

**MEMORANDUM FOR RECORD****SUBJECT**

Fargo-Moorhead Metropolitan Area Flood Risk Management Project – MFR-010 Utility Relocation Requirements – **Revision 01**

**Original Document Date: April 16, 2012**

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**REFERENCE**

EM 1110-2-1913, Design and Construction of Levees

**PURPOSE OF THIS MFR**

This memorandum discusses general requirements for utility relocations within the FMM Flood Risk Management Project. These requirements will aid impacted utility owners in developing a relocation plan. These requirements are general; each proposed utility relocation shall be reviewed by the Corps of Engineers (COE) on a case-by-case basis.

The proposed diversion project consists of a wide, deep diversion channel flanked on both sides by excavated material berms (Berms) and drainage channels. In addition, a levee will be included within the right bank (facing downstream) berm. To facilitate project completion, all existing utilities within the project work limits shall be either temporarily or permanently relocated outside grading limits prior to the start of construction activities. Utilities not permanently relocated prior to construction, shall be relocated after substantial completion of project features or during construction with prior COE approval.

This memorandum does not discuss proposed utility crossings of “Tieback Embankments” near the diversion inlet on the upstream end of the project. Requirements for these crossings will be discussed in a separate Memorandum for Record.

**RESPONSIBILITIES**

The COE shall be responsible for the flood diversion project design, identification of potential utility conflicts and for review and comment on utility relocation plans. The Local Sponsor shall be responsible for coordination with utility owners impacted by the proposed project and insuring that utility relocation plans are developed in a timely manner to insure relocations and abandonments are completed prior to diversion channel construction. The COE design schedule requires submittal of preliminary utility relocation plans a minimum of 30 days prior to the applicable diversion channel reach 65% design completion date.

**ALIGNMENT**

Utility owners shall develop a plan for relocation of utilities (electric, water, sewer,

communication, gas, etc.) that cross or lie within the limits of the proposed work. Utility companies shall submit proposed utility relocation plans to the COE for review and comment prior to utility relocation construction. It is desired that the number of utility crossing locations be minimized, so the use of utility corridors where multiple utilities cross on the same general location, is encouraged. If possible, all proposed utility crossings shall be aligned to cross perpendicular to the channel centerline at the crossing location. Variations to the crossing angle may be dictated by field conditions and the location of connecting utilities. Final crossing location and orientation relative to the proposed channel alignment shall be approved by the COE during project design stages.

Because of the large project footprint, and the need to keep the footprint clear of encroachments, overhead utility crossings within project limits will be limited to utility corridors at bridge locations. This requirement may be waived for electrical transmission lines where relocation to corridors at bridge crossings would be considered impractical due to cost or other considerations. All overhead utility crossings and relocations within the limits of the project shall be approved by the COE prior to construction.

## **ABANDONMENT AND REMOVAL**

Responsible utility companies shall disconnect, cap and abandon existing underground utility lines located within the project limits. Abandoned underground utility lines will be removed as necessary by the Flood Risk Management Project construction Contractor. Underground utility lines not scheduled for removal by the Contractor, shall be capped and grouted in place. Abandoned underground lines may be removed by the utility owner prior to construction with approval of the COE. Overhead utility lines and poles shall be removed from project limits by the responsible utility owner prior to construction.

## **CONSTRUCTION**

### **1. Diversion Channel Crossings**

- a. **Depth:** The depth of channel excavation for most areas of the project exceeds 20 feet at channel center. It is anticipated that some erosion of the channel may occur and an assumption that 5 feet of erosion occurs shall be used when locating the minimum elevation of the utilities. Heavy equipment will operate within the channel during construction and during future maintenance activities. To protect utilities from erosion and equipment surface loads, utilities crossing below the channel should be located a minimum of 10 feet below the low flow channel invert. Utilities susceptible to freezing (water & sewer) shall be located a minimum of 12.5 feet below the low flow channel invert.
- b. **Method of Construction:** Utilities placed in this area can be directionally drilled or open cut.
  - i. When installed using an open cut, bedding of utility lines within the pipe zone shall be in accordance with State and Local guidance/regulations. Backfill above

the pipe zone shall consist of material excavated for utility placement. At a minimum, the COE requires backfill to be compacted to 90% maximum density. It is suggested that laboratory tests for moisture-density relations be made in accordance with ASTM D698 (Standard Proctor); and field density tests be determined in accordance with ASTM D 2167 (Rubber Balloon Method) or ASTM D 6938 (Nuclear Method), the density test results shall be verified by performing an ASTM D 1556 density test at the start of the job and for every 10 ASTM D 6938 density tests.

- ii. When installed using directional drilling, drilling practices shall be in accordance with ASTM F 1962. On the right bank (looking downstream) side of the channel, there shall be no pipe entry/exit locations (pits) within 50' of either toe of the proposed levee. On the left bank side of the channel, there shall be no pipe entry/exit locations within the following distances from the channel side toe of the left bank EMB:  
50' on the diversion channel (right) side,  
200' on the EMB (left) side.

- c. Calculations are required to show that the line has adequate strength/flexibility to withstand heavy equipment loading during construction and possible future channel maintenance. In addition, the bottom of the channel may rebound due to the excavation of the diversion channel. Calculations are required to show that the line has adequate strength/flexibility to withstand expected rebound.

## 2. Levee Crossings

- a. Method of Construction: Both open cut and horizontal directional drilling are acceptable methods.
  - i. If open cut is utilized, the trench shall extend beneath and 20' beyond the proposed levee prism. At the COE's discretion, the new utility line may be required to be encased in Controlled Low-Strength Material (CLSM) (specification attached). When CLSM is required, the new utility line shall be placed on firm ground at the bottom of the trench and CLSM shall be placed in the trench to 1 foot above the top of pipe. The trench above the CLSM shall be backfilled with material excavated from the trench. At a minimum, the COE requires backfill to be compacted to 90% maximum density. It is suggested that laboratory tests for moisture-density relations be made in accordance with ASTM D698 (Standard Proctor); and field density tests be determined in accordance with ASTM D 2167 (Rubber Balloon Method) or ASTM D 6938 (Nuclear Method), the density test results shall be verified by performing an ASTM D 1556 density test at the start of the job and for every 10 ASTM D 6938 density tests.
  - ii. If horizontal directional drilling is utilized, it shall be accomplished pursuant to the attached "Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling", June 2002 and the St. Paul District's

“Guidance Pertaining to Horizontal Directional Drilling Under a Flood Barrier/Channel.” There shall be no pipe entry/exit locations (pits) within 50’ of either toe of the proposed levee.

- b. Depth: Depth of lines shall be a minimum of 10 feet below existing ground.
- c. Geotechnical analyses indicate that foundation materials are generally cohesive materials not susceptible to piping. Calculations are required to show that the line has adequate strength/flexibility to withstand the expected loading/settlement. Levees will be up to 15 feet high and settlement of the foundation materials is expected.

3. Excavated Material Berm/Local Drainage Ditch Crossings (Below and 50 feet beyond the proposed Berm/Ditch)

- a. Method of Construction: Utilities placed in this area can be directionally drilled or open cut.
  - i. When installed using an open cut, bedding of utility lines within the pipe zone shall be accordance with State and Local guidance/regulations. Backfill above the pipe zone shall consist of material excavated for utility placement. At a minimum, the COE requires backfill to be compacted to 90% maximum density. It is suggested that laboratory tests for moisture-density relations be made in accordance with ASTM D698 (Standard Proctor); and field density tests be determined in accordance with ASTM D 2167 (Rubber Balloon Method) or ASTM D 6938 (Nuclear Method), the density test results shall be verified by performing an ASTM D 1556 density test at the start of the job and for every 10 ASTM D 6938 density tests.
  - ii. When installed using directional drilling, drilling practices shall be in accordance with ASTM F 1962.
- b. Depth: Depth of bury shall be set by the utility company assuming that the area under the material berm will be stripped of topsoil (average thickness 18” – 24”) prior to berm construction, and heavy equipment will be operated over the entire area. Excavated material berms will typically be constructed to a maximum height of 21 feet, but could possibly be higher in certain locations, and settlement of foundation materials is expected. Berms could possibly be excavated to existing ground at some point in the future. In addition, there will be local drainage ditches constructed along the outside toe of the berm; ditches may be constructed to a depth of 6 feet or more below grade. It is recommended that the depth of bury for utilities in this area be a minimum of 3.5 feet below stripped topsoil, and 3.5 feet below ditch inverts where utilities cross drainage ditches. In the case of water and sewer lines that must be protected from frost, the recommended minimum depth should be 7.5 feet below stripped topsoil depth and 7.5 feet below ditch inverts at ditch crossings.
- c. Calculations are required to show that each utility line has adequate strength/flexibility to

withstand the expected loading/settlement. Calculations will be site specific based upon EMB height. COE will provide design files that show proposed EMB height for use in design calculations.

#### 4. Other Areas

- a. Utility crossings for all areas not covered by levee, berm or channel crossing shall be designed to withstand heavy loading from construction equipment and shall meet minimum frost protection depths as required.
- b. Utilities running parallel to the channel alignment must be located a minimum of 20 feet outside the outer most toe of levee/berm/ditch as applicable.

5. Submittal Requirements: Note that the Corps may take up to 30 days to review and accept submittal documents. Acceptance is required before relocation construction commences.

- a. Alignments as described in paragraph ALIGNMENT above
- b. Design calculations (as necessary)
- c. Locations of utility line markers or above ground appurtenances
- d. Work Plan: Indicate the intended sequence of work. Describe how connection to existing utility line will be accomplished. Include the type of and number of pieces of equipment that will be used during construction. Include a schedule which outlines construction, testing and start-up dates.
- e. Testing reports:
  - i. Results of leak and/or burst test testing, and any other testing shall be submitted;
  - ii. When directional drilling is used submittals and testing referenced in “Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling”, Chapter 2, paragraph “Permit Application Submittal” will be required. (Please note that the utility will not be applying for a COE permit as mentioned in this document. For this project, the COE will be approving submittals in lieu of issuing a permit).
- f. Product Data-Materials: Pipe, valves, fittings & appurtenances.
- g. As-Built Drawings: Submit As-Built drawings for the complete utility line relocation showing complete detail, including trench dimensions, pipe profile, valve locations, connection box locations, manholes, etc..
- h. The Corps of Engineers shall be notified a minimum of 30 days prior to start of construction. COE may view and inspect the relocation during construction, and shall be allowed access to the site to perform such activities.
- i. Letter from designer of record verifying that project design meets all applicable governmental, COE and industry design standards.

### **RAPID CLOSURE VALVES**

The need for rapid closure valves is dependent upon the type of utility relocation. Generally, rapid closure valves will be required on each side of pressure pipe crossings. The purpose of the valves is to provide pipeline isolation in the event of leakage, rupture, repairs or relocation. The

rapid closure valves shall be located a minimum of 20 feet beyond the outermost project feature (i.e., levee, berm or drainage ditch).

### **CASING FOR UTILITY LINES**

It is recommended that all pressurized utility lines (sewer, water and gas) crossing under the channel and levee be cased. The use of casing pipe should also be considered for other utility crossings. In general, casing pipe material shall be limited to one that can be joined together continuously, while maintaining sufficient strength to resist the high tensile stresses imposed during the pullback operation. When used, the COE recommends the use of HDPE or steel pipe. All casing specifications shall be submitted to the COE for review and comment prior to installation.

Casings shall serve the following two purposes:

- 1) If a line ruptures under the project, the casing pipe protects the project from damage from the escaping fluids and;
- 2) If a line needs repair, the carrier pipe can be pulled and repaired/replaced, then installed back within the casing pipe; avoiding the need for excavation to repair utility lines.

### **MAINTENANCE AND ABANDONMENT PLAN**

Responsible utility owners shall prepare a maintenance and abandonment plan for all utilities located within the limits of the subject project. The plan shall address applicable facility maintenance, leakage, repair (if applicable) and abandonment. All piping shall be provided with metallic marking tape or other applicable passive marking system to facilitate utility location by field personnel for future maintenance and repair.

### **CROSSING IDENTIFICATION**

Color coded fiberglass service line marker posts shall be provided for all underground utilities at each crossing point (wet and dry side). Markers (Length 72"; width 1".) shall identify service lines, valves & underground property

### **AS BUILT REQUIREMENTS**

Utility owner shall provide As-Built plans and As-Built survey data to COE for all relocations within the limits of the subject project. As-Built drawings shall be submitted in electronic format (Microstation is preferred). SDSFIE-compliant survey point data shall be submitted in ASCII text or shape file format. FGDC-compliant metadata files shall be submitted which describes, in general, when the as-built survey was conducted, who conducted the survey, how it was conducted, and the accuracy of the survey data. Surveys should be done in the project spatial reference system:

NAD83 (NSRS2007), North Dakota State Plane Coordinate System, South Zone



## **ATTACHMENTS**

1. Guidance Pertaining to Horizontal Directional Drilling Under a Flood Barrier/Channel
2. Draft Controlled Low-Strength Material (CLSM) Specification
3. Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling.



## **ATTACHMENT 1**

Guidance Pertaining to Horizontal Directional Drilling Under a Flood Barrier/Channel

**GUIDANCE**  
**Pertaining to**  
**Horizontal Directional Drilling Under a Flood Barrier/Channel**

The following information and guidance pertains to horizontal directional drilling (HDD) under an engineered flood barrier (i.e floodwall, levee embankment, diversion channel).

The two primary concerns with horizontal directional drilling (HDD) beneath a levee or floodwall are:

1. Hydrofracturing (drilling fluid pressure exceeding the tensile strength of the soil) the foundation soils beneath the flood barrier during drilling operations.
2. Development of a preferential seepage path along the pipeline/utility after installation.

Generally, the COE would require the following information in the permit application for any utilities installed by HDD that pass beneath a flood barrier.

1. Proposed drill path alignment (both plan and profile views).
2. Location of entry and exit points.
3. Proposed depth of cover.
4. Diameter of the borehole, diameter of pipe and type of pipe to be installed, if used, or diameter of utility.
5. Proposed method to fill annulus.
6. Location, elevations, and clearances of all utility crossings and structures.

Based on our recent experience, we feel comfortable with the following recommendations/guidelines:

- Allow the Contractor to proceed without actively monitoring the drill pressures. Suggest that only fresh drilling mud be used. It may not be necessary to insist on this provision depending on the length of flood barrier to be traversed, however it will be easier to maintain a proper viscosity if clean mud is used.
- If “mud motor” HDD technology is used, hold the density of the drilling fluid as close as possible to 8.4 lbs/gallon (or 45seconds/quart in a Marsh Funnel).
- Bentonite can be used to fill the annulus.

- Generally, depth of burial should be at least 10 feet below grade where the utility passes under the flood barrier.
- Fluid jetting methods should not be used as a means of cutting beneath a flood protection project.
- The Contractor will be responsible for repairing any soil fracturing, drilling fluid reaching the surface, etc. as well as any slope failure resulting from the drilling process. The Contractor should note any spots where fluid loss occurs, and the COE should get a record of the amount of fluid loss as well as the location.
- Prior to commencing, the Contractor should explain their method for maintaining directional control during drilling operations. In other words, how will he/she verify where the bit is horizontally and vertically so that it does not accidentally wander beneath the levee foundation any more than absolutely necessary?
- The Contractor should provide an “as-built” drawing upon completion of the directional drilling and installation of the line. This drawing should include alignment & profile data.
- It should be plainly stated that any foundation or flood barrier damage resulting from the directional drilling will be repaired by the Contractor to City/Gov’t specifications at Contractor expense.
- The Contractor should be informed that the suspension of the requirement to actively monitor downhole pressures does not relieve them of the ultimate responsibility of leaving the flood barrier foundation in the same condition, as it was before the horizontal drilling procedure was undertaken.

**ATTACHMENT 2**

Draft Controlled Low-Strength Material (CLSM) Specification

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CONTROLLED LOW-STRENGTH MATERIAL (CLSM)  
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PART 1 GENERAL

1.1 REFERENCES

All publications referenced shall be the most current version, edition, standard, latest revision, or reapproval unless otherwise stated. The following publications and standards listed below will be referred to only by the basic designation thereafter, and shall form a part of this specification to the extent indicated by the references thereto:

ASTM INTERNATIONAL (ASTM)

ASTM C 33/C 33M	(2011a) Standard Specification for Concrete Aggregates
ASTM C 94	(2011b) Ready-Mixed Concrete
ASTM C 150	(2011) Standard Specification for Portland Cement
ASTM C 220	(1991; R 2009) Standard Specification for Flat Asbestos-Cement Sheets
ASTM C 618	(2008) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 685	(2010) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 940	(2010a) Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM D 4832	(2010) Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5971	(2007) Standard Practice for Sampling Freshly Mixed Controlled Low-Strength Material
ASTM D 6023	(2007) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)
ASTM D 6103	(2004) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)

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1.2 DESIGN REQUIREMENTS

Controlled Low-Strength Material (CLSM) mixture proportion shall consist of 100 pounds or less of portland cement plus fly ash per cubic yard; pozzolan; sand; water; and a fluidifier, if required to obtain the required slump. The CLSM fill mixture proportion shall have a flow consistency of more than 8 inches. The flow consistency shall be determined in accordance with ASTM D 6103. CLSM fill shall have a compressive strength of 100 psi at 28 days. The compressive strength of the CLSM shall be determined in accordance with ASTM D 4832 after being made and cured in accordance with ASTM D 4832. The mixture proportions shall be reported in accordance with ASTM C 94. If the CLSM is to be placed using a concrete pump, the mixture proportions shall be designed so that it will not segregate in the pump line under pressure or when there is an interruption in flow.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Data

On-Site Batching and Mixing

Water Reducing

Concrete Mixture Proportions

The Contractor shall submit manufacturer's literature from suppliers which demonstrates compliance with applicable specifications for all equipment and materials.

SD-07 Schedules

Placing

The methods and equipment for transporting, handling, and depositing the CLSM backfill and CLSM fill shall be submitted to the Contracting Officer prior to the first placement.

SD-08 Statements

Concrete Mixture Proportions

CLSM mixture proportions shall be the responsibility of the Contractor and shall be designed in accordance with the criteria in paragraph DESIGN REQUIREMENTS. Ten days prior to placement of CLSM, the Contractor shall submit to the Contracting Officer the mixture proportions that will produce CLSM of the qualities required. Mixture proportions shall include the dry weights of cementitious material(s); and saturated surface-dry weights of the fine aggregate; the quantities, types, and names of admixtures; and quantity of water per cubic yard of concrete. All materials included in the mixture proportions shall be of the same type and from the same source as will be used on the project.

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SD-09 Reports

CLSM Mixture Proportions Tests

Applicable test reports shall be submitted to verify that the CLSM mixture proportions selected will produce CLSM of the quality specified. The results of all tests and inspections conducted at the project site shall be reported informally at the end of each shift and in writing weekly and shall be delivered to the Contracting Officer within 3 days after the end of each weekly reporting period.

SD-13 Certificates

Cement

Cementitious Material will be accepted on the basis of a manufacturer's certificate of compliance.

Aggregates

Aggregates will be accepted on the basis of certificate of compliance that the aggregates meet the requirements of the specifications under which it is furnished.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Ready-Mixed Concrete

Ready-mixed concrete shall conform to ASTM C 94, except as otherwise specified.

2.1.1.1 Volumetric Batching and Continuous Mixing

Volumetric batching and continuous mixing shall conform to ASTM C 685.

2.1.1.2 On-Site Batching and Mixing

The Contractor shall have the option of using an on-site batching and mixing facility. The method of measuring materials, batching operation, and mixer shall be submitted for review by the Contracting Officer. On-site plant shall conform to the requirements of either ASTM C 94 or ASTM C 685.

2.1.2 Portland Cement

Portland Cement shall conform to ASTM C 150, Type I or II, low alkali.

2.1.3 Pozzolan

Pozzolan shall be Class F or C fly ash conforming to ASTM C 618.

2.1.4 Sand

Sand shall meet the requirements of fine aggregate of ASTM C 33/C 33M.



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2.1.5 Fluidifier

The fluidifier shall give the CLSM fill the following salient characteristics:

- a. must have less than 1 percent bleed water in accordance with ASTM C 940
- b. have an initial set time of more than 5 hours in accordance with ASTM C 220 modified by using a Ferioli apparatus
- c. have a flow consistency equal to or more than 8 inches in accordance with ASTM D 6103
- d. have a compressive strength of 100 psi at 28 days in accordance with ASTM D 4832
- e. maintain a homogeneous mixture during pumping
  1. Quantity of admixture(s) required in the mixture proportion is governed by the salient characteristics specified.
  2. The admixture shall be added as directed by the manufacturer, in most cases it added to the CLSM at the job site and mixed for a minimum of 5 minutes at mixing speed.

2.1.6 Water

Water shall be potable water that is fresh, clean, and free from sewage, oil, acid, alkali, salts, or organic matter.

2.2 MIXING AND TRANSPORTING

The CLSM shall be mixed and transported in accordance with ASTM C 94.

PART 3 EXECUTION

3.1 TRENCH PREPARATION

Once the trench has been dug it shall be cleaned of all loose material and debris to the satisfaction of the Contracting Officer before any CLMS fill is placed. The new utility pipeline shall be placed on firm ground at the bottom of the trench and a minimum of 1 foot of CLSM fill shall be placed above the top of the pipeline. The pipeline shall be securely anchored to maintain its position and prevent it from any movement during placement of the CLSM.

3.2 PLACEMENT

3.2.1 General

CLSM placement shall not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement. When CLSM is mixed and/or transported by a truck mixer, the CLSM shall be delivered to the site of the work and discharge shall be completed within 1-1/2 hours (or 45 minutes when the placing temperature is 85 degrees F or greater unless a retarding admixture is used). The fluidifier shall not be added to the Ready Mix trucks until they have arrived onsite. The fluidifier shall be added to each truck at the proper dosage rate and mixed

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for 5 minutes and no more than 15 minutes before it is placed. CLSM shall be conveyed from the mixer to point of placement as rapidly as practicable by methods which prevent segregation or loss of ingredients.

### 3.2.2 Consolidation

Consolidation of the CLSM will not be required.

## 3.3 TESTS

### 3.3.1 General

The individuals who sample and test CLSM as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to ACI minimum guidelines for certification of concrete Field Testing Technicians, Grade I.

### 3.3.2 Inspection Details and Frequency of Testing

#### 3.3.2.1 Flow Consistency

Flow consistency shall be checked once during each shift that CLSM is produced for each class of concrete required. Samples shall be obtained in accordance with ASTM D 5971 and tested in accordance with ASTM D 6103. Whenever a test result is outside the specifications limits, the CLSM shall not be delivered to the placement and an adjustment should be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the water-cement ratio does not exceed that specified in the submitted CLSM mixture proportion.

#### 3.3.2.2 Compressive-Strength Specimens

At least one set of test specimens shall be made each day on CLSM placed during the day or every 10 cubic yards placed. Additional sets of test cylinders shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths are detected. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is accomplished in a completely random and unbiased manner. A set of test specimens for concrete with strength as specified in paragraph DESIGN REQUIREMENTS shall consist of six cylinders, one tested at 7 days, one tested at 14 days, and two tested at 28 days. Two cylinders shall be tested as directed. Test specimens shall be molded and cured in accordance with ASTM D 4832 and tested in accordance with ASTM D 4832. All compressive strength tests shall be reported immediately to the Contracting Officer.

### 3.3.3 Density

At least one set of test specimens shall be made each day on CLSM placed during the day or every 20 cubic yards placed. A random sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is accomplished in a completely random and unbiased manner. Test procedures and calculations shall be in accordance with ASTM D 6023.

### 3.3.4 Reports

The Contractor shall prepare reports of all tests and inspections conducted

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at the project site.

-- End of Section --

## **ATTACHMENT 3**

Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling

ERDC/GSL TR-02-9

Geotechnical and Structures  
Laboratory



**US Army Corps  
of Engineers®**  
Engineer Research and  
Development Center

# **Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling**

Carlos A. Latorre, Lillian D. Wakeley, and  
Patrick J. Conroy

June 2002

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# **Guidelines for Installation of Utilities Beneath Corps of Engineers Levees Using Horizontal Directional Drilling**

by Carlos A. Latorre, Lillian D. Wakeley

Geotechnical and Structures Laboratory  
U.S. Army Engineer Research and Development Center  
3909 Halls Ferry Road  
Vicksburg, MS 39180-6199

Patrick J. Conroy

U.S. Army Engineer District, St. Louis  
1222 Spruce Street  
St. Louis, MO 63103-2833

Final report

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# Preface

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The work documented in this report was performed during May through October 2001 as part of the technology transfer component of the Geotechnical Engineering Research Program (GTERP), specifically in the work unit entitled Applications of Trenchless Technology to Civil Works. Funding for preparation and publication of this report was provided by the U.S. Army Corps of Engineers as part of its ongoing support of civil works research. Mr. Carlos Latorre, U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL), is principal investigator for this work unit. The research team also includes Dr. Lillian D. Wakeley, GTERP Manager (ERDC, GSL), Mr. Patrick J. Conroy, U.S. Army Engineer District (USAED), St. Louis (MVS), and Mrs. Nalini Torres (ERDC, GSL). Mr. Jim Chang, CECW, is GTERP Technical Monitor.

The guidelines and specifications provided in this report are based on work completed previously by Dr. R. David Bennett, formerly GSL, ERDC; and Mr. Joseph M. Morones, State of California, Department of Transportation; and modified with their cooperation by Mr. Latorre. This report was prepared by Messrs. Latorre and Conroy and Dr. Wakeley. The authors gratefully acknowledge technical review of this document by Mr. George Sills, USAED, Vicksburg, Mr. Pete Cali, USAED, New Orleans; and Mr. John Wise, USAED, Fort Worth.

This report was completed at ERDC under the general supervision of Dr. Wakeley, Chief, Engineering Geology and Geophysics Branch, Dr. Robert L. Hall, Chief, Geosciences and Structures Division, GSL, and Dr. Michael J. O'Connor, Director, GSL.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

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# 1 Introduction

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## Background

Early methods of installing pipelines and utilities across rivers and streams involved excavation of trenches. After the placement of the pipeline, the trenches were backfilled to protect the pipeline from hazards. These early dredged crossings were generally sited at the channel crossing of the thalweg between bends of the river. Here the river is generally a wide, shallow rectangle. This location is chosen because of its hydraulic stability and the economic limitation of the dredging equipment.

In and across the U.S. Army Engineer Division, Mississippi Valley (MVD), lies the heart of the pipeline transmission network of the United States. Hundreds of individual pipelines traverse from Texas and out of the Gulf of Mexico across the numerous rivers, bayous, and wetlands of Louisiana to service the northeast population centers on the Atlantic coast. Along the leveed banks of the lower Mississippi River, pipeline crossings exist between almost every bendway. The crossings of these earthen flood control structures present a difficult and expensive construction problem resulting from concerns about the integrity of the levee which may be subjected to sliding, piping, and erosion failures.

## Horizontal Directional Drilling Method

In the early 1970s, a new process was introduced to install pipelines by use of horizontal directional drilling (HDD) techniques acquired from the oil and gas industry. The method has steadily grown to achieve worldwide acceptance and has been used in over 3,000 installations totaling over 1,288 km (800 miles) of pipelines. Today pipeline installations increasingly rely upon HDD technology as the primary method for crossings of watercourses, wetlands, utility corridors, roads, railroads, shorelines, environmental areas, and urban areas.

The placement of pipelines by the HDD method requires the drilling of a guided pilot bore, generally using a 7.3- to 11.43-cm- (2-7/8- to 4-1/2-in.-) diam drill pipe. At the lead, or downhole, end of the pilot string is a fluid powered cutting tool. The cutting tool is either a drill motor to which a bit is connected or a jet bit with nozzles. Drilling fluid is pumped through the string, and fluid causes the motor to rotate which turns the bit to cut the hole. With jet bits, the velocity from the jet nozzle erodes the hole in front of the drill pipe. Located

behind the drill head is a section of the drill pipe with a small bend or angular deviation. This section, known as a bent sub or bent housing, allows the motor or jet nozzle to be directed. A steering tool is latched onto a locking tool on the drill pipe. In this steering tool are a magnetometer and other devices to determine the azimuth, inclination, and orientation of the tool or tool face. Position determinations are made, and the data from the steering tool are plotted in the field to determine the profile and alignment of the bore. Analysis of this position plot is then used to determine drilling progress and path. At a desired location, the pilot drill pipe exits the ground. The pilot bore is then enlarged by pulling reaming tools back through the bore. Once this operation is completed, the pipeline or conduit is attached to the drill pipe and pulled back through the predrilled bore. This is accomplished as the drill pipe is removed, joint by joint, from the drilled path until the pipeline reaches the ground surface at the entry end of the bore.

One of the primary parameters in horizontal directional drilling is the drilling fluid or mud. The drilling mud is usually comprised of a bentonite and water mixture with the main function to power the downhole cutting tool used to open the bore. Secondary functions of the drilling mud are to serve as a lubricant for the pipeline during installation and, in cases of rock or hard ground bores, to remove cuttings from the bore.

The use of HDD has been restricted, in part, by major misunderstandings of how the HDD process actually functions. It is assumed by many that it is similar to well drilling or tunneling in that an open bore is required. This is true only in hard geologic materials such as rock. The majority of HDD pipeline crossings installed to date have been performed in soft ground comprised chiefly of alluvial deposits of silts, sand, and clay. In these types of soils, the process begins with a small pilot bore from which various cutters are inserted to loosen the soil as it is mixed into a slurry by injection of the drilling mud. Once this slurry pathway has been made large enough, generally 25.4 to 30.5 cm (10 to 12 in.) greater than the diameter of the pipeline, the installation of the pipeline commences by pulling the pipeline back through the soft slurry pathway. Some of the in situ soil and fluid are then compressed into the formation, and the remainder of the soil is actually pumped out of the path.

The information in this report represents some of the experiences of the Corps of Engineer (CE) Districts involving HDD for installation of utilities under levees. The experience of the U.S. Army Engineer District (USAED), St. Louis, in dealing with installation of communications systems was identified as having wide applicability to the Corps. Engineering documentation from two St. Louis District projects, the set of guidelines presented in "Installation of Pipelines Beneath Levees Using Horizontal Directional Drilling" (Staheli et al. 1998), Engineer Manual (EM) 1110-2-1913 (Headquarters, Department of the Army (HQDOA) 2000), and the State of California Department of Transportation (CalTrans) Encroachment Permits, "Guidelines and Specifications for Horizontal Directional Drilling Installations" (Morones 2000), provided the basis for this report. A paper on the subject was presented at the Corps Infrastructure Systems Conference in August 2001.

## Problem Identification

Although horizontal directional drilling could offer cost-effective, safe alternatives to installing pipelines with open trenching, the CE has no standard guidelines allowing the installation of pipelines with this construction method. As a result, permitting policies are extremely varied and some districts strictly prohibit the use of this technique. While recommended guidelines for pipeline installation using HDD were developed for use by the CE Districts through this work unit back in 1998, as part of a lengthy and detailed EM, the guidelines were not readily recognized by permitting offices as applicable to the questions they face. Also, there is growing pressure on Corps offices particularly by communications companies to install cables under levees.

## Objectives

The objectives are to provide and distribute this information to targeted potential users like the CE District permitting offices and engineers that receive applications from utility companies to install utilities under levees. This report addresses those questions and helps CE offices with the growing pressure they are receiving from private companies to allow them to install cables/pipelines under levees. These guidelines are presented in a quick and organized manner that will provide criteria by which to evaluate proposals (e.g., application review, approving, disapproving, and/or making recommendations) for levee crossings, beneath rivers, and within levee rights-of-way using HDD techniques without endangering the levees; and the use of HDD for pipeline installation in areas where the installation technique might be applicable and capable of providing a tremendous cost savings to the Corps of Engineers and the pipeline industry. These guidelines will also help to demonstrate that, very often, these techniques offer substantial economic and operational advantages over current practices. Last but not least, these guidelines will help us stay involved in the development of this fast and fairly new emerging technology.

## Potential Benefits

The pipeline industry would realize a tremendous benefit from the use of HDD in crossing of flood control levees. This benefit would include significant cost reduction in construction and maintenance presently required for levees and adjacent road crossings such as bridges, concrete boxes, earthen cover, and ramps. The use of the technique could also benefit the Corps of Engineers by: (a) eliminating blockage of levee crown from buried pipelines, pipeline bridges, or conduit boxes, (b) eliminating differential settlement imposed on levees by the construction of buried pipelines, pipeline bridges, or conduit boxes, (c) improving the operation and safety of grass cutting and other maintenance equipment on the levees, and (d) reducing risk of rupture of pipelines located above or near ground surface on levee slopes, (e) reducing disruption in urban areas, and (f) providing better public acceptance and increasing environmental consciousness.

## Potential Problem

While considering any alteration request, the District's prime objective is to protect the integrity of the flood protection systems. In the case of HDD, designers must be aware and take into account during the design stage the following:

- a.* Hydrofracture during installation.
- b.* Preferred seepage path after construction.

To allow third parties to utilize HDD techniques, the District needed methods and processes to prevent these problems from occurring.

## 2 HDD Guidelines and Specifications

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### Permit Application Submittal

The permit application package should contain the following information in support of the permit application.

- a.* Location of entry and exit point.
- b.* Equipment and pipe layout areas.
- c.* Proposed drill path alignment (both plan and profile view).
- d.* Location, elevations, and proposed clearances of all utility crossings and structures.
- e.* Proposed depth of cover.
- f.* Soil analysis.
- g.* Product material (HDPE/steel), length, diameter-wall thickness, reamer diameter.
- h.* Detailed pipe calculations, confirming ability of product pipe to withstand installation loads, and long-term operational loads.
- i.* Proposed composition of drilling fluid (based on soil analysis) viscosity and density.
- j.* Drilling fluid pumping capacity, pressures, and flow rates proposed.
- k.* State right-of-way lines, property, and other utility right-of-way or easement lines.
- l.* Elevations.
- m.* Type of tracking method/system.

- n. Survey grid establishment for monitoring ground surface movement (settlement or heave) because of the drilling operation.
- o. Contractor’s work plan (see page 11 in this document).

All additional permit conditions shall be set forth in the special provisions of the permit.

Table 1 outlines recommended depths for various pipe diameters:

<b>Table 1 Recommended Minimum Depth of Cover<sup>1</sup></b>	
<b>Diameter</b>	<b>Depth of Cover</b>
50 mm (2 in.) to 150 mm (6 in.)	1.2 m (4 ft)
200 mm (8 in.) to 350 mm (14 in.)	1.8 m (6 ft)
375 mm (15 in.) to 600 mm (24 in.)	3.0 m (10 ft)
625 mm (25 in.) to 1,200 mm (48 in.)	4.5 m (15 ft)
<sup>1</sup> These depths do not apply for crossing under flood protection projects. (Permission to reprint granted by California Department of Transportation, Office of Encroachment Permits, January 10, 2001).	

The permittee/contractor shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring.

Upon completion of the work, the permittee shall provide an accurate as-built drawing of the installed pipe.

## Soil Investigations

A soil investigation should be undertaken. This investigation must be suitable for the proposed complexity of the installation to confirm ground conditions.

### Soil analysis

**Common sense must be utilized when requiring the extensiveness of the soil analysis.** A soil analysis is required in order to obtain information on the ground conditions that the contractor will encounter during the HDD operation.

If the contractor can go to the project site and complete an excavation with a backhoe to 0.03 m (1 ft) below the proposed depth of the bore, that is a soil investigation. In all cases when an excavation is made in creating an entrance and exit pit for an HDD project, that is also an example of a soil investigation. The HDD process is in itself a continual and extensive soil analysis as the pilot bore is made. As the varying soils and formations are encountered, the drilling slurry will change colors, therefore providing the contractor with continual additional information.

The purpose and intent of the soil analysis is to assist the contractor in developing the proper drilling fluid mixture and to ensure the CE and the Levee Board that the contractor is aware of the conditions that do exist in the area of the proposed project. This prepares the contractor in the event they should encounter a zone of pretectionics and that they would need additives or preventive measures in dealing with inadvertent returns (hydrofractures).

The discretion on the extensiveness of the soil analysis is left to each individual CE District permitting office and/or Levee Board, respectfully, for their respective areas. The HDD inspector/geotechnical engineer plays a large role in assisting the District Permitting Office and Levee Board in making decisions on the extensiveness. Each individual HDD inspector/geotechnical engineer has a general knowledge of the soil conditions in their area of responsibility.

In many circumstances, the soil information has already been prepared, either by the CE District, Levee Board, or by City and County Entities. This information, if available, should be provided to the requesting permittee.

### **Determination of soil investigations**

The CE District Geotechnical Engineer (DGE) should determine the extensiveness of the Soil Investigation to be performed based on the complexity of the HDD operation. DGE may recommend, according to the guidelines listed below, a combination of or modification to the guideline to fit the following respective areas:

- a. Projects less than 152 mm (500 ft) in length, where the product or casing is 20 cm (8 in.) or less in diameter.<sup>1</sup>
  - (1) A field soil sampling investigation to a depth of 0.3 m (1 ft) below the proposed drilling.
  - (2) Subsurface strata, fill, debris, and material.
- b. Projects less than 244 m (800 ft) in length, where the product or casing is 36 cm (14 in.) or less in diameter.<sup>1</sup>
  - (1) A field soil sampling investigation to a depth of 0.3 m (1 ft) below the proposed drilling.
  - (2) Subsurface strata, fill, debris, and material.
  - (3) Particle size distribution (particularly, percent gravel and cobble).
- c. Projects where the product or casing is 41 cm (16 in.) or greater in diameter. A geotechnical evaluation by a qualified soil engineer is necessary to determine the following:<sup>1</sup>

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<sup>1</sup> Does not apply when crossing a flood protection project.



- (1) Subsurface strata, fill, debris, and material.
  - (2) Particle size distribution (particularly percent gravel and cobble).
  - (3) Cohesion index, internal angle of friction, and soil classification.
  - (4) Plastic and liquid limits (clays), expansion index (clays), soil density.
  - (5) Water table levels and soil permeability.
- d.* Projects where the product or casing is 61 cm (24 in.) or greater in diameter, or when project crosses flood control projects. A geotechnical evaluation by a qualified soil engineer is required to determine the following:
- (1) Subsurface strata, fill, debris, and material.
  - (2) Particle size distribution (particularly, percent gravel and cobble).
  - (3) Cohesion index, internal angle of friction, and soil classification.
  - (4) Plastic and liquid limits (clays), expansion index (clays), soil density, and standard penetration tests.
  - (5) Rock strength, rock joint fracture and orientation, water table levels, and soil permeability.
  - (6) Areas of suspected and known contamination should also be noted and characterized.

Boreholes or test pits should be undertaken at approximately 75- to 125-m (250- to 410-ft) intervals where a proposed installations greater than 305 m (1,000 ft) in length and parallel to an existing road. Additional boreholes or test pits should be considered if substantial variations in soil conditions are encountered.

Should the soil investigation determine the presence of gravel, cobble, and/or boulders, care should be exercised in the selection of drilling equipment and drilling fluids. In such ground conditions, the use of casing pipes or washover pipes may be required or specialized drilling fluids utilized. Fluid jetting methods used as a means of cutting **should only be considered** where soils have a high cohesion such as stiff clays. Jetting should not be allowed when crossing under a flood protection project.

## **Preconstruction and Site Evaluation**

The following steps should be undertaken by the permittee/contractor in order to ensure safe and efficient construction with minimum interruption of normal, everyday activities at the site:

- a. Notify owners of subsurface utilities along and on either side of the proposed drill path of the impending work through USA alert (the one-call program). All utilities along and on either side of the proposed drill path are to be located.
- b. Obtain all necessary permits or authorizations to carry construction activities near or across all such buried obstructions.
- c. Expose all utility crossings using a hydroexcavation, hand excavation, or other approved method (potholing) to confirm depth.
- d. Arrange construction schedule to minimize disruption (e.g., drilling under major highways and/or river crossings).
- e. Determine and document the proposed drill path, including horizontal and vertical alignments and location of buried utilities and substructures along the path.

The size of excavations for entrance and exit pits should be of sufficient size to avoid a sudden radius change of the pipe and consequent excessive deformation at these locations. Sizing the pits is a function of the pipe depth, diameter, and material. All pits, over 1.52 m (5 ft) in depth must abide by Occupational, Safety, and Health Administration (OSHA) regulations.

Prior to commencement of the project, the area should be physically walked over and visually inspected by District Geotechnical Engineer, the driller, and members of the Levee Board for potential entry/exit sites. The following should be addressed:

- a. When on CE/Levee Board property, it should be established whether or not there is sufficient room at the site for: entrance and exit pits; HDD equipment and its safe unimpeded operation; support vehicles; fusion machines; aligning the pipe to be pulled back in a single continuous operation.
- b. Suitability of soil conditions should be established for HDD operations. (The HDD method is ideally suited for soft subsoils such as clays and compacted sands. Subgrade soils consisting of large grain materials like gravel, cobble, and boulders make HDD difficult to use and may contribute to pipe damage.)
- c. The site should be checked for evidence of substructures, such as man-hole covers, valve box covers, meter boxes, electrical transformers, conduits or drop lines from utility poles, and pavement patches. HDD may be a suitable method in areas where the substructure density is relatively high.

## Installation Requirements

The permittee shall ensure that appropriate equipment is provided to facilitate the installation: in particular, the drill rig shall have sufficient pulling capacity to meet the required installation loads determined by the detailed pipe calculations. The drill rig should have the ability to provide pull loads, push loads, torque, and the permittee shall ensure that they are monitored during the drilling operation. The permittee shall ensure the drill rod can meet the bend radii required for the proposed installation (a general rule of thumb is 100 times, in feet, the diameter of the installed pipe in inches).

During construction, continuous monitoring and plotting of pilot drill progress shall be undertaken. This is necessary to ensure compliance with the proposed installation alignment and allow for the undertaking of appropriate course corrections that would minimize “dog legs,” should the bore begin to deviate from the intended bore path. The actual path of the pilot hole should be plotted against the design drill path.

Monitoring shall be accomplished by manual plotting based on location and depth readings provided by the onboard locating/tracking system or by hand-held walkover tracking systems. These readings map the bore path based on information provided by the locating/tracking system. Readings or plot points shall be undertaken on every drill rod.

For installations where tight control of alignment and grade is required, readings shall be undertaken every 1.0 to 1.5 m (3 to 5 ft). At the completion of the bore, an as-built drawing shall be provided. Prior to commencement of a directional drilling operation, proper calibration of the sonde equipment shall be undertaken.

Monitoring of the drilling fluids such as the pumping rate, pressures at the drill rig and pressures in the annular space behind the drill bit (when drilling under flood control projects), viscosity, and density during the pilot bore, back reaming, and/or pipe installation stages shall be undertaken to ensure adequate removal of soil cuttings and the stability of the borehole is maintained. Excess drilling fluids shall be contained at entry and exit points until recycled or removed from the site. Entry and exit pits should be of sufficient size to contain the expected return of drilling fluids and soil cuttings.

The permittee shall ensure that all drilling fluids are disposed of in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in contaminated ground, the drilling fluid shall be tested for contamination and disposed of appropriately. Restoration of damage to a levee caused by hydrofracture or any other aspect of the directional drilling operation shall be the responsibility of the permittee. Plans for all restoration or repair work shall be submitted for approval by the Levee District or Corps of Engineers District.

To minimize heaving during pullback, the pullback rate shall be determined by which maximizes the removal of soil cuttings and which minimizes compaction of the ground surrounding the borehole. The pullback rate shall also

minimize overcutting of the borehole during the back reaming operation to ensure that excessive voids are not created and result in postinstallation settlement.

The permittee shall, prior to and upon completion of the directional drill, establish a Survey Grid Line and provide monitoring as outlined in their submitted detailed monitoring plan. Subsurface monitoring points shall be established along the HDD centerline and along any flood protection project that the HDD crosses under to provide early indications of settlement, since large voids may not materialize during drilling as a result of pavement bridging.

Should settlement occur, all repairs would be the responsibility of the permittee. To prevent future settlement should the drilling operation be unsuccessful, the permittee shall ensure the backfill of any void(s) with grout or backfilled by other means. Plans for all restoration or repair work shall be submitted for approval.

### **Considerations**

The following considerations must be taken into account.

- a. *Different ground conditions:* The availability of adequate geotechnical information is invaluable in underground construction; it acts to reduce the risk born by the permittee/contractor. However, even in the presence of good geotechnical data, unexpected ground conditions may be encountered. The Contractor's plan should describe the response to different ground conditions.
- b. *Turbidity of water and inadvertent returns:* During construction, events like drill bit lockup or being off the design drill path may lead to work stoppage. The permittee/contractor should offer a mechanism to mutually address and mitigate these problems if and when they should arise. For example, contingency plans for containment and disposal of inadvertent returns or hydrofractures.

### **Permittee/contractor responsibilities**

The permittee/contractor should provide the following items: construction plan, site layout plan, project schedule, communication plan, safety procedures, emergency procedures, company experience record, contingencies plan, and drilling fluid management plan.

**Construction plan requirements.** The permittee shall identify in the construction plan:

- a. Location of entry and exit pits.
- b. Working areas and their approximate size.

- c.* Proposed pipe fabrication and layout areas.
- d.* State right-of-way lines, property lines.
- e.* Other utility right-of way and easement lines.
- f.* Pipe material and wall thickness.
- g.* Location of test pits or boreholes undertaken during the soil investigation.
- h.* Identify the proposed drilling alignment (both plan and profile view) from entry to exit.
- i.* Identify all grades and curvature radii.
- j.* All utilities (both horizontal and vertical).
- k.* Structures with their clearances from the proposed drill alignment.
- l.* Confirm the minimum clearance requirements of affected utilities and structures.
- m.* Required minimum clearances from existing utilities and structures.
- n.* Diameter of pilot hole, and number and size of prereams/backreams.
- o.* Access requirements to site (if required).
- p.* Crew experience.
- q.* Type of tracking equipment.

**Locating and tracking.** The permittee shall describe the method of locating and tracking the drillhead during the pilot bore. Systems include walkover, wire-line, or wireline with wire surface grid. The locating and tracking system shall be capable of ensuring the proposed installation can be installed as intended.

Typical walkover sondes have an effective range of 10 to 15 m, depending on the Electro-magnetic properties of the soil and the extent of local magnetic interference. Depending on the profile of the borehole, the driller may lose contact with the sondes over certain sections of the alignment. As much as practically possible, the sonde should maintain contact with the drill bit. If the “blind” section is expected to be too long or in the vicinity of a buried object, the project engineer may specify the use of a wire-line system or a magnetic navigation tool.

The locating and tracking system shall provide the following information:

- a.* Clock and pitch information.
- b.* Depth.

- c. Beacon temperature.
- d. Battery status.
- e. Position (x,y).
- f. Azimuth: Where direct overhead readings (walkover) are not possible.

Figure 1 shows a universal housing that will work with any drill-string on all HDD rigs. The placement of the sonde should be before the backreamer. This housing can be utilized in the initial pilot bore. After exiting, the cutting head can be removed and the reamer installed. This housing chamber can utilize any of the sonde batteries manufactured, regardless of manufacturer. There is also a 6-cm (2.5 in.) mini-sonde combination available for smaller rigs.

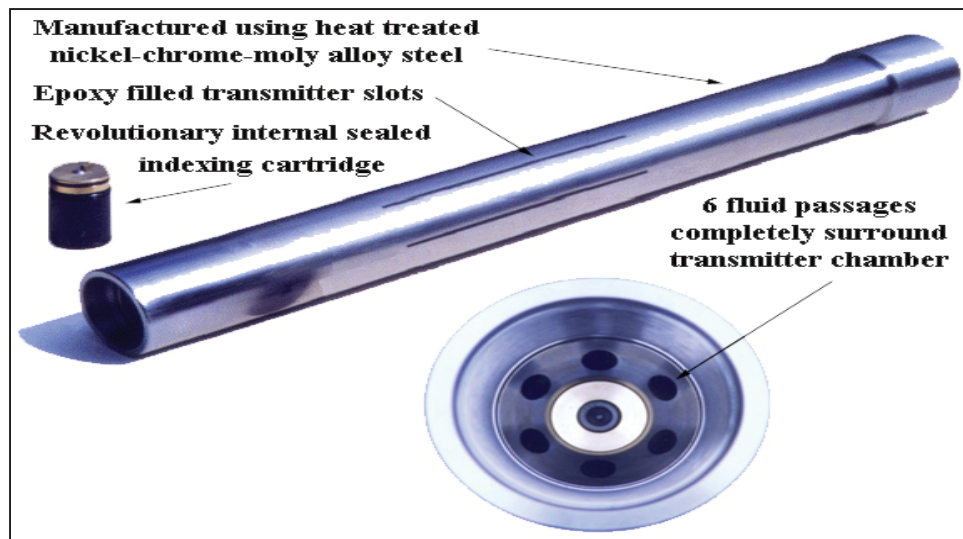


Figure 1. Universal housing for drill-string on HDD rigs (Permission to reprint granted by California Department of Transportation, Office of Encroachment Permits, January 10, 2001)

**Drilling fluids management plan.** The following information should be provided as part of the drilling fluid management plan. The proposed viscosities for soil transportation to the entry and exit pits are:

- a. Pumping capacity and pressures must be estimated.
- b. Source of fresh water for mixing the drilling mud must be identified. (Necessary approvals and permits are required for sources such as streams, rivers, ponds, or fire hydrants.)
- c. Method of slurry containment must be described and detailed.
- d. Method of recycling drilling fluid and spoils (if applicable) must be explained.

- e. Method of transporting drilling fluids and spoils offsite must be described.

Drilling fluid pressures in the borehole should not exceed that which can be supported by the foundation soils. Calculation of maximum allowable pressures shall be done for all points along the drill path, taking into account the shear strength of the foundation soils, the depth of the drill path, the bore diameter, and the elevation of the groundwater table. Drilling fluids serve the following functions:

- a. Remove cuttings from the bottom of the hole and transport them to the surface.
- b. Hold cuttings in suspension when circulation is interrupted.
- c. Release cuttings at the surface.
- d. Stabilize the hole with an impermeable cake.
- e. Cool and lubricate the drill bit and drill string.
- f. Control subsurface pressures.
- g. Transmit hydraulic horsepower.
- h. Cool the locating transmitter sonde preventing burnout.

**Previous experience.** The permittee's contractor should provide a list of projects completed by his company, location, project environment (e.g., urban work, river crossing), product diameter, and length of installation. The permittee's contractor should also provide a list of key personnel.

**Safety.** The drilling unit should be equipped with an electrical strike safety package. The package should include warning sound alarm, grounding mats (if required), and protective gear. The permittee/contractor should have a copy of the company safety manual that includes:

- a. Operating procedures that comply with applicable regulations, including shoring of pits and excavations when required.
- b. Emergency procedures for inadvertently boring into a natural gas line, live power cable, water main, sewer lines, or a fiber-optic cable, which comply with applicable regulations.
- c. Emergency evacuation plan in case of an injury.

**Contingency plans.** The Contingency plan should address the following:

- a. Inadvertent return, spill (e.g., drilling fluids, and hydraulic fluids), including measures to contain, clean, and repair the affected area.

- b.* Cleanup of surface seepage of drilling fluids and spoils (i.e., hydrofracture).

**Communication plan.** The communication plan should address the following:

- a.* The phone numbers for communication with owner or his representative on the site.
- b.* Identification of key person(s) who will be responsible for ensuring that the communications plan is followed.
- c.* Issues to be communicated including safety, progress, and unexpected technical difficulties.

**Traffic control.**

- a.* When required, the permittee/contractor is responsible for supplying and placing warning signs, barricades, safety lights, and flags or flagmen, as required for the protection of pedestrians and vehicle traffic.
- b.* Obstruction of the roadway, on major road, should be limited to off-peak hours.

## **Additional Requirements**

Information that may be required, include other permits, bonding, and certification as listed in the following sections.

### **Additional permits**

- a.* Obtaining water (i.e., hydrants, streams, etc.)
- b.* Storage, piling, and disposal of material.
- c.* Water/bentonite disposal.
- d.* Any other permits required carrying out the work.

### **Bonding and certification requirements**

- a.* Payment bond (if required).
- b.* Performance bond (if required).
- c.* Certificate of insurance.
- d.* WCB certificate letter.



- e. ACSA certificate of recognition.

## Drilling Operations

The following points provide general remarks and rules of thumb related to the directional boring method.

- a. Only operators who have “Proof of Training” by the North American Society of Trenchless Technology (NASTT) should be permitted to operate the drilling equipment in CE/Levee Board property.
- b. Drilling mud pressure in the borehole should not exceed that which can be supported by the foundation soils to prevent heaving or a hydraulic fracturing of the soil (i.e., hydrofracture). Allowing for a sufficient cover depth does not necessarily guarantee against hydrofracture. Sound, cautious drilling practice minimizes the chance of hydrofracture occurrence. Also, measuring mud pressures in the annular space behind the drill bit and comparing these mud pressures with the calculated maximum allowable pressures help minimize the occurrence of hydrofracture. Typical bore depth of 0.75 to 1.0 m gives pipes with an Outside Diameter (O.D.) of 50-200 mm a minimum cover of 0.65 m. While circumstances may dictate greater depths, shallower depths are not recommended.
- c. The drill path alignment should be as straight as possible to minimize the fractional resistance during pullback and to maximize the length of the pipe that can be installed during a single pull.
- d. It is preferable that straight tangent sections be drilled before the introduction of a long radius curve. Under all circumstances, a minimum of one complete length of drill rod should be utilized before starting to level out the borehole path.
- e. The radius of curvature is determined by the bending characteristics of the product line, and it is increasing with diameter.
- f. Entrance angle of the drill string should be between 8 and 20 deg, with 12 deg being considered optimal. Shallower angles may reduce the penetrating capabilities of the drilling rig, while steeper angles may result in steering difficulties, particularly in soft soils. A recommended value for the exit angle of the drill string is within the range of 5 to 10 deg.
- g. Whenever possible, HDD installation should be planned so that back reaming and pulling for a leg can be completed on the same day. If necessary, it is permissible to drill the pilot hole and preream one day, and complete both the final ream and the pullback on the following day.
- h. If a drill hole beneath a levee must be abandoned, the hole should be backfilled with grout or bentonite to prevent future subsidence.

- i.* Pipe installation should be performed in a manner that minimizes the over-stressing and straining of the pipe. This is of particular importance in the case of a polyethylene pipe.

### **Equipment setup and site layout**

- a.* Sufficient space is required on the rig side to safely set up and operate the equipment. The workspace required depends on the type of rig to be used. A small rig may require as little as 3- by 3-m working space, while a large river crossing unit requires a minimum of 30- by 50-m working area. A working space of similar dimensions to that on the rig side should be allocated on the pipe side, in case there is a need to move the rig and attempt drilling from this end of the crossing.
- b.* If at all possible, the crossing should be planned to ensure that drilling proceed downhill, allowing the drilling mud to remain in the hole, minimizing inadvertent return.
- c.* Sufficient space should be allocated to fabricate the product pipeline into one string, thus enabling the pullback to be conducted in a single continuous operation. Tie-ins of successive strings during pullback may considerably increase the risk of an unsuccessful installation.

### **Drilling and back-reaming**

- a.* Drilling mud should be used during drilling and back reaming operations. Using water exclusively may cause collapse of the borehole in unconsolidated soils. While in clays, the use of water may cause swelling and subsequent jamming of the product.
- b.* Heaving may occur when attempting to back-ream a hole that is too large. This can be avoided by using several prereams to gradually enlarge the hole to the desired diameter.
- c.* A swivel should be included between the reamer and the product pipe to prevent the transfer of rotational torque to the pipe during pullback.
- d.* In order to prevent over stressing of the product during pullback, a weak link, or break-away pulling head, may be used between the swivel and the leading end of the pipe. More details regarding breakaway pulling heads can be found in paragraph entitled “Break-away Pulling Head.”
- e.* The pilot hole must be back-reamed to accommodate and permit free sliding of the product inside the borehole. A rule of thumb is to have a borehole 1.5 times the outer diameter of the product. This rule of thumb should be observed particularly with the larger diameter installations ( $\geq 250$ -mm O.D.). Some recommended values for final preream diameter

as a function of the product O.D. are given in Table 2. These values should be increased by 25 percent if excessive swelling of the soil is expected to occur or the presence of boulders/cobbles is suspected.

- f. The conduit must be sealed at either end with a cap or a plug to prevent water, drilling fluids, and other foreign materials from entering the pipe as it is being pulled back.
- g. Pipe rollers, skates, or other protective devices should be used to prevent damage to the pipe from the edges of the pit during pullback, eliminate ground drag, or reduce pulling force and subsequently reduce the stress on the product.
- h. The drilling mud in the annular region should not be removed after installation but permitted to solidify and provide support for the pipe and neighboring soil.

<b>Table 2 Recommended Back-Ream Hole Diameter (after Popelar et al. 1997)</b>	
<b>Nominal Pipe Diameter, mm</b>	<b>Back-Ream Hole Diameter, mm</b>
50	75 to 100
75	100 to 150
100	150 to 200
150	250 to 300
200	300 to 350
250	350 to 400
≥300	At least 1.5 times product OD

## **Drilling Fluid - Collection and Disposal Practices**

The collection and handling of drilling fluids and inadvertent returns, along with the need to keep drilling fluids out of streams, streets, and municipal sewer lines, have been among the most debated topics. These points include:

- a. Drilling mud and additives to be used on a particular job should be identified in the permit package, and their Material Safety Data Sheets (MSDS) should be provided to the Permit Office.
- b. Excess drilling mud slurry shall be contained in a lined pit or containment pond at exit and entry points, until recycled or removed from the site. Entrance and exit pits should be of sufficient size to contain the expected return of drilling mud and spoils.
- c. Methods to be used in the collections, transportation, and disposal of drilling fluids, spoils, and excess drilling fluids should be in compliance with local ordinances, regulations, and environmentally sound practices in an approved disposal site.

- d. The slurry should be tested for contamination and disposed of in a manner which meets government requirements when working in an area of contaminated ground.
- e. Precautions should be taken to keep drilling fluids out of the streets, manholes, sanitary and storm sewers, and other drainage systems, including streams and rivers.
- f. Recycling drilling fluids is an acceptable alternative to disposal.
- g. All diligent efforts should be made by contractor to minimize the amount of drilling fluids and cuttings spilled during the drilling operation, and complete cleanup of all drilling mud overflows or spills shall be provided.

There are legitimate concerns associated with the fluid pressures used for excavation during the horizontal directional drilling process and the risk of hydraulic fracturing. Reasonable limits must be placed on maximum fluid pressures in the annular space of the bore to prevent inadvertent drilling fluid returns to the ground surface. However, it is equally important that drilling pressures remain sufficiently high to maintain borehole stability, since the ease in which the pipe will be inserted into the borehole is dependent upon borehole stability. Limiting borehole pressures are a function of pore pressure, the pressure required to counterbalance the effective normal stresses acting around the bore (depth), and the undrained shear strength of the soil.

## **Tie-Ins and Connections**

Trenching may be used to join sections of conduits installed by the directional boring method. An additional pipe length, sufficient for joining to the next segment, should be pulled into the entrance pit. This length of the pipe should not be damaged or interfere with the subsequent drilling of the next leg. The contractor should leave a minimum of 1 m of conduit above the ground on both sides of the borehole.

## **Alignment and Minimum Separation**

The product should be installed to the alignment and elevations shown on the drawings within the prespecified tolerances (tolerance values are application dependent, for example, in a major river crossing, a tolerance of  $\pm 4$  m from the exit location along the drill path center line may be an acceptable value). This tolerance is not acceptable when installing a product line between manholes. Similarly, grade requirements for a water forcemain are significantly different from those on a gravity sewer project.

When a product line is installed in a crowded right-of-way, the issue of safe minimum separation distance arises. Many utility companies have established regulations for minimum separation distances between various utilities. These

distances needed to be adjusted to account for possible minor deviation when a line product is installed using HDD technology. As a rule of thumb, if the separation distance between the proposed alignment and the existing line is 5 m or more, normal installation procedures can be followed. If the separation is 1.5 m or less, special measures, such as observation boreholes are required. The range between 1.5 and 5 m is a “gray” area, typically subject to engineering judgment (a natural gas transmission line is likely to be treated more cautiously than a storm water drainage line).

## Break-Away Pulling Head

Recent reports from several natural gas utility companies reveal concerns regarding failure experienced on HDPE pipes installed by horizontal directional drilling. These failures were attributed to deformation of the pipe due to the use of excessive pulling force during installation. A mitigation measure adopted by some gas companies involves the use of break-away swivels to limit the amount of force used when pulling HDPE products. Some details regarding these devices and their applications are given below.

- a. The weak link used can be either a small diameter pipe (but same SDR) or specially manufactured break-away link. The latter consists of a breaking pin with a defined tensile strength incorporated in a swivel. When the strength of the pin is exceeded it will break, causing the swivel to separate. A summary of pulling head specifications is given in Table 3 (all products are SDR 11). Note that the values provided in Table 3 could be considered conservative.

<b>Table 3 Pulling Head Specifications</b>		
<b>Pipe Diameter (in.)<sup>1</sup></b>	<b>Diameter of Break-Away Swivel (in.)</b>	<b>Maximum Allowable Pulling Force (lb)<sup>2</sup></b>
1-1/4	7/8	850
2	1-1/4	1,500
4	1 3/8	5,500
6	2-1/2	12,000
8	3	18,500

<sup>1</sup>To convert inches to centimeters, multiply by 2.54.  
<sup>2</sup>To convert pounds to kilograms, multiply by 0.4535.

- b. The use of break-away swivels is particularly warranted when installing small diameter HDPE pipes (up to 10-cm (4 in.) O.D.). Application of such devices in the installation of larger diameter products is not currently a common practice.
- c. If the drilling equipment-rated pulling capacity is less than the safe load, the use of a weak link may not be required.

- d. Exceeding the product elastic limit can be avoided simply by following good drilling practices, namely: regulating pulling force; regulating pulling speed; proper ream sizing; and using appropriate amounts of drilling slurry fluid.

## **Protective Coatings**

In an HDD installation, the product may be exposed to extra abrasion during pullback. When installing a steel pipe, a form of coating which provides a corrosion barrier as well as an abrasion barrier is recommended during the operation, the coating should be well bonded and have a hard smooth surface to resist soil stresses and reduce friction, respectively. A recommended type of coating for steel pipes is mill applied Fusion Bonded Epoxy.

## **Site Restoration and Postconstruction Evaluation**

All surfaces affected by the work shall be restored to their preconstruction conditions. Performance criteria for restoration work will be similar to those employed in traditional open excavation work. If required, the permittee/contractor shall provide a set of as-built drawings including both alignment and profile. Drawings should be constructed from actual field readings. Raw data should be available for submission at any time upon request. As part of the “As-Built” document, the contractor shall specify the tracking equipment used, including method or confirmatory procedure used to ensure the data were captured.

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<b>14. ABSTRACT</b> Applications for permits to drill beneath levees are increasing in permitting offices of the U.S. Army Corps of Engineer Districts. This report provides a basis for consistent and science-based consideration of these permit applications. It describes methods of horizontal directional drilling (HDD) beneath levees and lists the types of geotechnical and other data that are essential to judging the safety of proposed drilling for infrastructure modifications and installation of utilities. Critical considerations include setback distances, levee toe stability, thickness and integrity of the top stratum, and other geotechnical parameters. Data provided for vertical and horizontal permeabilities, top stratum thickness, hydraulic gradient at levee toe, and other parameters are based on experience in the U.S. Army Engineer Districts, Vicksburg and St. Louis, and the California Department of Transportation. In appropriate geotechnical settings with appropriate operational care, utilities can be installed beneath flood-control levees using HDD without compromising the integrity and function of the levee.					
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