

Lakeland Water Utilities

Directional Bore Standards

**Design, Requirements and
Post-Construction**

June 11, 2018

**DIRECTIONAL BORE
DESIGN, REQUIREMENTS, AND POST-CONSTRUCTION
STANDARDS**

This information is provided as part of the Engineering Standards Manual referenced by Ordinance 3175, passed and certified February 5, 1990.

Water Utilities has updated this information for the use of engineers, developers, and customers of the City of Lakeland's Water Utilities. **The following standards are applicable to both Water and Wastewater Systems for the City of Lakeland.** As Director, it is my goal that this information will assist each user to formalize their request and facilitate faster service from Water Utilities.

Future revisions may be required and will be available. I would encourage the user to maintain the following revision log, so that Water Utilities Engineering will be able to adequately address any concerns.

Please use this information and call Water Utilities Engineering if you need additional information or clarification.

Approved by:



Robert Conner
Director of Water Utilities

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**CITY OF LAKE LAND WATER UTILITIES DEPARTMENT
DEVELOPER DIRECTIONAL BORE STANDARDS**

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**CITY OF LAKELAND WATER UTILITIES DEPARTMENT
DIRECTIONAL BORE STANDARD**

1.0 DESIGN / PRECONSTRUCTION REQUIREMENTS

1.1 General

The purpose of this standard is to provide guidelines for use by the development community and others during the design and installation of underground water mains and wastewater force mains using horizontal directional bores integral to the development of commercial, industrial, or subdivision properties.

1.2 References

References for horizontal directional drilling include Mini-Horizontal Directional Drilling Manual (1995), North American Society of Trenchless Technology (NASTT), Chicago, IL; PPI Handbook of Polyethylene Piping (1998), Plastics Pipe Institute, Washington, D.C.; PLEXCO Polyethylene Industrial Piping Systems; Technical Information; Technical Note: Horizontal Directional Drilling (Guided Bore) with PLEXCO Pipe, et al.

1.3 Engineer Responsibilities

The design ENGINEER assumes all responsibility for proper design of the directional bore.

1.3.1 The ENGINEER should determine if the soils at the site are suitable for directional drilling based on previous experience with the site soils or a geotechnical investigation.

1.3.2 All existing utilities, surface and subsurface structures must be located (in three dimensions) for the design. To protect HDPE pipe against excessive pulling load, a break away device should always be used at the head of the HDPE pipe. A breakaway device is a mechanical linkage located between the reamer and the pulling eye. "Weak Link" pipe sections (pipe with thinner pipe wall thickness than the product pipe) and/or wire is not acceptable. An acceptable breakaway device is the "Break-Away D. Drill" swivel by Condux International, Inc. or equivalent.

1.3.3 The minimum ground cover over a directionally bored water or wastewater utility line shall be 36 inches. There shall be at least 18 inches vertical clearance when crossing under any existing water main with a wastewater force main.

1.3.4 The ENGINEER should limit curvature (within manufacturer's and City of Lakeland's guidelines) in any direction to lessen force on the pipe during pullback. Ideally, the directional bore should lie in a vertical plane passing through the beginning and ending points.

1.3.5 The ENGINEER shall submit, as part of the permits application plans submittal package, design calculations indicating predicted / permissible (maximum safe) pull force, pipe pull rating, and minimum permissible pipe bend radius. Maximum safe pull force shall be shown on the project design drawings are listed in 1.3.5.1 thru 1.3.5.7. Additional discussion can be found in Appendix A.

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1.3.5.1 The pullback force is calculated at the leading end of the pipe behind the pulling head.

- 1.3.5.2 The frictional resistance is highest just prior to movement and decreases with movement. When pullback ceases, frictional forces and drag forces increase due to the thixotropic nature of drilling mud. The mud starts to gel when it is undisturbed.
- 1.3.5.3 Buoyant force pushes the pipe up against the top of the borehole, creating frictional drag between the pipe and the borehole.
- 1.3.5.4 Minimum curvature at the entry and exit pits is limited by the steering capabilities of the boring equipment.
- 1.3.5.5 When the bending radius is too small, the safe pulling strength of HDPE pipe may be significantly reduced by the additional tensile stresses due to curvature.
- 1.3.5.6 All bending stresses due to various curvatures in the boring path are additive and should be subtracted from the safe pull force.
- 1.3.5.7 The "safe" pull-load is time dependent. The pullback speed should be between 1 to 2 feet per minute.
- 1.3.6 The ENGINEER must show the directional bore in profile view on the plans, showing the pipe as it should be installed. Maximum pull strength and minimum radius of curvature shall be listed. All existing utilities shall be shown on the plans.
- 1.3.7 The ENGINEER shall provide signed and sealed "As-Built" drawings of the constructed bore path, including any abandoned in place bores. The ENGINEER shall certify that the pipe was installed within acceptable limits per the pipe specifications. This shall include the exact installation location for both horizontal and profile views of the bore(s).

1.4 Contractor Responsibilities

- 1.4.1 The CONTRACTOR shall supply all labor, supervision, tools and equipment, and materials necessary to install carrier pipe by directional bore method for potable water, wastewater, or reclaimed water systems. Installation of the carrier pipe system includes the installation of water mains or wastewater force mains and/or any other devices or materials deemed necessary for the respective systems. For CITY projects, materials may be supplied by the City. All additional costs incurred by the City of Lakeland shall be passed on to the contractor for connection of HDPE pipe to required joints, fittings, or valves; if the pipe is "ovalized i.e. "ring deflection" or "out-of-round" by more than 5% (five percent) and can not be joined using standard connection procedures or methods. If the carrier pipe is supplied by the CITY and does not meet above standards, all corrective action shall be at cost to the CITY.
- 1.4.2 The CONTRACTOR shall provide experienced operators to perform directional boring. The operator shall have performed at least three directional bores of similar pipe diameter and bore length.
- 1.4.3 The CONTRACTOR shall be fully responsible for placement of the pipe per the ENGINEER's specifications. See Paragraph 2.2.8 for tolerances.

1.4.4 The CONTRACTOR shall supply experienced persons who have received proper training in the use of the fusion equipment according to the recommendations of the pipe manufacturer and fusion equipment supplier to perform thermal fusion of the specific HDPE pipe to be used.

1.4.5 The contractor shall cleanup the work area and properly remove and dispose of all boring materials.

1.5 Equipment

1.5.1 The directional drilling equipment shall consist of a directional-drilling rig of sufficient capacity to perform the bore and pull back the pipe.

1.5.2 The steerable, directional-boring equipment shall produce a stable fluid lined tunnel with a minimum burial depth of 36-inches for the carrier pipe installation.

1.5.3 The tunneling equipment shall employ a fluid cutting technique. The soil shall be cut by small diameter, high-pressure jets of drilling fluid. The jets shall cut the soil in advance of the boring tool, impregnating and lining the tunnel wall with drilling fluid. The drilling fluid shall be inert and pose no environmental risk, such as bentonite or a polymer-surfactant mixture producing a slurry of proper consistency.

1.5.4 The hydraulic power system shall be self-contained and free of leaks, with sufficient pressure and volume to power the drilling operation.

1.5.5 Calibration of the electronic detection system shall be verified by uncovering the tool (head) at the first ten (10) foot point.

1.5.6 The boring tool (head) shall be remotely steerable by means of an electronic detection system. The tool (head) location shall be monitored in three dimensions and logged every 10 feet from the drilling rig. The boring tool shall pull the carrier pipe through the fluid lined tunnel.

1.5.7 The rig shall have means to monitor and record the maximum pullback force during the pullback operation. The pulling strength of the boring equipment shall not exceed the HDPE pipe safety pull strength as per the manufacturer's recommendation.

1.5.8 The butt fusion machine used to join sections of HDPE pipe shall have controls and gauges for setting pressures and temperatures used for facing, heating, and fusing.

1.5.8.1 Facing should be conducted at a pressure that produces properly faced pipe ends.

1.5.8.2 Heating pressure should be set so that the pipe ends maintain contact against the heater, but are not forced against the heater (zero contact pressure).

1.5.8.3 Fusing pressure shall be as recommended by the pipe manufacturer and fusion equipment supplier.

1.5.8.4 Heater surfaces must be clean and free of contaminants such as dirt, oil, grease, and melted or charred plastic. To clean the heater, only wooden implements and clean, dry, lint-free non-synthetic cloths should be used.

1.5.8.5 The heater should be checked periodically for uniform surface temperature using a surface pyrometer.

1.6 Directional Bore Pipe

1.6.1 Pipe shall be High Density Polyethylene (HDPE) as per AWWA C906.

1.6.2 Carrier: HDPE pipe shall be DR 11, working pressure rating of 160 psi, 4 to 24 inches. The following are approved pipe manufacturers:

- Rinker Polypipe (USA)
- JM Pipe (USA)
- Charter Plastics (USA)
- CP Chem Performance Pipe (USA)

1.6.3 Material for pipes to be used for potable water application shall be approved by the National Sanitation Foundation (NSF).

1.6.3.1 All material must be inspected by Water Utilities Engineering 2 (two) full working days before the bore begins.

1.6.3.2 All pipe and fittings, sizes 4 inch and larger shall meet the requirements of AWWA Standard C 906-90 (or most recent revision).

1.6.3.3 All pipe and fittings shall be ductile iron pipe size.

1.6.3.4 All pipe and fittings shall meet the requirements of ANSI NSF Standard 61.

1.6.3.5 All pipe and fittings shall be made of materials conforming to polyethylene code designation PE 3408.

1.6.3.6 Standard dimension ratio shall be DR11.

1.6.4 Color Coding: The piping shall be permanently coded to provide service identification. Stripes along the entire outside length of the pipe, 120 degrees apart, shall be made by co-extrusion or impregnation in accordance with the following schedule. Fully colored pipe co-extruded from permanently pigmented HDPE is also acceptable.

<u>SERVICE</u>	<u>STRIPED PIPE</u>	<u>SOLID-COLORED PIPE</u>
Potable Water	Blue stripes	Blue
Reclaimed Water	Purple stripes	Purple
Wastewater	Green stripes	Green

- 1.6.5 Markings on the pipe shall include the following:
- Nominal size and OD base.
 - Standard material code designation.
 - Dimension.
 - Pressure class.
 - AWWA designation (AWWA C906).
 - Material test category of pipe.
- 1.7 Drilling Fluid (“MUD”)
- 1) All drilling fluid must be homogenous in nature
 - 2) All drilling fluid must have a pH of 8.5 to 10.0
 - 3) “Mud” viscosity must meet minimum viscosity as set by the manufacturer for soil conditions expected to be encountered
 - 4) Contractor shall have appropriate additives for drilling fluid available for different soil conditions (clay, sand, silt, etc.) that may be encountered.
- 1.8 Tracer Wire
- 1.8.1 All piping shall be installed with a continuous, insulated, solid #4 gauge copper wire for water main, force main, or reclaimed location purposes by means of an electronic line tracer.
- 1.8.2 The wire insulation shall be solid color in accordance with the coding described in 1.6.4 above. Blue coated (for water mains), or purple (for reclaimed water), or green coated (for wastewater), 2 (two) wires must be taped along all pipes. See City of Lakeland Standards and Specifications for detailed tracer wire requirements, including gauge size.
- 1.8.3 Upon completion of the directional bore, the CONTRACTOR shall demonstrate to the CITY that the wire is continuous and unbroken through the entire run of the pipe by providing full signal conductivity (including splices) when energizing for the entire run in the presence of the INSPECTOR. If the wire is broken, the CONTRACTOR shall repair or replace it. See Paragraph 2.2.12.
- 1.9 Fittings, Restrainers, and Valves
- 1.9.1 Pipe flange joints shall be made using a flange adapter which is butt fused to the HDPE pipe.
- 1.9.1.1 A back-up ring shall be fitted behind the flange adapter sealing surface flange for bolting to the mating flange. Standard back-up rings shall be AWWA C207 Class D for 160 psi and lower pressure ratings.
- 1.9.1.2 One edge of the back-up ring must be chamfered to fit up against the back of the sealing surface flange.
- 1.9.2 Mechanical joints to polyethylene pipe shall be fully constrained by compressing the pipe OD against a rigid tube or stiffener in the pipe bore.
- 1.9.2.1 The stiffener shall be stainless steel.

1.9.2.2 Approved joint restraining devices are Mega-Lug and Mechanical Joint Restrainer (MJR).

1.9.3 Valves

1.9.3.1 All directional bores shall have a valve installed at each end of the bore pipe. The size of valves shall be in accordance with the size of the bore pipe.

1.9.3.2 All valves shall meet standards set forth by the latest edition of the City of Lakeland, Water Utilities Department Water Operations Policies, Standards, & Specifications for Subdivisions and Commercial Development.

1.10 Maintenance of Traffic

1.10.1 The maintenance of traffic, in accordance with the governing right-of-way authority and the Florida Department of Transportation (FDOT) Policies and Procedures, shall be the responsibility of the CONTRACTOR.

1.10.2 If the CONTRACTOR has the capability within his organization; he shall provide the necessary personnel and equipment for maintenance of traffic. Persons participating in maintenance of traffic operations must be FDOT qualified and copies of their certificates verifying their qualifications shall be provided to Water Utilities Engineering prior to start of the directional work.

1.10.3 If the CONTRACTOR is unable to provide the required maintenance of traffic; he shall subcontract the work to supply the necessary personnel and equipment. The use of a subcontractor's personnel and equipment shall in no way transfer the responsibility for the maintenance of traffic from the CONTRACTOR.

2.0 CONSTRUCTION REQUIREMENTS

2.1 General

2.1.1 All directional bore operations shall be contained within right-of-way and / or easements shown on the DRAWINGS.

2.1.2 Work shall not start until the CONTRACTOR has all necessary permits from the appropriate governing regulatory agencies, including the City of Lakeland Public Works Engineering group, and not until Water Utilities Engineering has been given 2 (two) working days prior notification to inspect construction materials. Any material may be rejected if out of specification or damaged (i.e. out-of-round, deep cuts, etc.).

2.1.3 CONTRACTOR shall not begin drilling operation until the INSPECTOR is present. The INSPECTOR must be present during the entire boring operation once the ground is penetrated.

2.1.4 The CONTRACTOR is to schedule the directional bore such that the INSPECTOR is on site and that the bore is completed before 4:00PM. Directional bores shall not start after 1:00PM or subject to permit conditions unless approved by City of Lakeland Water Utilities Engineering and permitting agency.

2.2 Contractor Responsibilities

2.2.1 The CONTRACTOR shall provide the following materials and services for directional bore unless otherwise specified by OWNER / DEVELOPER:

- Traffic control.
- Tracer wire for carrier pipe per City of Lakeland Water Utilities Standards and Specifications
- Site preparation and excavation.
- Dewatering – Groundwater Pump or Well Point System as needed.
- Sheeting and shoring, as necessary.
- All fusion welding.
- Preliminary site restoration (fill open pits, grading).
- Site clean up including removal and proper disposal of all waste materials and drilling fluid.
- Must have a vacuum truck on job site for proper clean up of drilling fluid. This will be required as the conditions warrant or at the direction of the City.
- All HDPE fittings, couplings, and carrier pipe (unless otherwise specified).
- Final site restoration (sod, seed, mulch, concrete/ asphalt repair).
- Required Right-Of-Way Permits.

2.2.2 The CONTRACTOR shall record data on the bore log (see section 2.2.3) and shall also ensure the following items are monitored and controlled:

- Calibrate locator/tracking system
- Field verify calibration by field measurement of actual location of first rod
- Ensure that the flow of bentonite is continuous
- Ensure pulling pressure does not exceed pipe manufacturer's specifications
- Fusing of pipe is within pipe manufacturer's specifications
- Cool down time is calculated and complied with
- Pipe is fused prior to start of all bores.

2.2.3 The CONTRACTOR shall record location and depth measurements every ten (10) feet over the course of the bore and provide that data to the CITY. Data collected by the City inspector does not relieve the Contractor from the responsibility of recording his own data. The CONTRACTOR shall log all necessary data from the locator / tracking system:

- Position.
- Roll Angle.
- Tilt Angle.
- Depth – Every ten (10) feet.
- Temperature of Data Transmitter.
- Remaining Battery Life.
- Pull Back Force (Maximum pull back force shall be recorded).
- Drilling Fluid Pressure

- 2.2.5 An INSPECTOR for the CITY shall witness and verify the CONTRACTOR'S logging of pertinent data. The INSPECTOR may log his own data in the Department's own Directional Bore Log sheet for the City's use.
- 2.2.6 CONTRACTOR shall notify all involved agencies prior to start of construction. The CONTRACTOR is responsible for verifying that all permits are current and not expired. The CONTRACTOR shall notify the ENGINEER of Record and the CITY if expired.
- 2.2.7 The CONTRACTOR shall call "Sunshine State One-Call" (phone number: 800-432-4770) 2 full days prior to performing any excavation. The CONTRACTOR shall confirm the location of utilities before starting the directional bore. This shall be done by hand digging within the tolerance zone of marked utilities.
- 2.2.8 The CONTRACTOR shall perform directional bore in accordance with the approved project DRAWINGS. In no case shall the bore extend into private property unless an easement is provided prior to start of construction. Vertical tolerances shall be plus or minus 1 foot of elevations shown on drawings. Horizontal tolerances shall be plus or minus 1 foot of alignment shown in drawings. These tolerances shall be met unless required separations for other utilities must be met and puts the bore in conflict. Failure to meet tolerances, if not pre-approved by ENGINEER, may be grounds for rejecting the bore. The CONTRACTOR may, at the discretion of the ENGINEER, be required to abandon the bore and re-drill a new one at CONTRACTOR's own expense.
- 2.2.9 The CONTRACTOR shall provide all structures, safety equipment, and professional services required for the health and safety of the general public and of personnel involved in directional boring work in accordance with the requirements of the Federal, State, and Local Authorities. This includes proof of construction personnel certificates of trench safety training at the time of construction.
- 2.2.10 The CONTRACTOR shall take all measures necessary to protect surrounding public and private property, adjacent buildings, roads, drives, sidewalks, drains, sewers, utilities, trees, structures, and appurtenances from damage due to directional bore work.
- 2.2.11 The CONTRACTOR shall exercise due care at all times and shall not apply more than the safe pull force to the carrier pipe recommended by the ENGINEER. This shall be accomplished using an approved breakaway connector between the reamer and the pulling eye.
- 2.2.12 The CONTRACTOR shall install a blue coated tracer wire on all water carrier pipe and green coated tracer wire on all wastewater force main carrier pipe and purple for reclaimed water carrier pipe. The CONTRACTOR will be responsible to provide a tracer wire that tests positive for continuity the entire length of the bore prior to acceptance by the INSPECTOR.

- 2.2.13 The CONTRACTOR shall be fully responsible for all steerable, fluid lined directional boring operation. Any noticeable surface defects resulting from operation of this boring equipment shall be repaired by the CONTRACTOR at his expense. The CONTRACTOR is recommended to take preconstruction videos of the construction site to avoid unwarranted claims for damages resulting from the construction.
- 2.2.14 The CONTRACTOR shall meet all CITY insurance requirements, as defined by the City's Risk Management Department, when working in a right-of-way, using a right-of-way use permit.

2.3 Drilling Requirements

- 2.3.1 The horizontal alignment shall be as shown on the drawings, plus or minus 1 foot. The vertical alignment shall be as shown on the drawings, plus or minus 1 foot. If the CONTRACTOR cannot meet these tolerances for whatever reason, he shall confer with the ENGINEER prior to the start of the bore and the ENGINEER shall approve any changes.
- 2.3.2 The pipe shall have a minimum cover of 36 inches.
- 2.3.3 Compound curvatures should be minimized as the pulling force of the pipe may be significantly increased by the additional tensile stresses due to curvatures. This is limited by the maximum deflection as set forth by the HDPE pipe manufacturer or AWWA Standards, whichever is more stringent.
- 2.3.4 The entry angle should be 12° to 14° ideally (not to exceed 15°). Exit angle should be 6° to 12° (maximum) to facilitate the pullback operation and minimize capstan effect tensile stresses on the pipe.
- 2.3.5 Erosion and sedimentation control measures and on-site containers shall be installed to prevent drilling mud from spilling out of entry and/or exit pits.
- 2.3.6 Drilling mud shall be disposed of off-site in accordance with applicable local, State and Federal requirements and/or permit conditions.
- 2.3.7 Pilot holes shall be drilled on bore path with no deviation greater than plus or minus 1 foot horizontally or vertically from the design over a length of 100 feet. In the event that the allowable deviation is exceeded, the CONTRACTOR shall notify the ENGINEER/CITY, and the CITY may require the ENGINEER/DEVELOPER/CONTRACTOR to pull back and re-drill from a location along the bore path before the deviation. Contractor shall use appropriate reamer type (winged, fluted, barrel, etc) for expected soil conditions.
- 2.3.8 Upon successful completion of the pilot hole, the borehole shall be reamed to a minimum of 25 percent greater than the outside diameter of the pipe being installed. For bores with more than two radii of curvature (entrance and exit), the borehole should be reamed up to 50 percent larger than the outside diameter of the carrier pipe. Pre-reaming may be necessary dependent on size of material to be pulled.

All pipe to be pulled (6" and larger) shall be pre-reamed prior to pullback.

Additional passes for pre-reaming may be required for larger pipe. Incremental increases of 4"-6" shall be used as needed until appropriate bore hole size has been achieved.

Pre-reaming does not constitute pull back of product with final size reamer head attached. Pre-reaming must be accomplished with no product attached to the reamer head on all bore pipe 6" and larger. The bore product may be pulled back on final pass of pre-reaming, if the reamer head is no larger than 6" from the previous pass.

All bore pipe to be pulled back on final pass shall have a "breakaway" device installed. The breakaway limit shall be per Appendix B of this publication. These breakaway device limits shall be limited to DR 11 pipe only. These limits are not to be used with other types of pipes or materials.

2.3.9 The CONTRACTOR shall not attempt to ream at a rate greater than the drilling equipment and mud system are designed to safely handle. Normal rate of drilling should be between one to two feet per minute.

2.3.10 In the event of a drilling hole blowout, the CONTRACTOR shall be responsible for restoring to original condition any damaged property and cleaning up the environment in the vicinity of the blowout.

2.4 Pipe Installation

2.4.1 After reaming the borehole to the required diameter, the pipe shall be pulled through the hole. In front of the pipe shall be a swivel and barrel reamer to compact the borehole walls.

2.4.2 Once pullback operations have commenced, the operation shall continue without interruption until the pipe is completely pulled into the borehole. The frictional resistance is the highest just prior to movement and decreases with movement. When pullback ceases, frictional forces and drag forces increase due to the thixotropic nature of drilling mud. The mud starts to gel when it is undisturbed. Therefore, PULLBACK SHALL NEVER BE STOPPED, EXCEPT FOR DRILLING ROD REMOVAL, UNTIL THE PIPE IS COMPLETELY PULLED INTO ITS PERMANENT POSITION.

2.4.3 Adequate lengths of pipe shall be provided at both the launching and receiving ends to facilitate service connection assemblies.

2.4.4 After pullback, pipe may take several hours to recover from the axial strain. When pulled from the reamed borehole, the pull-nose should be pulled out 3-4 percent longer than the total length of the pull to avoid having the pull-nose sucked back below the borehole exit level due to stretch recovery and thermal contraction to an equilibrium temperature.

2.4.5 The pipe entry and exit area shall be graded as needed (by contractor) to provide support for the pipe and to allow free movement into the borehole. The pipe shall be guided into the borehole to avoid deformation of, or damage to, the pipe.

- 2.4.6 The pipe shall be installed in a manner that does not cause upheaval, settlement, cracking, and movement or distortion of surface features. Any damages caused by the CONTRACTOR's operations shall be corrected by the CONTRACTOR.
- 2.4.7 In the event that unexpected subsurface conditions impeding drilling operations are encountered, the procedure shall be stopped and not continued until the CITY has been consulted. The pipe which has already been pulled into the hole shall be pulled back through the borehole using slings and whatever equipment is available on site to avoid damage to the pipe and having the drilling mud set up around the pipe.
- 2.4.8 If the final grade of the finished bore is not satisfactory to the CITY or any other jurisdictional entity, the pipe shall be abandoned, fully pressure grouted in place in accordance with the jurisdictional entity, and an alternate installation shall be made. The abandoned pipe shall be properly shown on "as-built" drawings to be submitted following conclusion of the construction work.
- 2.4.9 The INSPECTOR shall inspect the installed pipe for roundness and / or damage. Evidence of over-pulling or significant surface scratching shall be brought to the attention of the ENGINEER and the CITY. Deformations of more than 10 percent may be grounds to abandon the bore and have the CONTRACTOR re-drill another line.

2.5 Butt Fusion Procedure

- 2.5.1 Fusion welds shall be performed by an experienced technician that has been properly trained to meet the pipe manufacturer's procedures. All welds shall meet the pipe manufacturer's recommendations.
- 2.5.2 As the pipe ends are melted against the heater during the heating period, the molten plastic will swell and form small melt beads around the pipe ends. The melt beads should be the same size on both pipe ends, and uniformly sized all the way around.
- 2.5.3 After pre-heating has been completed, the ends should be separated just enough to remove the heater, observed for uniformity of the beads and quickly (within three seconds) brought together with the recommended fusion pressure.
 - 2.5.3.1 If melted plastic sticks to heater, the two ends should not be joined. The ends should be allowed to cool and the procedure started over.
 - 2.5.3.2 Excessive pressure should not be used as this will squeeze too much melt out of the fusion area and result in a weakened joint. The resulting bead should be approximately twice as wide as it is tall and the "V" between beads should be approximately half as deep as of the height of the beads.
- 2.5.4 The CONTRACTOR may do a preliminary pressure test on the completed string of pipe prior to installation. A pressure test shall be required on the completed directional bore prior to final acceptance.

- 2.6 Connecting Two Adjoining Sections of Directionally Bored Pipe
 - 2.6.1 If the overall length of the required utility installation can not be safely pulled using one directional bore, then the CONTRACTOR shall be required to make more than one pull to accomplish the installation.
 - 2.6.2 Where two adjacent pulls meet; the CONTRACTOR shall dig a pit and join the two sections together at the elevation of the two segments as if it were a continuous pull-in.
 - 2.6.3 The two sections of HDPE shall be joined together using an electrofusion coupling per the manufacturer's recommendations.
- 2.7 Qualifications for Rejection of Directional Bore
 - 2.7.1 If a City of Lakeland Water Utilities Line Inspector is not present during the entire bore.
 - 2.7.2 If the installed "Breakaway" devices should fail during pull back.
 - 2.7.3 If the drilling fluid is "lost" during the pull back of the product and can not be regained within the required timeframe of the manufacturer or if more than a reasonable amount of fluid is used to fill an unknown void and flow can not be regained. No pipe shall be pulled without visible flow of drilling fluid.
 - 2.7.4 If the pipe shall fail a hydraulic pressure test as specified by the manufacturer.
 - 2.7.5 If at any time when the product is pulled back and any exposed areas have a greater than allowable "gouging" or visible marring of the pipe.
 - 2.7.6 If the vertical and horizontal limits are not within tolerances, this may be cause for rejection of bore.
 - 2.7.7 Any other defect in material or workmanship which would affect the quality, performance, or installation life of the installed pipeline.

3.0 POST-CONSTRUCTION

- 3.1 General
 - 3.1.1 The as-built variance from the specified bore path shall not exceed plus or minus 1 foot in the vertical plane and plus or minus 1 foot in the horizontal plane.
 - 3.1.2 The CONTRACTOR shall be considered as having completed the requirements of the directional bore when he has successfully completed the work, including pressure testing, to the satisfaction of the DEVELOPER/OWNER's ENGINEER and the CITY INSPECTOR.
 - 3.1.3 The completed HDPE water main or force main shall be pressure tested at 150 psig for two hours for final acceptance and the pressure shall not fall below 145 psig during the test period.

3.1.4 Pressure testing shall occur after installation and shall be pressured to 160 psig, adding water as needed to maintain pressure. When the pressure stabilizes, the pressure shall be maintained for three hours. After three hours, the pressure should be reduced to 150 psig and tested at 150 psig for two hours.

3.2 As-Builts

When the directional bore is completed, the CONTRACTOR shall provide data log sheets and marked up as built drawings to the INSPECTOR, and the DEVELOPER/OWNER's ENGINEER, as required.

APPENDIX A DIRECTIONAL BORE DESIGN FACTORS

Calculations for computing the maximum safe pullback force should be submitted with the project design package.

The following equations from the PLEXCO Polyethylene Industrial Piping Systems; "Technical Information; Technical Note: Horizontal Directional Drilling (Guided Bore) with PLEXCO Pipe", are presented for estimating some, but not all of the factors to be considered in designing a successful directional bore. They are based upon approximations and are for "ideal" conditions. They are by no means all of the considerations to be used in designing a directional bore.

The designer is totally responsible for the design of the directional bore and use of the following shall not transfer any of that responsibility to the CITY. The CITY makes no claim to the accuracy or completeness of the equations.

- (a) **PULLBACK FORCE:** The pullback force is calculated at the leading end of the pipe behind the pulling head. For pipe pulled in straight level bores, the frictional resistance or required pulling force, F_p , is approximated by:

$F_p = \mu \times w_B \times L$, Where μ is the coefficient of friction between pipe and ground; w_B is the net downward or upward force on the pipe (lb/ft); and L is length (ft).

- (b) **FRictional RESISTANCE OF DRILLING MUD:** The frictional resistance is highest just prior to movement and decreases with movement. When pullback ceases, frictional forces and drag forces increase due to the thixotropic nature of drilling mud. The mud starts to gel when it is undisturbed. Therefore, pullback should never be stopped, except for drilling rod removal, until the pipe is completely pulled into its permanent position.

(c) **BOUYANT FORCE:** The pullback force will depend on whether the pipe is full or deliberately weighted to reduce buoyancy. Buoyant force pushes the pipe up against the top of the borehole, creating frictional drag between the pipe and the borehole. The buoyant weight of the pipe is, $F_b = (\gamma_b \pi D^2)/576 - w_a$. Where: D = pipe outside diameter, γ_b = specific weight of the mud slurry (lb/ft³), and w_a = weight of empty pipe.

- (d) **MINIMUM RADIUS OF CURVATURE:** Drill path curvature, at the entry and exit pits, is limited by the steering capabilities of the boring equipment. Drilling rod typically has a recommended bend radius of $1200 \times D_{ROD}$, where D_{ROD} is the nominal rod diameter. When the bending radius is around $150 \times D_{PIPE}$ or less, the safe pulling strength of PE pipe may be significantly reduced by the additional tensile stresses due to curvature.

- (e) **CAPSTAN EFFECT:** For pipe pulled around a curve (vertical or horizontal) creating an angle, θ (in radians), the capstan effect, $F_c = e^{\mu\theta}(\mu w_b L)$

Where: μ = coefficient of friction between pipe and slurry or pipe and ground,
 w_b = net downward (or upward) force on pipe (lb/ft),
 e = natural logarithm base ($e = 2.71828$), and
 L = length (ft).

- (f) **SAFE PULL FORCE:** The safe pull stress, σ_{SP} , may be calculated by subtracting the bending stress due to curvature from the allowable tensile stress:

$$\sigma_{SP} = \sigma_{allow} - \frac{(E \times D)}{2r}$$

The "safe pull force" can be found by multiplying the safe pull stress by the cross-sectional area of the pipe.

Where: σ_{allow} = allowable tensile stress (psi), D = outer diameter of pipe (in), DR = Dimension Ratio, and E = time-dependent modulus of elasticity (psi) from tables.

- (g) **NET SAFE PULL FORCE:** All tensile stresses due to various curvatures in the boring path are additive and should be subtracted from the safe pull force.
- (h) **TIME DEPENDENCE:** The “safe” pull-load is time dependent. See ASTM F-1804 for safe pullback values for PE pipe, less bending stresses.

For additional sources of information, the designer is referred to the following reference sources:

Mini-Horizontal Directional Drilling Manual (1995), North American Society of Trenchless Technology (NASTT), Chicago, IL

PPI Handbook of Polyethylene Piping (1998), Plastics Pipe Institute, Washington, D.C.

**APPENDIX B
DIRECTIONAL BORE GUIDELINES**

Directional Bore – Safe Pull Strength (for DR11, DIP Size HDPE)

Pipe Size (inches)	Safe Pull Strength (lbs)	Max. Breakaway Strength (lbs)	Minimum Bend Radius (in)	Wall Thickness (in)	Maximum Defect Depth
4	7,600	7,500	96	.36	1/16
6	15,800	15,000	138	.55	1/11
8	27,200	27,000	181	.73	5/32
10	41,000	40,000	222	.91	3/16
12	57,900	57,000	264	1.10	1/4

- Schedule the bore with Water Utilities 48 hours (2 working days) prior to boring
- If bore is over 100 linear feet, contractor needs to fuse pipe together the day before
- Contractor needs to physically locate existing utilities, following the 48 hour Sunshine One-Call Guidelines
- Material Inspection: To be done before the bore is scheduled.
- Surface cuts or scratches greater than or equal to maximum defect depth are not acceptable
- Blue stripe or Blue Extruded for Water
- Green stripe or Green Extruded for Sewer
- Purple stripe or Purple Extruded for Reclaimed Water
- #10 gauge solid strand – (2) wires attached to pipe

Performing the bore:

- Set up the bore log
- Calibrate Contractor’s locator with actual depth measurement – check the depth of the first rod
- Ream the bore hole
- Check the flow of bentonite – must be continuous
- Check the pulling pressure
- Do not allow operator to exceed safe pull strength
- Mark up drawing with “As-Built” data
- Record pull back pressure
- Fuse DR11 together – minimum 440° F to maximum 460° F
- Cool down time (min/ weld) equals: Pipe Diameter ÷ 2

**City of Lakeland Water Utilities
Directional Bore Log**

Project Name: _____

Project Number: _____ **Date:** _____

Contractor/Site Representative: _____

Bore Location/Number: _____ **Size/Material:** _____

Starting Location: _____ **Bore Rod Length:** _____

	Total Length Bored	Distance from Start Point	Depth	Pull Back Pressure	Drilling fluid Pressure	Comments
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.						
23.						
24.						

***Lengths to be measured in rod length increments**

Inspector/City Representative: _____ **Contractor:** _____