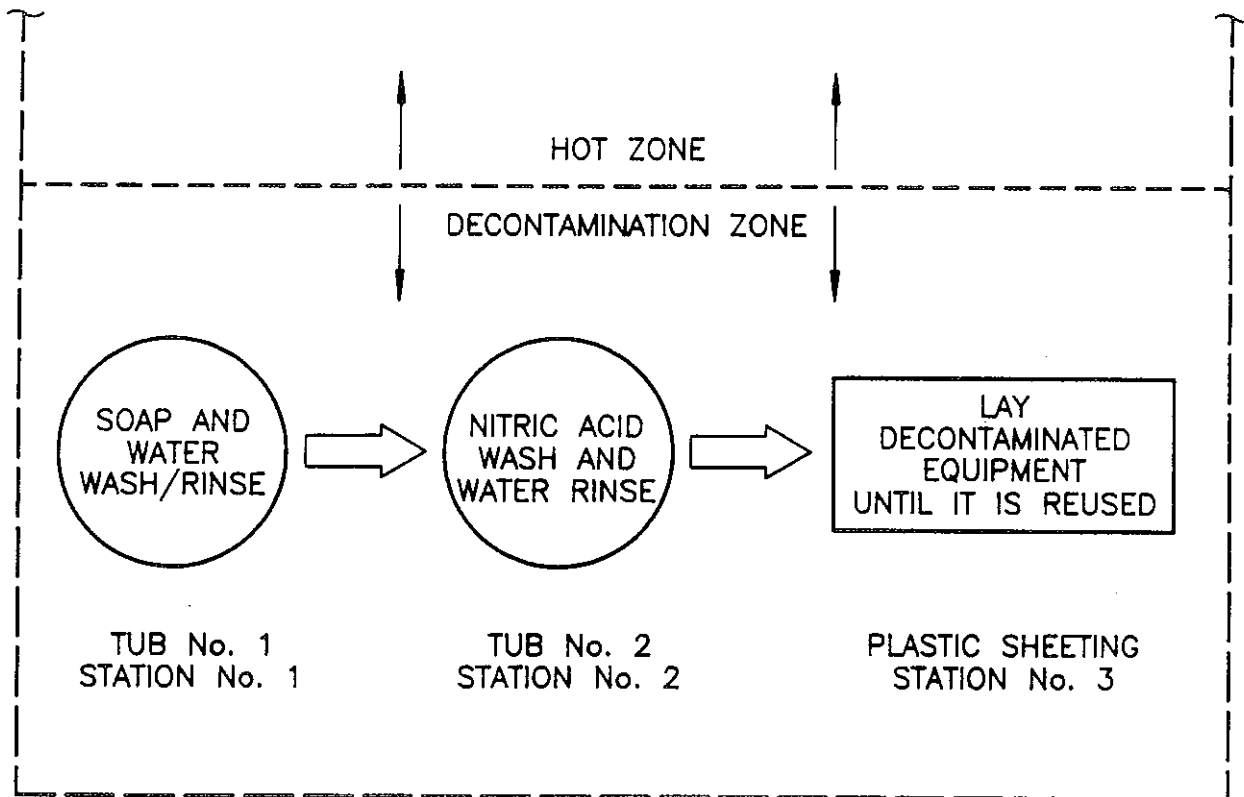
<u>Item</u>	<u>Quantity</u>
Alconox	a
Tap water	a
Hard-bristle brushes	1
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
30-gallon plastic trash can or plastic overpack drum	1
55-gallon drum(s)	a
Spray paint	a
Drum label(s)	a
Steam cleaner	Optional

Equipment List for Decontamination of Surface Pumps

<u>Item</u>	<u>Quantity</u>
Polyethylene tubing	a
Plastic sheeting or garbage bags	a

^a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

^b Type of protective equipment as specified in the site-specific Health and Safety Plan.



TYPICAL DECONTAMINATION
STATIONS LAYOUT
PREPARED FOR
ARCO
ANACONDA, MONTANA

⚠	4-2-92	ISSUED FOR CLARK FORK RIVER SUPERFUND SITE STANDARD OPERATING PROCEDURES	B.K.R.	DEM	MMW	DATE: 2-25-92	FIGURE G-8-1	DRAWING NUMBER 89-121-A435
No.	DATE	ISSUE / REVISION	OWN. BY	CK'D BY	AP'D BY	SCALE: N.T.S.		

5. Place split spoon sampler on the ground surface and advance sampler to the desired depth using the rig hammer.
6. After driving the split spoon sampler its entire length (18 inches) or upon refusal of advancement, recover the split spoon sampler. Refusal is defined as 100 blows with the rig hammer and less than 6 inches advancement of the split spoon sampler. Less than 100 blows may be defined as refusal if there is no split spoon advancement. This decision will be made at the discretion of the field sampler.
7. After recovery of the split spoon sampler, open the spoon and place the spoon containing the soil sample into a holding device, maintaining the intervals as sampled.
8. Sampling personnel will then describe the soil sample based on the site-specific SAP instructions, and fill out the appropriate bound field logbooks, field profile sheets, field site sheets, and quality assurance/quality control documentation.
9. Decontaminate the split spoon sampler according to procedures presented in the SOP G-8.
10. Repeat steps 3 to 9 until sampling is completed.
11. The drill rig tools and sampling equipment will be decontaminated prior to moving onto the next site. The drill rig will be left in a safe and secure fashion at the end of each shift.

BACKHOE PIT EXCAVATIONS

The following procedures are designed to be used during the operation of backhoe equipment to excavate sites prior to soil sampling operations. The procedures listed below may be modified in the field by the agreement of the lead site sampler and backhoe operators based on field and site conditions after appropriate annotations have been made in the appropriate bound field logbook.

1. Locate the site as directed in the site-specific SAP. Identify locations of underground utilities.
2. Place the backhoe tractor in a safe position. This will be based on the operators judgment and site conditions.
3. Begin backhoe excavation. Place excavated materials a sufficient distance from the excavation to prevent the return of excavated materials to the pit. Topsoil will be determined by the technical field support, removed, and segregated from the underlying soils.
4. Continue excavation of the pit to the required depth. This depth shall not exceed 5 feet from the ground surface unless the proper pit exit trenches, shoring, and sloping excavations have been excavated to prevent accidental burials of sampling crew and to meet or exceed all OSHA Construction Standards (29 CFR 1926; Appendix A) for entrance by sampling personnel.

5. Sampling personnel may enter the pit after all excavation is complete and the excavation is deemed safe to occupy. The site safety officer shall be the oversight authority and will determine what is safe and what is not safe. "Safe" for backhoe pit excavations is defined as meeting or exceeding all OSHA Construction Standards (29 CFR 1926; Appendix A), for entrance by sampling personnel.
6. Soil profile descriptions shall be made from a hand cleaned surface along the pit wall using the Unified Soil Classification System.
7. Soil sampling will follow soil profile description and establishment of sampling intervals based on the site-specific SAP. Soil samples will be collected with decontaminated stainless steel or plastic sampling tools and bowls from the appropriate intervals. A sample collected from a depth increment shall be a representative composite of the entire interval and not biased by sample mass collected largely from the top or bottom of the increment.
8. All pertinent field quality assurance/quality control documentation, bound field logbooks, sample labels, profile sheets, and field site sheets shall be completed prior to refilling the pit.
9. After items 1 through 8 have been completed to the satisfaction of the lead sampler, the site pit shall be refilled with the previously excavated materials. The earthen materials are to be replaced in the same order they were excavated with topsoil placed on top of the filled pit. There will be some unavoidable mixing of soil during the excavation.
10. Decontaminate all sampling equipment (SOP G-8).

11. Move to the next site. If the previous site was the last site of the day, decontaminate the backhoe bucket, secure, and park the backhoe tractor rig for the evening.

HAND DUG PITS

The following procedures are designed to be used during the operation of hand tools to excavate sites prior to soil sampling operations. The procedures listed below may be modified in the field by the agreement of the lead site sampler and field personnel based on field and site conditions after appropriate annotations have been made in the appropriate bound field logbook.

1. Locate the site as directed in the site-specific SAP.
2. Select the appropriate orientation for the excavation. This will be based on the lead field sampler's judgment and site conditions.
3. Begin pit excavation. Place excavated materials a sufficient distance from the excavation to prevent the return of excavated materials to the pit. Topsoil is to be placed separately from the underlying soils. Placement of excavated materials on a sheet of plastic is recommended to facilitate returning excavated material to the pit.
4. Continue excavation of the pit to the required depth. This depth shall not exceed 24 inches from the ground surface.
5. Soil profile descriptions shall be made from a hand cleaned surface along the pit wall using the Unified Soil Classification System.

6. Soil sampling will follow soil profile description and establishment of sampling intervals based on the site-specific SAP. Soil samples will be collected with decontaminated stainless steel or plastic sampling tools and bowls from the appropriate intervals. A sample collected from a depth increment shall be representative composite of the entire interval and not biased by sample mass collected largely from the top or bottom of the increment.
8. All pertinent field quality assurance/quality control documentation, bound field logbooks, sample labels, profile sheets, and field site sheets shall be completed prior to refilling the pit.
9. After items 1 through 8 have been completed to the satisfaction of the lead sampler, the site pit shall be refilled with the previously excavated materials. The earthen materials are to be replaced in the same order they were excavated with topsoil placed on top of the filled pit. There will be some unavoidable mixing of soil during the excavation.
10. Decontaminate all sampling equipment (SOP G-8).
11. Move to the next site. If the previous site was the last site of the day, decontaminate the field sampling equipment, secure all equipment, and exit the site.

ATTACHMENT TO SOP SS-1
29 CFR 1926 SUBPART P-EXCAVATION, TRENCHING,
AND SHORING

Subpart P—Excavations

AUTHORITY: Sec. 107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable, and 29 CFR part 1911.

SOURCE: 54 FR 45959, Oct. 31, 1989, unless otherwise noted.

§ 1926.650 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(b) *Definitions applicable to this subpart.*

Accepted engineering practices means those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed, specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system) means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or sides means the vertical or inclined earth surfaces formed as a result of excavation work.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickout means the accidental release or failure of a cross brace.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with § 1926.652 (c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides. See "Faces."

Sloping (Sloping system) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the ex-

cavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp means a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box. See "Shield."

Trench shield. See "Shield."

Uprights means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

§ 1926.651 General requirements.

(a) *Surface encumbrances.* All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

(b) *Underground installations.* (1) The estimated location of utility in-

stallations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

(3) When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.

(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

(c) *Access and egress*—(1) *Structural ramps.* (i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(iii) Structural members used for ramps and runways shall be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be at-

tached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

(2) *Means of egress from trench excavations.* A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(d) *Exposure to vehicular traffic.* Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) *Exposure to falling loads.* No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with § 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.

(f) *Warning system for mobile equipment.* When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) *Hazardous atmospheres—(1) Testing and controls.* In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50-1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be ex-

pected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) *Emergency rescue equipment.* (i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

(h) *Protection from hazards associated with water accumulation.* (1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but

could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.

(i) *Stability of adjacent structures.*

(1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided

to protect employees from the possible collapse of such structures.

(j) *Protection of employees from loose rock or soil.* (1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) *Inspections.* (1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) *Fall protection.* (1) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(2) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be back-filled.

§ 1926.652 Requirements for protective systems.

(a) *Protection of employees in excavations.* (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 5 feet (1.52m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) *Design of sloping and benching systems.* The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:

(1) *Option (1)—Allowable configurations and slopes.* (i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

(2) *Option (2)—Determination of slopes and configurations using Appendices A and B.* Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements

set forth in appendices A and B to this subpart.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and shall include all of the following:

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include at least the following:

(A) The magnitude of the slopes that were determined to be safe for the particular project;

(B) The configurations that were determined to be safe for the particular project; and

(C) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

(c) *Design of support systems, shield systems, and other protective systems.*

Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

(1) *Option (1)—Designs using appendices A, C and D.* Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

(2) *Option (2)—Designs Using Manufacturer's Tabulated Data.* (i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and include all of the following:

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

(d) *Materials and equipment.* (1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued

use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) *Installation and removal of support*—(1) *General*. (i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

(vi) Backfilling shall progress together with the removal of support systems from excavations.

(2) *Additional requirements for support systems for trench excavations*. (i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.

(f) *Sloping and benching systems*. Employees shall not be permitted to work on the faces of sloped or benched

excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

(g) *Shield systems*—(1) *General*. (i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) *Additional requirement for shield systems used in trench excavations*. Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

APPENDIX A TO SUBPART P—SOIL CLASSIFICATION

(a) *Scope and application*—(1) *Scope*. This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) *Application*. This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in § 1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in § 1926.652(c), and the use of the data is

predicated on the use of the soil classification system set forth in this appendix.

(b) *Definitions.* The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS-121.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil means soil that does not exhibit visible signs of moisture content.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or shear vane.

Soil classification system means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The cate-

gories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil means soil which is underwater or is free seeping.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

- (i) The soil is fissured; or
- (ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
- (iii) The soil has been previously disturbed; or
- (iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
- (v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

- (i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or
- (ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.
- (iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.
- (iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
- (v) Dry rock that is not stable; or
- (vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:

- (i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or
- (ii) Granular soils including gravel, sand, and loamy sand; or
- (iii) Submerged soil or soil from which water is freely seeping; or
- (iv) Submerged rock that is not stable, or
- (v) Material in a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) *Requirements*—(1) *Classification of soil and rock deposits.* Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) *Basis of classification.* The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) *Visual and manual analyses.* The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) *Layered systems.* In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) *Reclassification.* If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) *Acceptable visual and manual tests.*—

(1) *Visual tests.* Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) *Manual tests.* Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) *Plasticity.* Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8-inch thread can be held on one end without tearing, the soil is cohesive.

(ii) *Dry strength.* If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) *Thumb penetration.* The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488—"Standard Recommended Practice for Description of Soils (Visual—

Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests.* Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shear vane.

(v) *Drying test.* The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

APPENDIX B TO SUBPART P—SLOPING AND BENCHING

(a) *Scope and application.* This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and bench-

ing protective systems is to be performed in accordance with the requirements set forth in § 1926.852(b)(2).

(b) *Definitions.*

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and raveling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements—(1) Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least $\frac{1}{2}$ horizontal to one vertical ($\frac{1}{2}$ H:1V) less steep than the maximum allowable slope.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with § 1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

TABLE B-1
MAXIMUM ALLOWABLE SLOPES

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V) [1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP [3]
STABLE ROCK TYPE A [2] TYPE B TYPE C	VERTICAL (90°) 3/4 : 1 (53°) 1 : 1 (45°) 1 1/2 : 1 (34°)

NOTES:

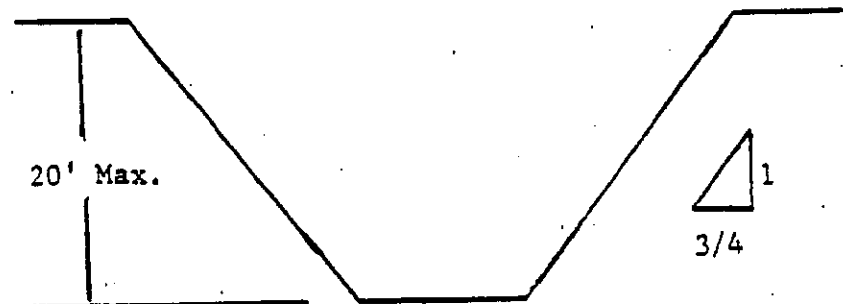
- Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
- A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).
- Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

*Figure B-1***Slope Configurations**

(All slopes stated below are in the horizontal to vertical ratio)

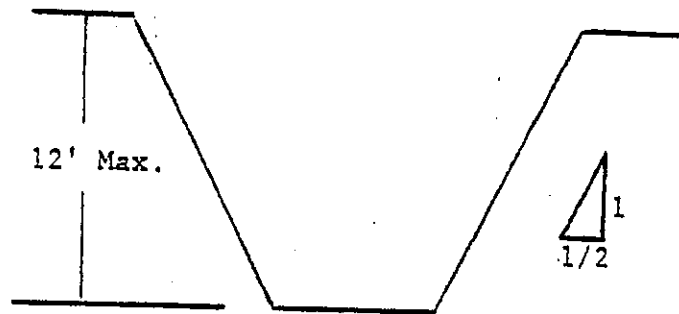
B-1.1 Excavations made in Type A soil.

- All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of 3/4:1.



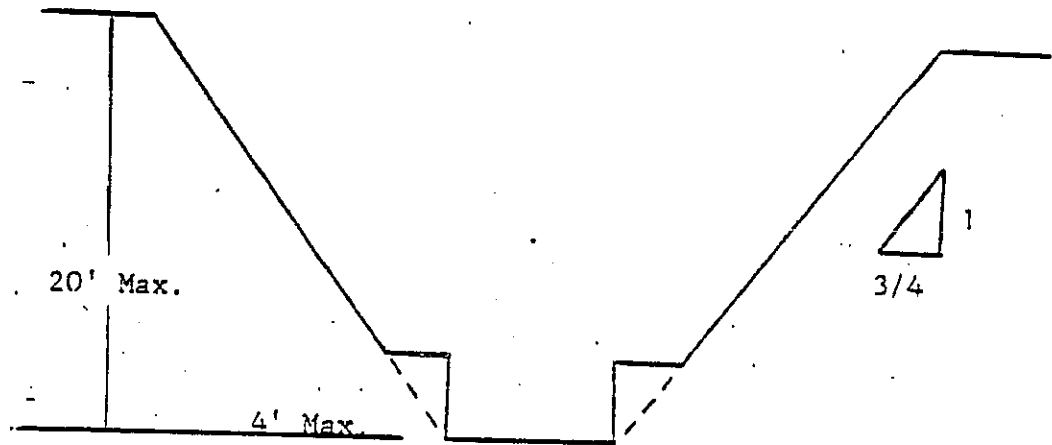
SIMPLE SLOPE—GENERAL

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of $\frac{1}{2}$:1.

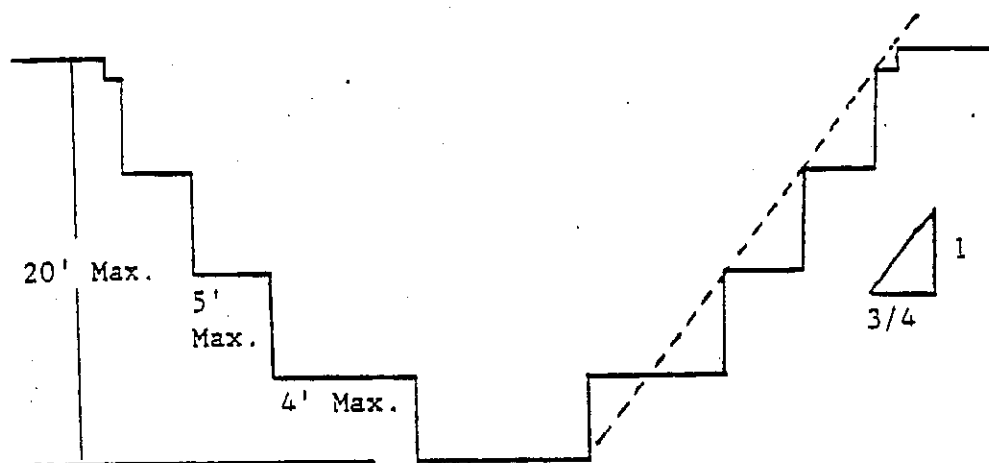


SIMPLE SLOPE—SHORT TERM

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of $\frac{3}{4}$ to 1 and maximum bench dimensions as follows:

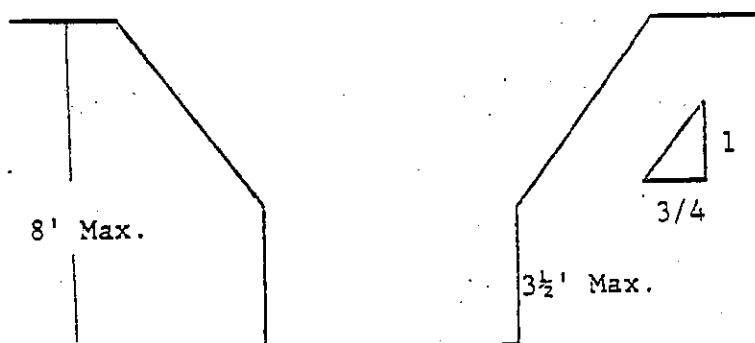


SIMPLE BENCH



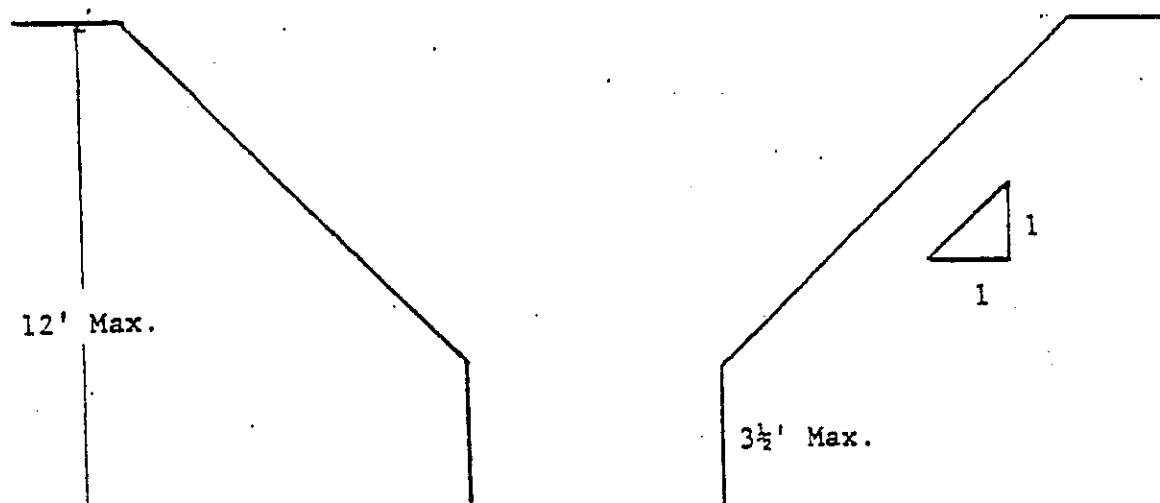
MULTIPLE BENCH

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of $3\frac{1}{2}$ feet.



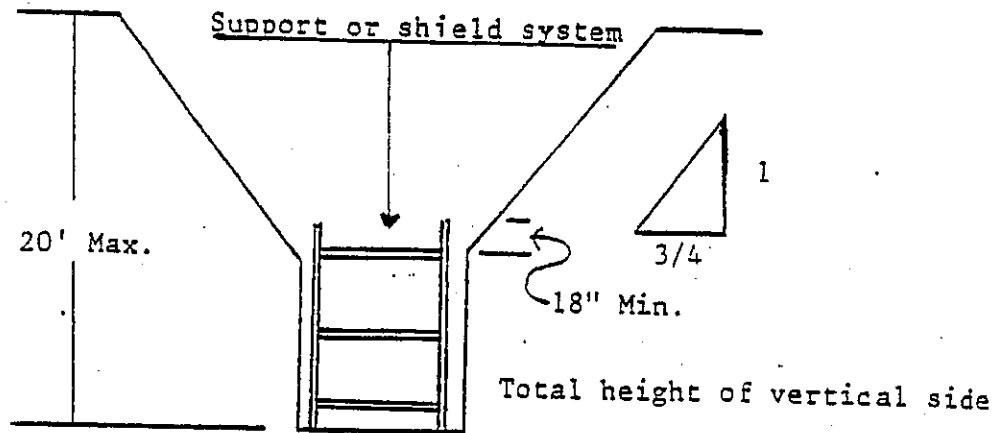
UNSUPPORTED VERTICALLY SIDED LOWER PORTION—MAXIMUM 8 FEET IN DEPTH

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of $3\frac{1}{2}$ feet.



UNSUPPORTED VERTICALLY SIDED LOWER PORTION—MAXIMUM 12 FEET IN DEPTH

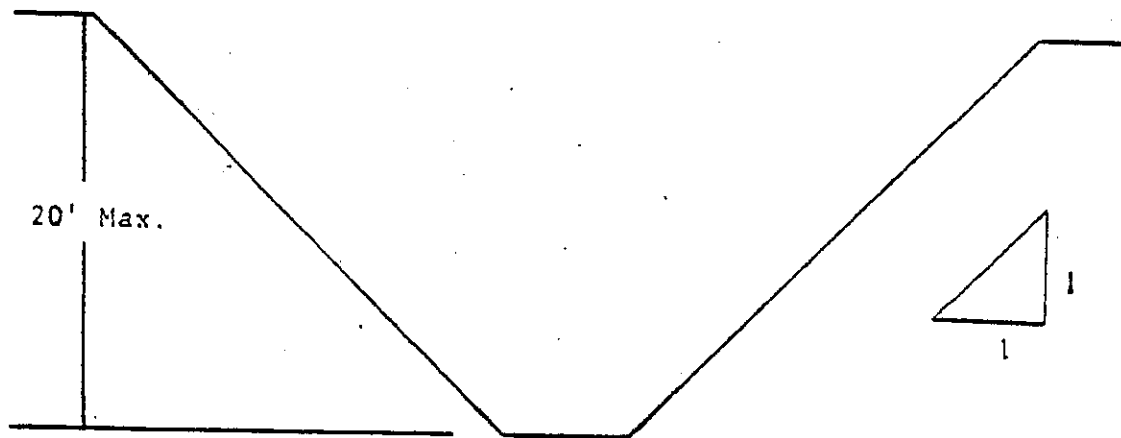
All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of $\frac{3}{4}:1$. The support or shield system must extend at least 18 inches above the top of the vertical side.

**SUPPORTED OR SHIELDED VERTICALLY SIDED LOWER PORTION**

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

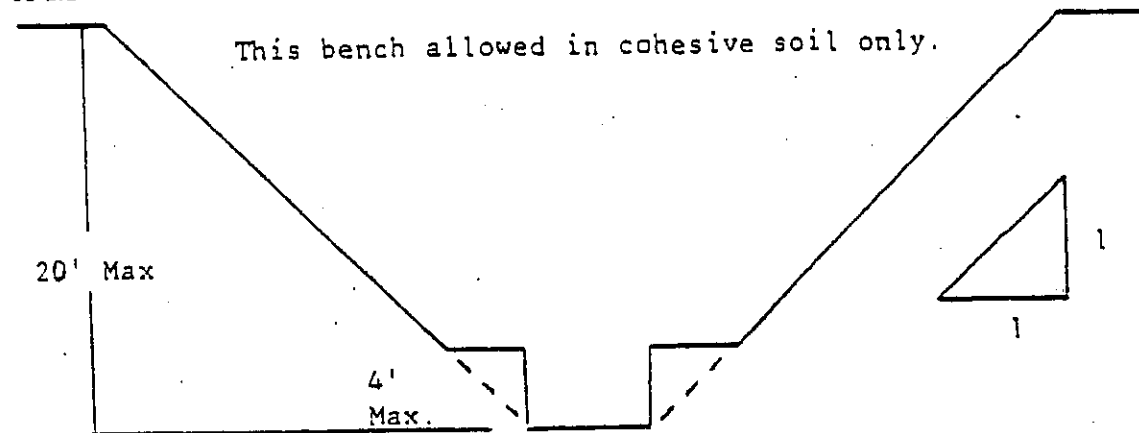
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

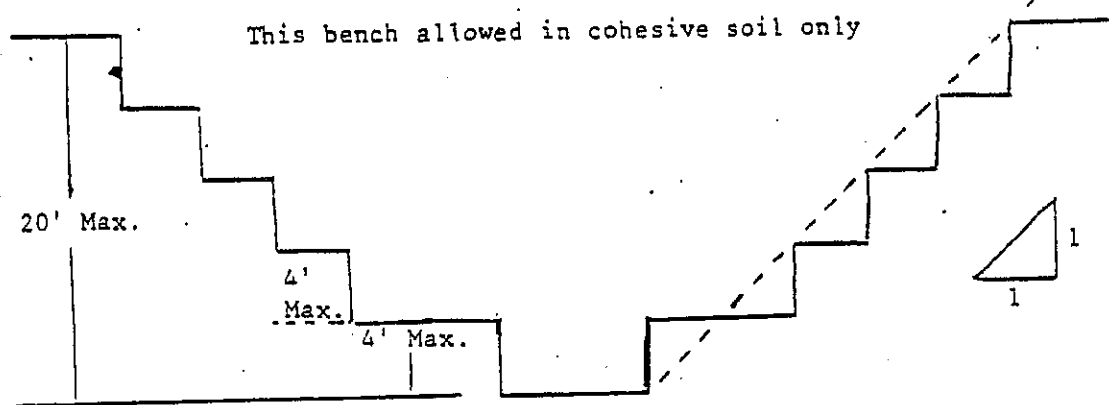


SIMPLE SLOPE

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

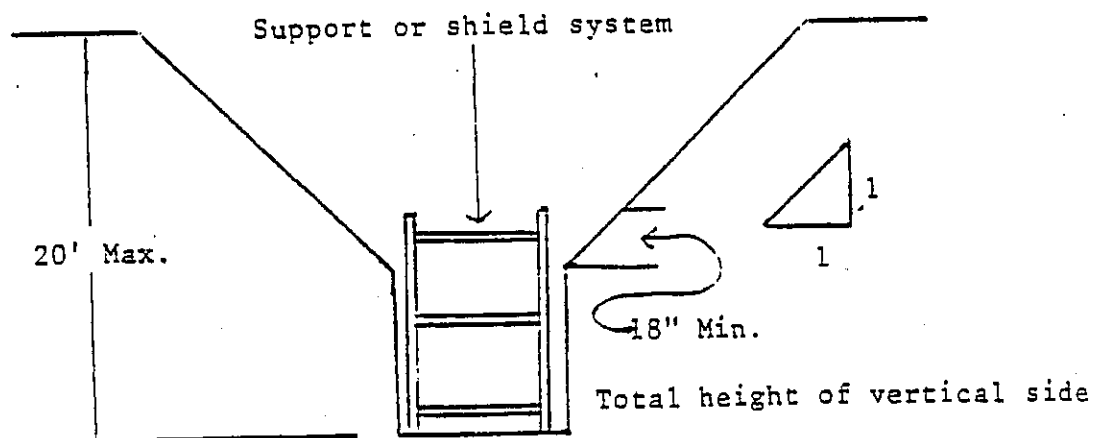


SINGLE BENCH



MULTIPLE BENCH

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

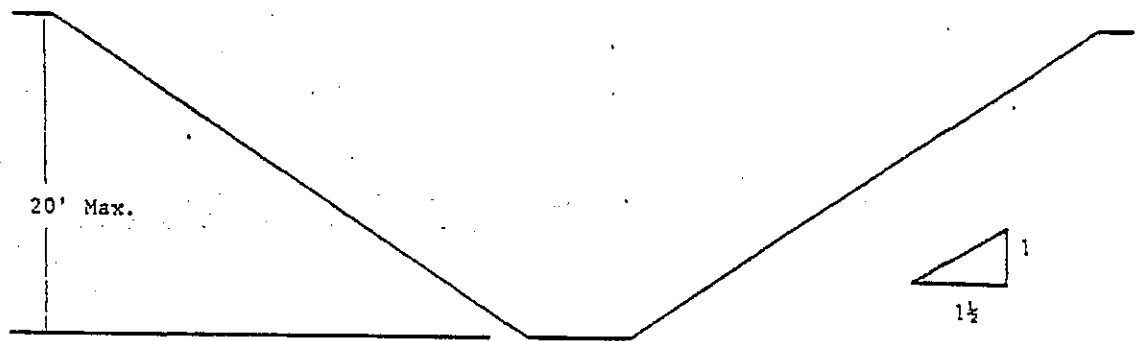


VERTICALLY SIDED LOWER PORTION

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

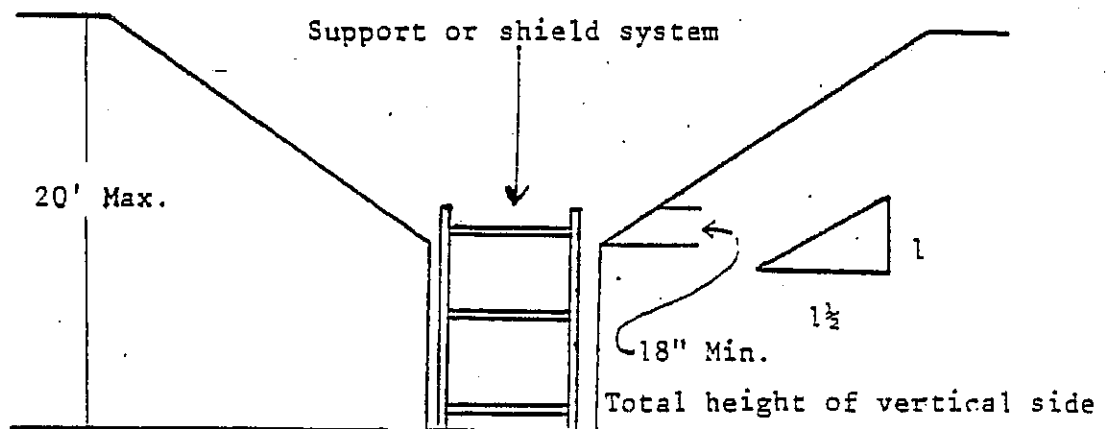
B-1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of $1\frac{1}{2}:1$.



SIMPLE SLOPE

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of $1\frac{1}{2}:1$.

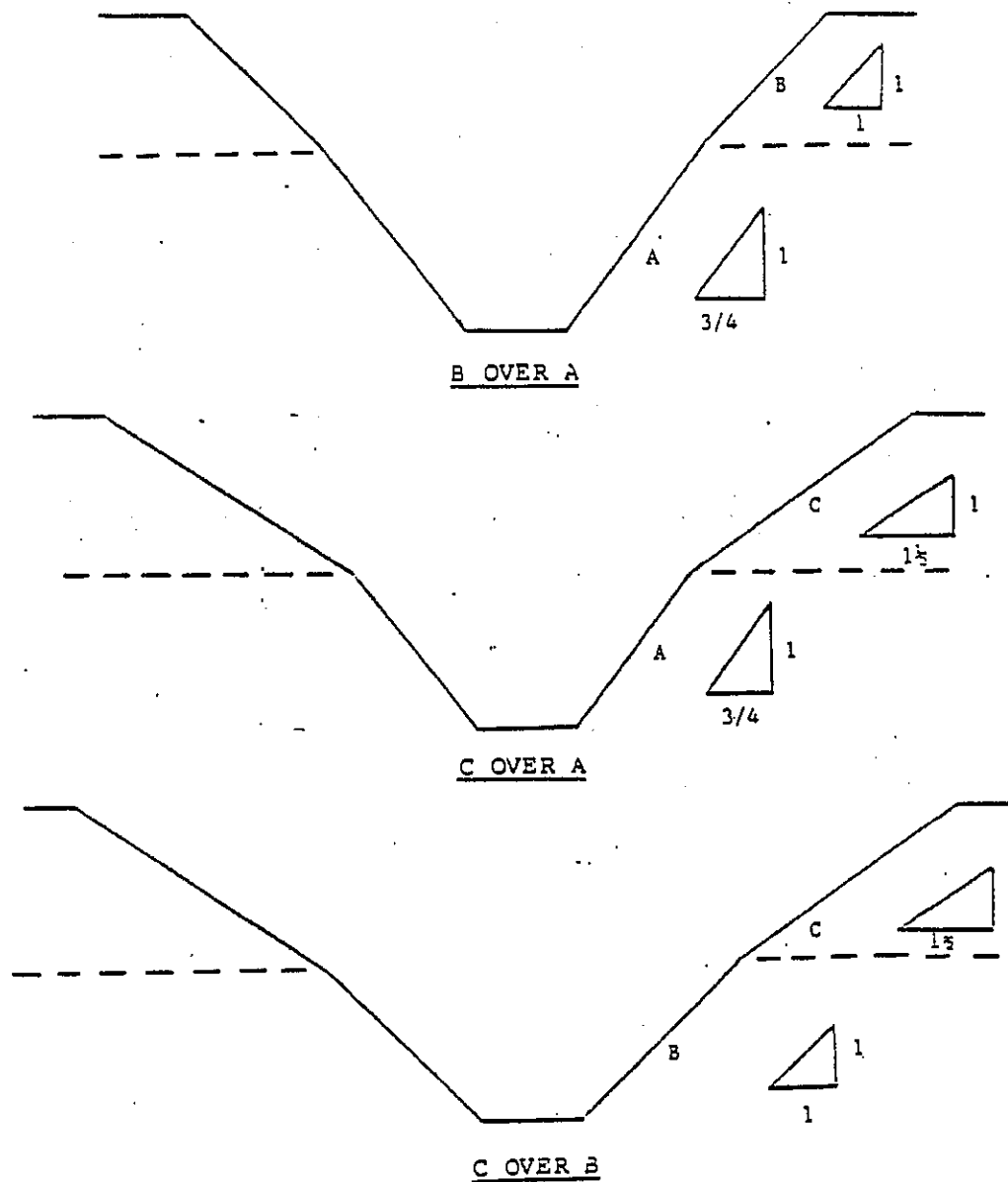


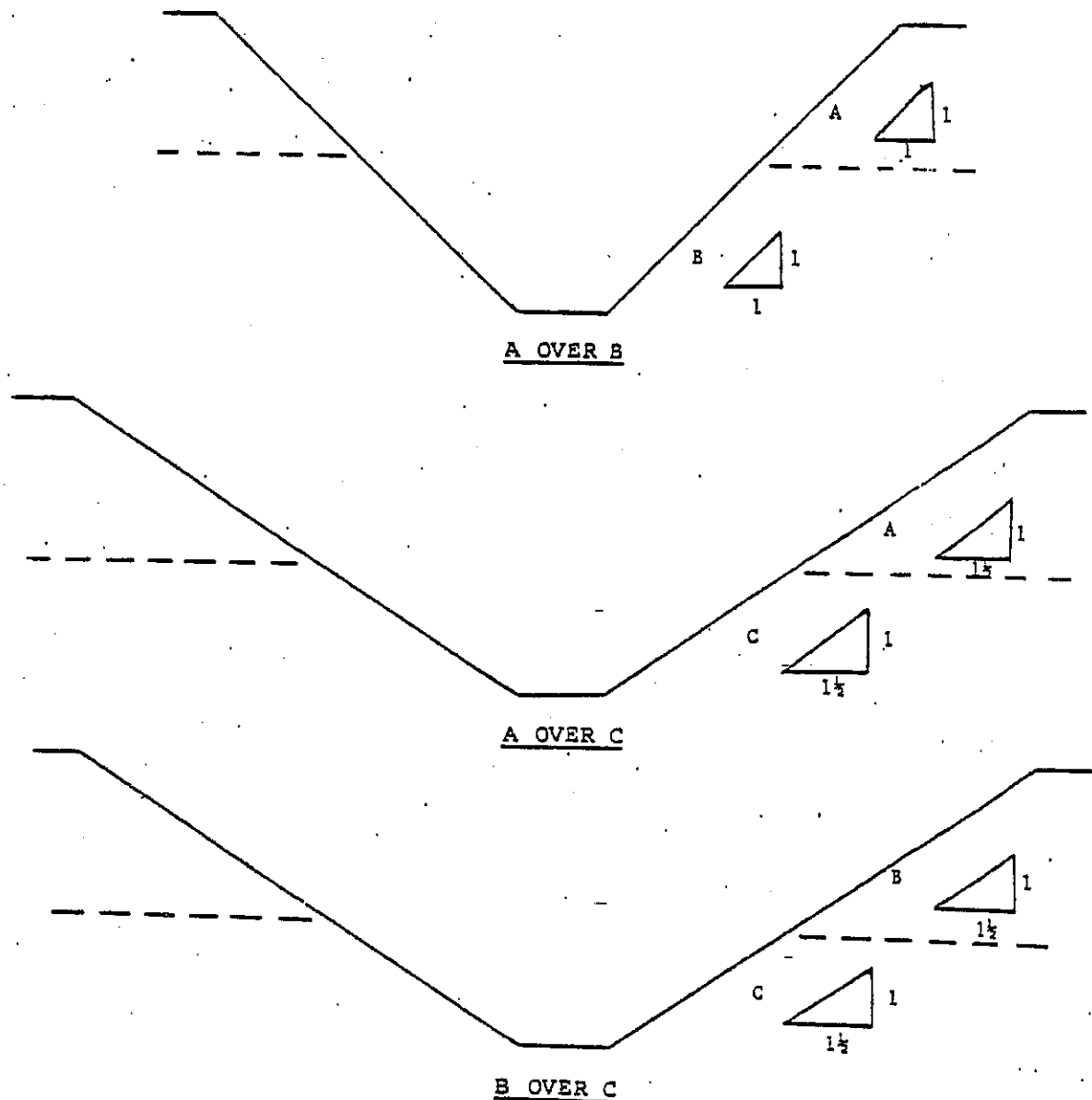
VERTICAL SIDED LOWER PORTION

3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.4 Excavations Made in Layered Soils

1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.





2. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

APPENDIX C TO SUBPART P—TIMBER SHORING FOR TRENCHES

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with § 1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such

as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in § 1926.652(b) and § 1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2, and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following

paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.

(d) *Basis and limitations of the data.*—(1) *Dimensions of timber members.* (i) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under § 1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.* (i) It is not intended that the timber shoring specifications apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with § 1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables.* The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) *Examples to Illustrate the Use of Tables C-1.1 through C-1.3.*

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide.

From Table C-1.1, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4×4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3×8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4×6 crossbraces at eight feet horizontally and four feet vertically.

Space 8×8 wales at four feet vertically.

Space 2×6 uprights at four feet horizontally.

Arrangement #3

Space 6×6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8×10 wales at four feet vertically.

Space 2×6 uprights at five feet horizontally.

Arrangement #4

Space 6×6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10×10 wales at four feet vertically.

Space 3×8 uprights at six feet horizontally.

(2) Example 2.

A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1

Space 6×6 crossbraces at six feet horizontally and five feet vertically.

Space 8×8 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #2

Space 6×8 crossbraces at eight feet horizontally and five feet vertically.

Space 10×10 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #3

Space 8×8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Space 2×6 uprights at two feet vertically.

(3) Example 3.

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8×8 crossbraces at six feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Position 2×6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8×10 crossbraces at eight feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Position 2×6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) Example 4.

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8×10 crossbraces at six feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Use 3×6 tight sheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) Notes for all Tables.

1. Member sizes at spacings other than indicated are to be determined as specified in §1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A $P_a = 25 \times H + 72 \text{ psf}$ (2 ft Surcharge)

SIZE (ACTUAL) AND SPACING OF MEMBERS **																
DEPTH OF TRENCH (FEET)	CROSS BRACES						MALES		VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	UPRIGHTS				
	WIDTH OF TRENCH (FEET)						VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)								
	HORIZ. SPACING (FEET)	UP TO														
		4	6	9	12	15										
5 TO	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	---	Not Req'd	---						8
	UP TO 8	4X4	4X4	4X6	6X6	6X6	4	---	Not Req'd	---				2X6		2X8
10	UP TO 10	4X6	4X6	4X6	6X6	6X6	4		8X8	4			2X6			
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4		8X8	4				2X6		
10 TO	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	---	Not Req'd	---					3X8	
	UP TO 8	4X6	4X6	6X6	6X6	6X6	4		8X8	4		2X6				
15	UP TO 10	6X6	6X5	6X6	6X8	6X8	4		8X10	4			2X6			
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4		10X10	4				3X8		
15 TO	UP TO 6	6X6	6X6	6X6	6X8	6X8	4		6X8	4	3X6					
	UP TO 8	6X6	6X6	6X6	6X8	6X8	4		8X8	4	3X6					
20	UP TO 10	8X8	8X8	8X8	8X8	8X10	4		8X10	4	3X6					
	UP TO 12	8X8	8X8	8X8	8X8	8X10	4		10X10	4	3X6					
OVER 20																
SEE NOTE 1																

SEE NOTE 1

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-1.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P_a = 45 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**										
	CROSS BRACES					WALES			UPRIGHTS		
	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)		
	HORIZ. SPACING (FEET)	UP TO 4	UP TO 6	UP TO 9	UP TO 12				CLOSE	2	3
5	UP TO 6	4X6	4X6	6X6	6X6	5	6X8	5			
TO	UP TO 8	6X6	6X6	6X6	6X8	5	8X10	5			2X6
10	UP TO 10	6X6	6X6	6X6	6X8	5	10X10	5			2X6
	See Note 1										
10	UP TO 6	6X6	6X6	6X6	6X8	5	8X8	5		2X6	
TO	UP TO 8	6X8	6X8	6X8	8X8	5	10X10	5		2X6	
15	UP TO 10	8X8	8X8	8X8	8X10	5	10X12	5		2X6	
	See Note 1										
15	UP TO 6	6X8	6X8	6X8	8X8	5	8X10	5	3X6		
TO	UP TO 8	8X8	8X8	8X8	8X10	5	10X12	5	3X6		
20	UP TO 10	8X10	8X10	8X10	10X10	5	12X12	5	3X6		
	See Note 1										
OVER 20	SEE NOTE 1										

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C P = 80 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**											UPRIGHTS		
	CROSS BRACES						VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) (See Note 2)				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)								CLOSE				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15								
5 TO 10	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	2X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6				
10 TO 15	See Note 1													
	UP TO 6	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6				
	UP TO 8	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6				
15 TO 20	See Note 1													
	See Note 1													
	UP TO 6	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
OVER 20	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed Oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *
 SOIL TYPE A P_a = 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (SIZES) AND SPACING OF MEMBERS **									
	CROSS BRACES					HALES		UPRIGHTS		
	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)		
	HORIZ. SPACING (FEET)	UP TO 4	UP TO 6	UP TO 9	UP TO 12			CLOSE	4	5
5	UP TO 6	4X4	4X4	4X4	4X4	4	Not Req'd			
TO	UP TO 8	4X4	4X4	4X4	4X6	4	Not Req'd			
10	UP TO 10	4X6	4X6	4X6	6X6	4	8X8		4X6	
	UP TO 12	4X6	4X6	4X6	6X6	4	8X8			4X6
10	UP TO 6	4X4	4X4	4X4	6X6	4	Not Req'd			4X10
TO	UP TO 8	4X6	4X6	4X6	6X6	4	6X8		4X6	
15	UP TO 10	6X6	6X6	6X6	6X6	4	8X8			
	UP TO 12	6X6	6X6	6X6	6X6	4	8X10		4X6	4X10
15	UP TO 6	6X6	6X6	6X6	6X6	4	6X8			
TO	UP TO 8	6X6	6X6	6X6	6X6	4	8X8			
20	UP TO 10	6X6	6X6	6X6	6X6	4	8X10			
	UP TO 12	6X6	6X6	6X6	6X6	4	8X12		4X12	
OVER 20										

SEE NOTE 1

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P = 45 X H ÷ 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **										
	CROSS BRACES					MALES		UPRIGHTS			
	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)			
	HORIZ. SPACING (FEET)	UP TO 4	UP TO 6	UP TO 9	UP TO 12			CLOSE	2	3	4
5	UP TO 6	4X6	4X6	4X6	6X6	5	6X8			3X12 4X8	4
TO	UP TO 8	4X6	4X6	6X6	6X6	5	8X8		3X8		4X8
10	UP TO 10	4X6	4X6	6X6	6X8	5	8X10			4X8	
	See Note 1										
10	UP TO 6	6X6	6X6	6X6	6X8	5	8X8		3X6	4X10	
TO	UP TO 8	6X8	6X8	6X8	8X8	5	10X10		3X6	4X10	
15	UP TO 10	6X8	6X8	8X8	8X8	5	10X12		3X6	4X10	
	See Note 1										
15	UP TO 6	6X8	6X8	6X8	8X8	5	8X10		4X6		
TO	UP TO 8	6X8	6X8	6X8	8X8	5	10X12		4X6		
20	UP TO 10	8X8	8X8	8X8	8X8	5	12X12		4X6		
	See Note 1										
OVER 20	SEE NOTE 1										

* Douglas Fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P_a = 80 \text{ X H} \div 72 \text{ psf}$ (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S&S) AND SPACING OF MEMBERS **										UPRIGHTS	
	GROSS BRACES					MALES					MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)	
	HORIZ. SPACING (FEET)		WIDTH OF TRENCH (FEET)			VERT. SPACING (FEET)		SIZE (IN)		VERT. SPACING (FEET)		CLOSE
	UP	TO	UP	TO	UP	UP	TO	UP	TO	UP	TO	
5 TO 10	UP	TO	4	6	9	12	15	8X8	5	8X8	5	3X6
	UP	TO	6X6	6X6	6X6	6X6	8X8	8X8	5	10X10	5	3X6
	UP	TO	6X6	6X6	8X8	8X8	8X8	8X8	5	10X12	5	3X6
	See Note 1											
10 TO 15	UP	TO	6X8	6X8	6X8	8X8	8X8	8X8	5	10X10	5	4X6
	UP	TO	8X8	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6
	See Note 1											
	See Note 1											
15 TO 20 OVER 20	UP	TO	8X8	8X8	8X8	8X10	8X10	8X10	5	10X12	5	4X6
	See Note 1											
	See Note 1											
	See Note 1											
SEE NOTE 1												

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

APPENDIX D TO SUBPART P—ALUMINUM HYDRAULIC SHORING FOR TRENCHES

(a) *Scope.* This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with § 1926.652(c)(2).

(b) *Soil Classification.* In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables D-1.1, D-1.2, D-1.3 and D-1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D-1.2 are for vertical shores in Types A and B soil. Tables D-1.3 and D-1.4 are for horizontal waler systems in Types B and C soil.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations (footnotes) regarding Table D-1.1 through D-1.4 are presented in paragraph (g) of this appendix.

(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring; Typical Installations."

(d) *Basis and limitations of the data.*

(1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D-1 Tables. Aluminum material is 6061-T6 or material of equivalent strength and properties.

(2) Hydraulic cylinders specifications. (i) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working ca-

capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) *Limitation of application.*

(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with § 1926.652.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables D-1.1, D-1.2, D-1.3 and D-1.4.* The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D-1.1 and D-1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D-1.3 and D-1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

*(f) Example to Illustrate the Use of the Tables:**(1) Example 1:*

A trench dug in Type A soil is 8 feet deep and 3 feet wide. From Table D-1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:

A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per footnote (g)(7) to the D-1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D-1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D-1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c.

vertically. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) Footnotes, and general notes, for Tables D-1.1, D-1.2, D-1.3, and D-1.4.

(1) For applications other than those listed in the tables, refer to § 1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to § 1926.652(c)(2) and § 1926.652(c)(3).

(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5×3.5×0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities. (i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.

(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch. thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) See appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See appendix D, item (d), for basis and limitations of the data.

ALUMINUM HYDRAULIC SHORING TYPICAL INSTALLATIONS

FIGURE NO. 1
VERTICAL ALUMINUM
HYDRAULIC SHORING
(SPOT BRACING)

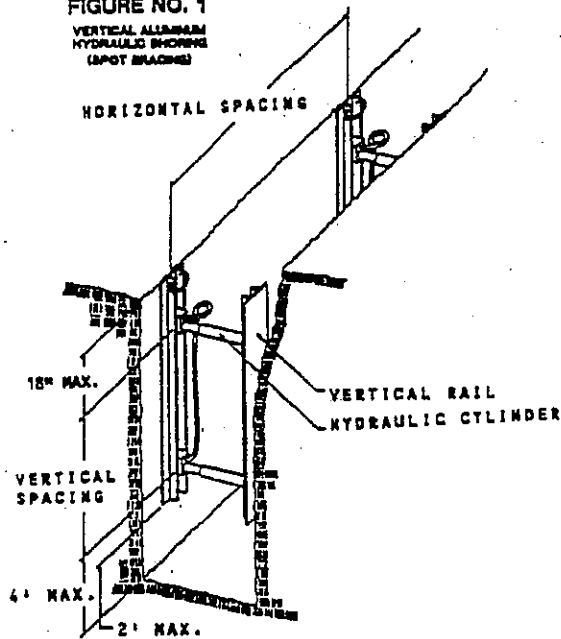


FIGURE NO. 2
VERTICAL ALUMINUM
HYDRAULIC SHORING
(WITH PLYWOOD)

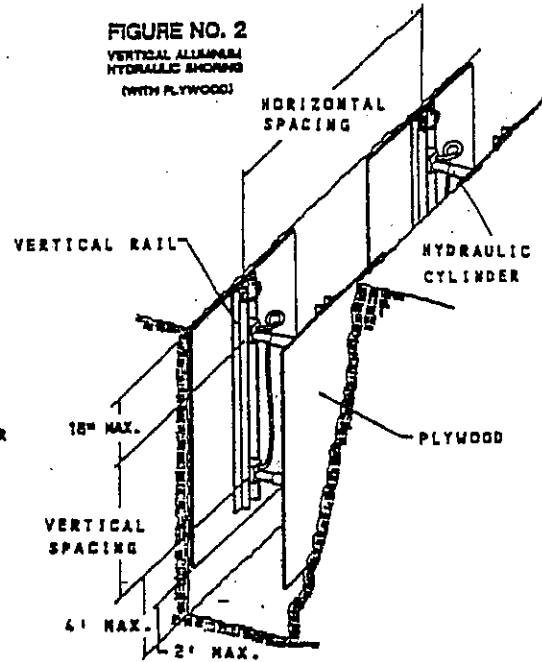


FIGURE NO. 3
VERTICAL ALUMINUM
HYDRAULIC SHORING
(STACKED)

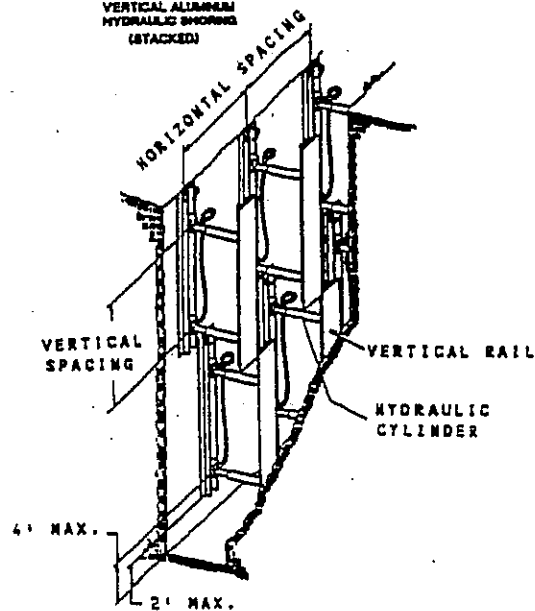


FIGURE NO. 4

ALUMINUM HYDRAULIC SHORING
WALER SYSTEM
(TYPICAL)

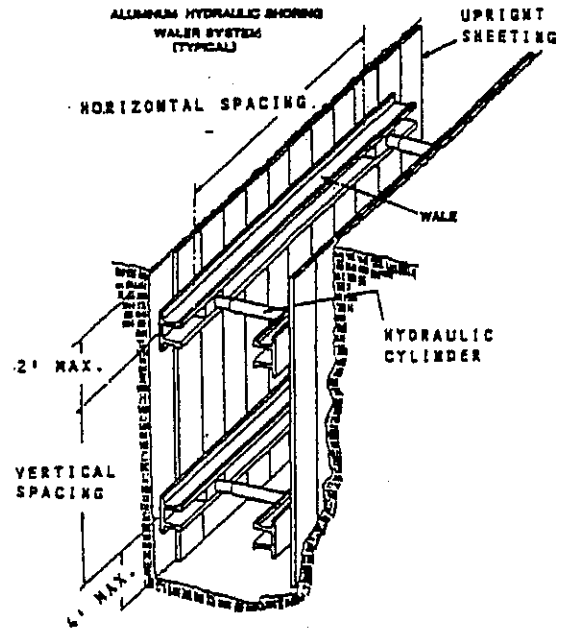


TABLE D - I.I
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE A

HYDRAULIC CYLINDERS				
DEPTH OF TRENCH (FEET)	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)	
			UP TO 8	OVER 8 UP TO 12
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)
OVER 10 UP TO 15	8			
OVER 15 UP TO 20	7			
OVER 20	NOTE (1)			

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Note (1): See Appendix D, Item (g) (1)

Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.2
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

HYDRAULIC CYLINDERS					
DEPTH OF TRENCH (FEET)	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	6.5				
OVER 15 UP TO 20	5.5				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Note (1): See Appendix D, Item (g) (1)

Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.3
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS							TIMBER UPRIGHTS		
	VERTICAL SPACING (FEET)	SECTION MODULUS (IN ³)	WIDTH OF TRENCH (FEET)							MAX. HORIZ. SPACING (ON CENTER)		
			UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15			SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN	8.0	2 IN	3 IN			
		7.0	9.0	2 IN	9.0	NOTE(2)	9.0	NOTE(2)	3 IN			3x12
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN	6.0	2 IN	3 IN		3x12	
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN	5.5	2 IN	3 IN			
		7.0	6.0	3 IN	6.0	NOTE(2)	6.0	3 IN	3 IN	3x12		
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN	3 IN			
OVER 20	NOTE (1)											

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Notes (1): See Appendix D, item (g) (1)

Notes (2): See Appendix D, Item (g) (2)

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

TABLE D - 1.4
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE C

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
	VERTICAL SPACING (FEET)	SECTION MODULUS (IN ³)	WIDTH OF TRENCH (FEET)						MAX. HORIZ. SPACING (ON CENTER)		
			UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN			
		7.0	6.5	2 IN	6.5	2 IN NOTE(2)	6.5	3 IN	3x12		
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE(2)	4.0	3 IN			
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN	3x12		
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE(2)	3.5	3 IN			
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN	3x12		
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)

Notes (1): See Appendix D, item (g) (1)

Notes (2): See Appendix D, Item (g) (2)

* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

APPENDIX E TO SUBPART P—ALTERNATIVES TO TIMBER SHORING

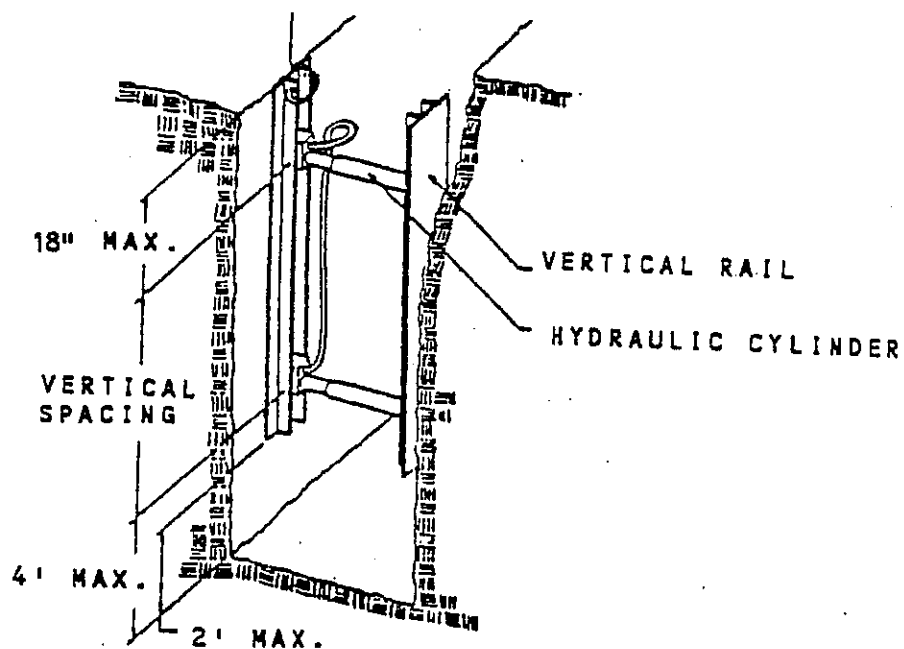


Figure 1. Aluminum Hydraulic Shoring

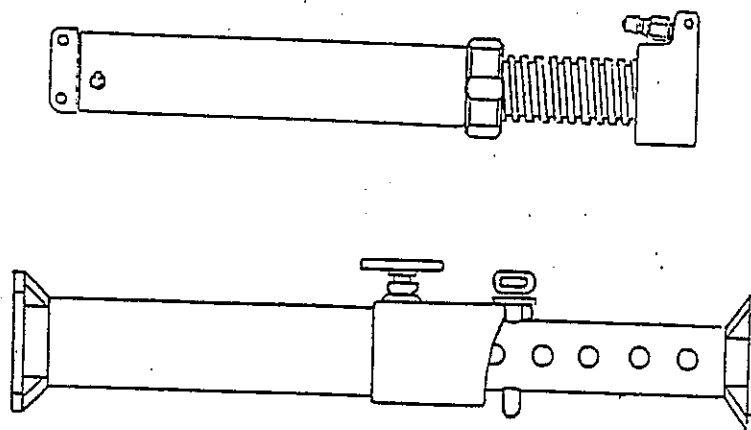


Figure 2. Pneumatic/hydraulic Shoring

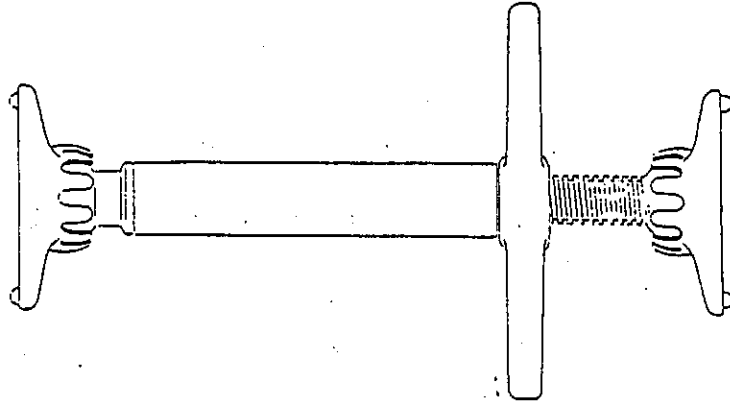


Figure 3. Trench Jacks (Screw Jacks)

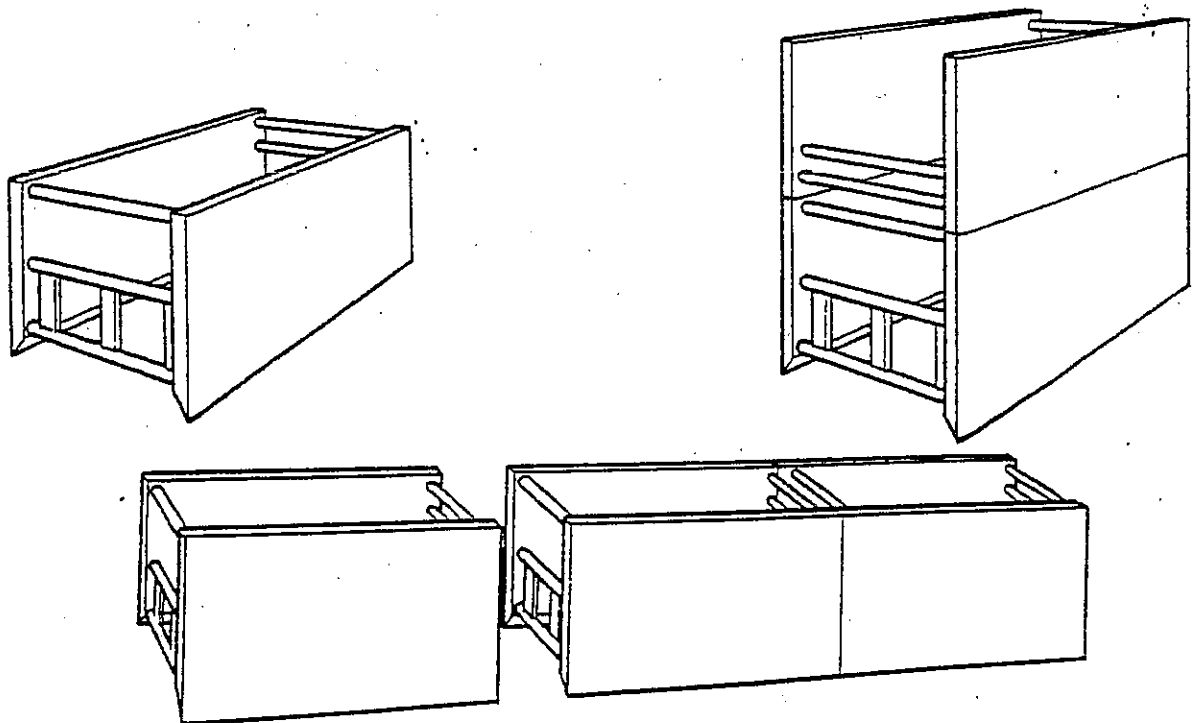


Figure 4. Trench Shields

APPENDIX F TO SUBPART P—SELECTION OF PROTECTIVE SYSTEMS

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with § 1926.652 (b) and (c).

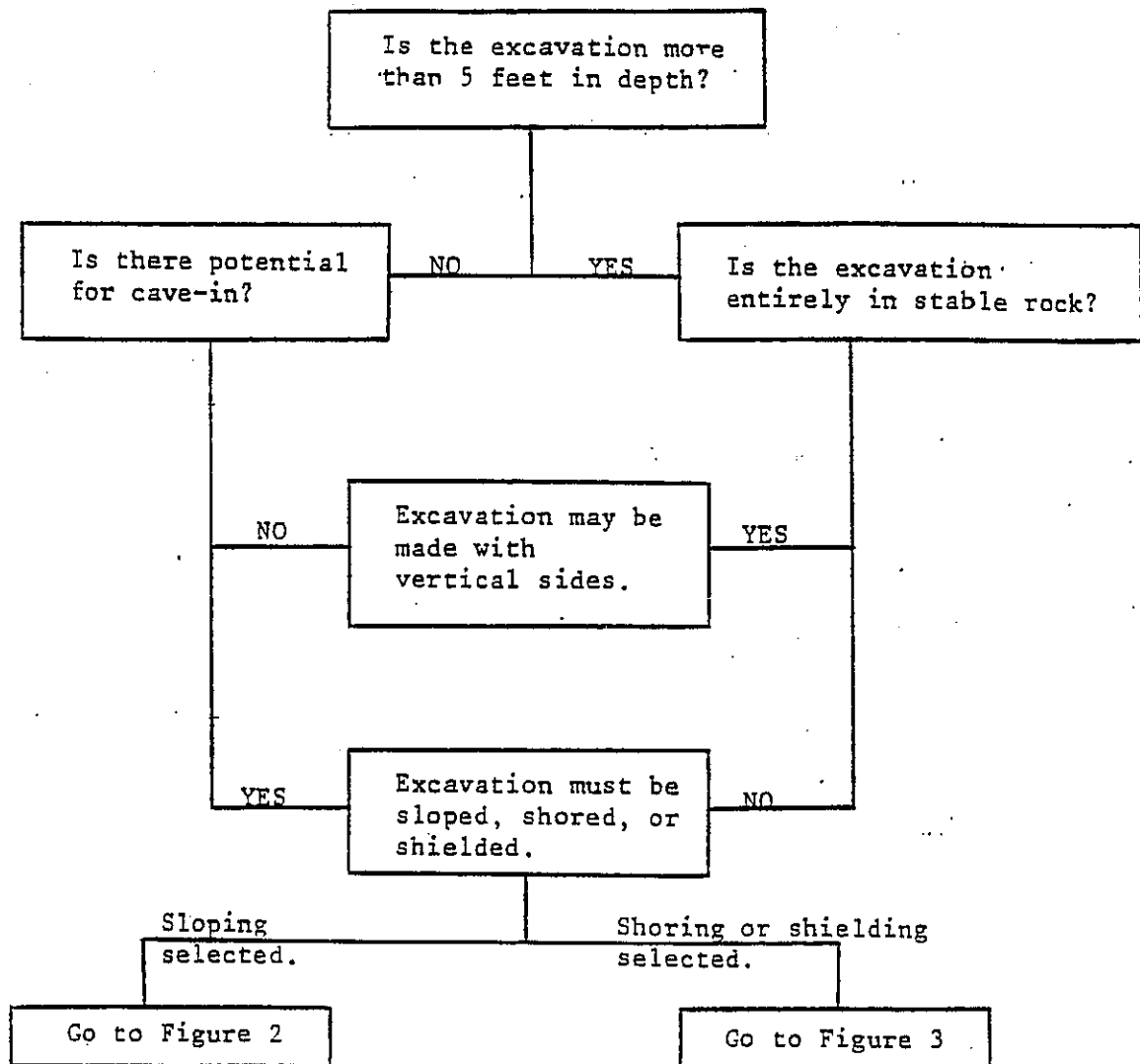
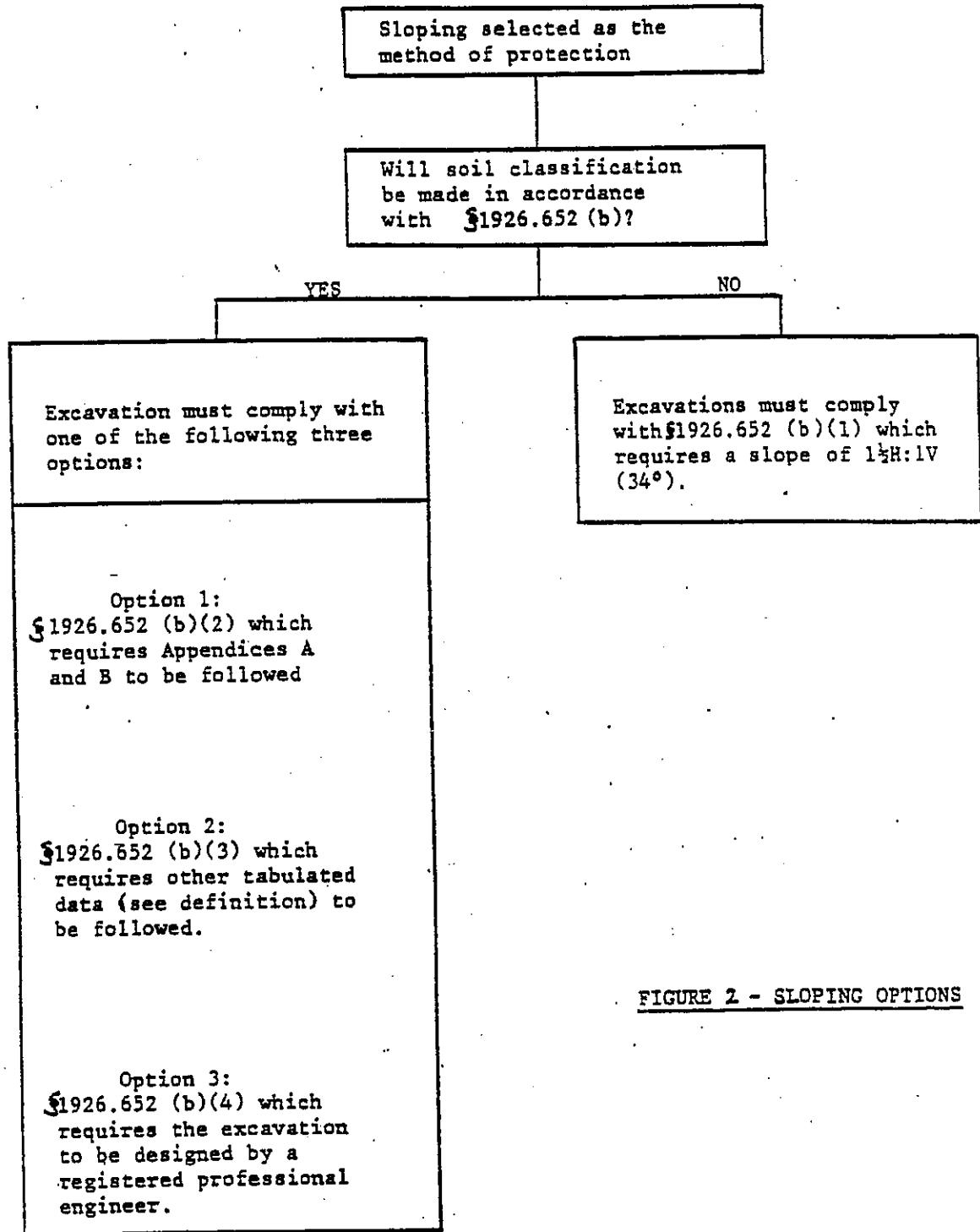


FIGURE 1 - PRELIMINARY DECISIONS

FIGURE 2 - SLOPING OPTIONS

Shoring or shielding selected
as the method of protection.

Soil classification is required
when shoring or shielding is
used. The excavation must comply
with one of the following four
options:

Option 1

§1926.652 (c)(1) which requires
Appendices A and C to be followed
(e.g. timber shoring).

Option 2

§1926.652 (c)(2) which requires
manufacturers data to be followed
(e.g. hydraulic shoring, trench
jacks, air shores, shields).

Option 3

§1926.652 (c)(3) which requires
tabulated data (see definition)
to be followed (e.g. any system
as per the tabulated data).

Option 4

§1926.652 (c)(4) which requires
the excavation to be designed
by a registered professional
engineer (e.g. any designed
system).

FIGURE 3 - SHORING AND SHIELDING OPTIONS