OVERVIEW AND INTRODUCTION OF TRENCHLESS INSTALLATION WITHIN MDOT RIGHT-OF -WAY

October, 2006

1 General Description of Trenchless Methods

1.1 Available Technologies

This document describes some of the popular trenchless technologies and how can inspectors, engineers, and contractors use these technologies correctly and avoid pavement damage. The methods discussed in this document include:

1. Horizontal Auger Boring (HAB)
2. Pipe Ramming
3. Pipe Jacking
4. Horizontal Directional Drilling (HDD)
5. Microtunneling
6. Pipe Bursting

The methods listed above are becoming more commonly used, particularly HDD, HAB and pipe bursting. However, it is important to include the appropriate MDOT central office and/or region staff specialists in the review process. This can help to ensure the proposed technique is appropriate for the soil conditions and location

1.2 Descriptions of Methods

Horizontal Auger Boring: A technique for forming a bore from a drive pit to a reception pit, by means of a rotating cutting head. Spoil is removed back to the drive shaft by helically wound auger flights rotating in a steel casing. The equipment may have limited steering capability. See Guided Horizontal Auger Boring (Figure 1.2.1).

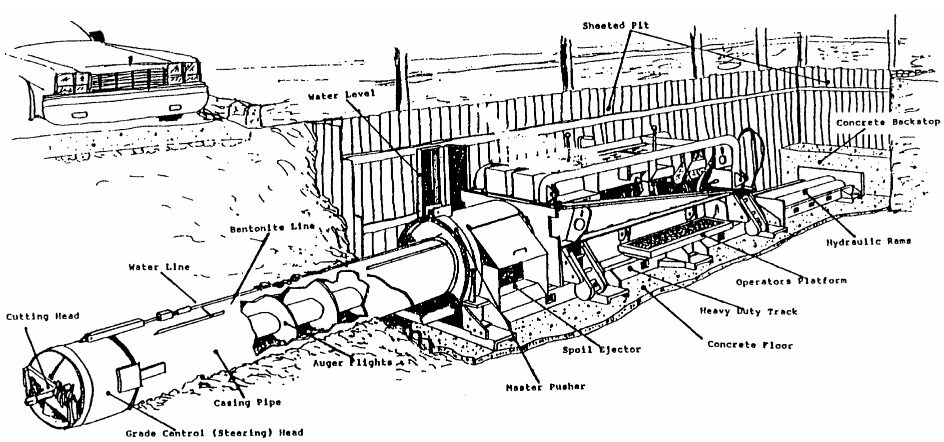

Figure 1.2.1 Horizontal Auger Boring

Pipe ramming: A technique for installing steel casing from a drive shaft to a reception shaft utilizing the dynamic energy from a percussion hammer attached to the end of the pipe. A continuous casing support is provided and over-excavation or water is not required. This is a 2-stage process (Figure1.2.2).

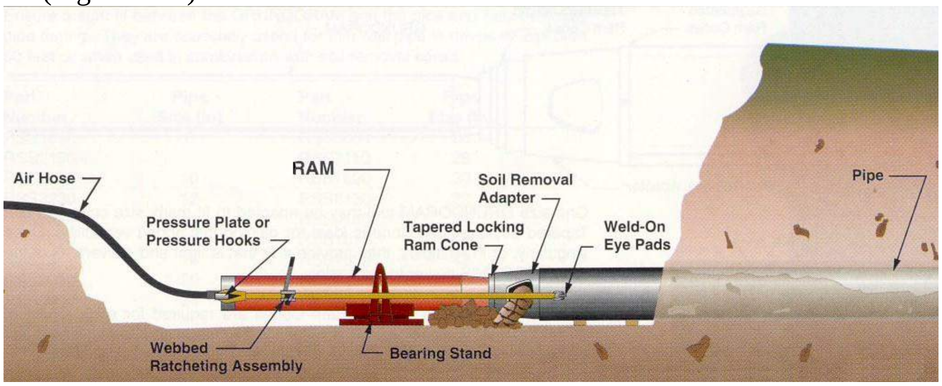

Figure1.2.2 Pipe Ramming

Pipe jacking: A system of directly installing pipes behind a Shield Machine by hydraulic jacking from a Drive Shaft such that the pipes form a continuous string in the ground. Usually personnel are required inside the pipe to perform the excavation or spoil removal process. The excavation can be performed manually or mechanically (Figure 1.2.3).

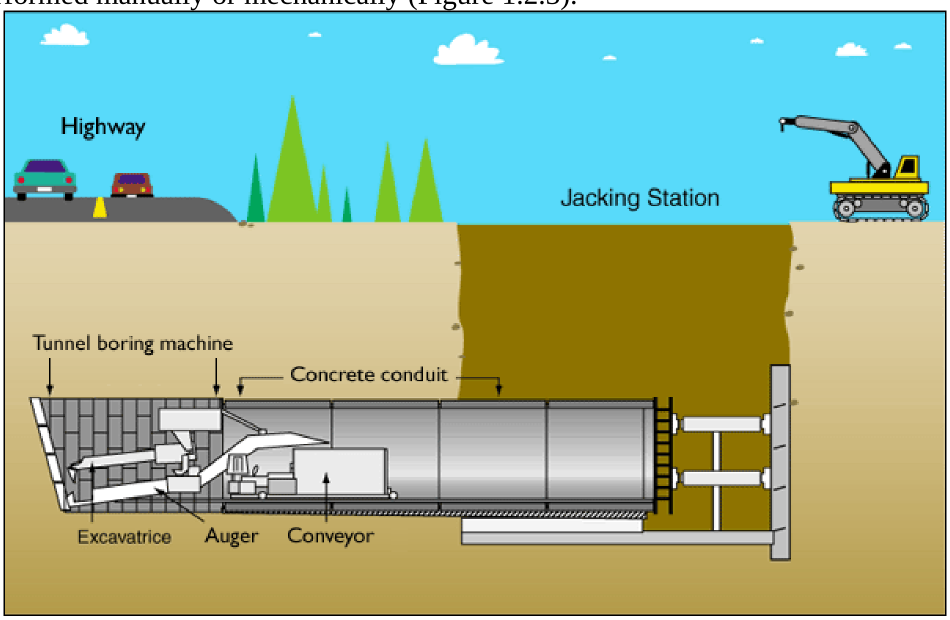

Figure 1.2.3 Pipe Jacking

Horizontal directional drilling: A steerable system for the installation of pipes, conduits, and cables in a shallow arc using a surface launched drilling rig. Traditionally HDD is applied to large scale crossings such as rivers in which a fluid filled pilot bore is drilled without rotating the drill string, and this is then enlarged by a wash over pipe and back reamer to the size required for the product pipe (Figure 1.2.4).

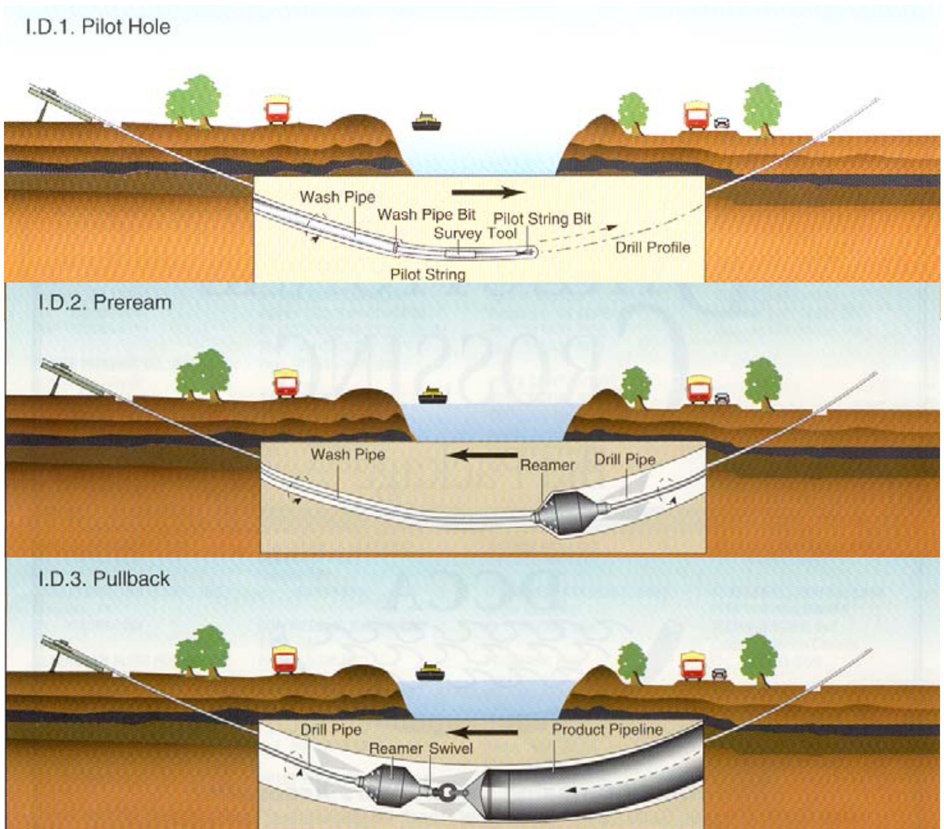

Figure1.2.4 Horizontal Directional Drilling

Microtunneling: A trenchless construction method for installing pipelines with the following features (Figure 1.2.5):

- Remote Controlled – The Micro Tunnel Boring Machine (MTBM) is operated form a control panel, normally located on the surface. It simultaneously installs pipe as spoil being excavated and removed.
- Guided – The guidance system usually refers to a laser beam projected onto a target in the MTBM, capable of installing gravity sewers or other types of pipeline to the required tolerance for line and grade.
- Jacking Pipe – The process of constructing a pipeline by consecutively pushing the MTBM through the ground using a jacking system.
- Face Support – Continuous pressure is provided to the face of the excavation to balance groundwater and earth pressure.

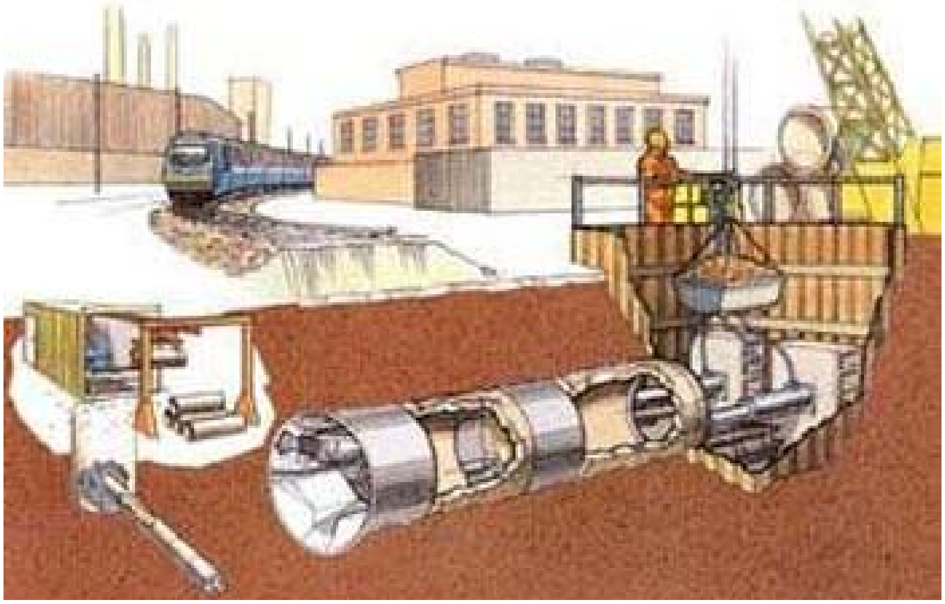

Figure 1.2.5 Microtunneling

Pipe bursting: A technique for breaking existing pipe by brittle fracture, using force from within, applied mechanically. Pipe remains are forced into the surrounding soil. At the same time a new pipe, of the same or larger diameter, is drawn behind the bursting tool (Figure 1.2.6).

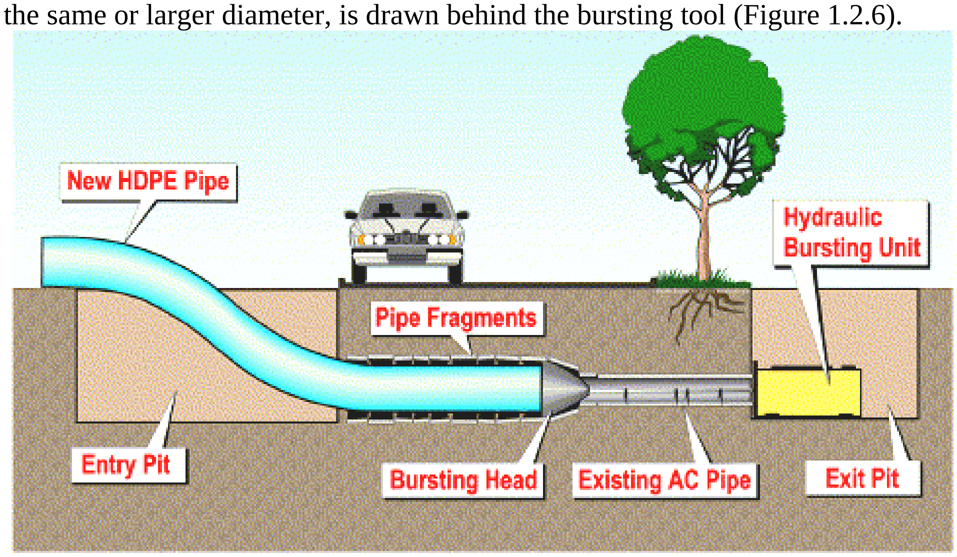

Figure 1.2.6 Pipe Bursting

1.3 Advantages and Limitations of Trenchless Technology

As technology advances, the ability to perform trenchless utility installation and maintenance will also advance, allowing a progressing greater proportion of such work to be completed without trenching through the pavement structure.

To this end, this document presents basic information about the methods, material, equipment, and applications available for use in trenchless utility construction, and provides insights into conditions and situations where trenchless applications would not be appropriate, thus requiring trenching operations. It should be recognized that there are many conditions where trenchless applications are not appropriate, such as emergencies, where immediate trenching of the pavement is necessary, and advanced planning simply cannot be done. In other cases, conditions such as the nature of the soils and rocks below the surface, or the presence and/or uncertain location of existing utilities preclude the use of trenchless technology.

2 Summary of Methods

This section provides a summary of information on all the methods described in the previous section. This section includes the following discussions:

- Selecting the appropriate methods based on type of construction and type of utility.
- Advantages and limitations of each method.

These sections are intended to provide additional information to help agencies and contractors to determine the most appropriate method of trenchless technology, or if trenching is indeed the most appropriate method of utility construction. This is not a complete catalog of methods and applications, and the reader should consult references and a trenchless technology contractor for a detailed analysis of a particular situation.

2.1 Appropriate Method for Utility Installation

This section provides information on the various trenchless methods and their applicability to the individual types of utilities and types of construction. The four major types of construction include:

- New installation
- Online replacement
- Renovation
- Repair and maintenance

These Additional Conditions have a focus on new installation methods, including six major applications: Horizontal Auger Boring, Pipe ramming, Pipe jacking, Horizontal directional drilling, Microtunneling, and Guided boring. Also, Pipe bursting in the category of online replacement is considered in order to fit the need of MDOT inspection practice.

The technique selected also depends on the type of utility, including:

- Water
- Sanitary and Storm Sewers

- Gas
- Electricity
- Telecommunications (including cable television)

The trenchless technology methods most suited for the construction and utility type are shown in the following table, which are limited by construction type: new installation (Table 4.1.1).

Table 2.1.1 Appropriate Techniques for Trenchless New Installation.

TECHNIQUE	Water	Sanitary and Storm Sewers	Gas	Electricity	Telecommunications
Horizontal Auger Boring	√		√	√	√
Pipe Ramming	√	√	√	√	√
Pipe Jacking		√			
Directional Drilling	√	√	√	√	√
Microtunneling		√			
Pipe Bursting	√	√	√		

Restriction on the construction method could include, among others, ground conditions, availability of trenchless technology contractors and equipment, cost, safety, and the technical feasibility of the various methods desired. The appropriate techniques in the preceding tables are only recommendations, and should not be taken as absolute.

Standard pipe sizes, bore lengths, and depths are also a consideration in determining the appropriate method. Table 4.1.2 provides an indication of the range of depth, length and diameter of the various methods.

Table 2.1.2 Range of Application for Trenchless New Installation

Range of Application			
Method	**Depth**	**Length**	**Diameter**
Horizontal Auger Boring	≥4 ft	40-600 ft	8-60 in
Pipe Ramming	Minimum 1 ft/in diameter	40-200 ft	4-42 in
Pipe Jacking	Varies	No theoretical limit- 1600 ft	42-120 in
Maxi and Midi HDD	<160 ft	400-600 ft	3-54 in
Mini HDD	<50 ft	40-60 ft	2-14 in
Microtunneling	>60 in	80-1500 ft	10-120 in
Pipe Bursting	>30 in	300-400 ft	2-48 in

As described above, the range of application guidelines in the previous table should be used as a general guide in determining an appropriate method for trenchless construction. As technology improves within the various methods, each may expand its range of depth, length, and diameter application.

Select materials approved for installation within the right-of-way based on their suitability for the construction method as defined in Table 2.1.3.

Table 2.1.3 CHARACTERISTICS OF TRENCHLESS CONSTRUCTION METHODS

Type[1]	Pipe/Casing Installation Mode	Suitable[2] Pipe/Casing	Soil Excavation Mode	Soil Removal Mode
HAB	Jacking	Steel	Mechanical	Augering
PR	Hammering/Driving	Steel	Mechanical	Augering, Hydraulic, Compressed Air, or Compaction
PJ	Pipe Jacking	Steel, RCP, GFRP	Manual or Mechanical	Augers, Conveyors, Manual Carts, Power Carts, or Hydraulic
HDD	Pulling	Steel, PVC, HDPE	Mechanical and Hydraulic	Hydraulic, Mechanical Reaming and Compaction
MT	Jacking	Steel, RCP, GFRP, PCP, VCP, DIP	Mechanical	Augering or Hydraulic (Slurry)
PB	Pulling	(Steel, Clay, HDPE, MDPE[3]) (Clay, Plain Concrete Pipe, RCP, Steel, PVC, ACP, DIP[4])	Mechanical	Compaction

[1] HAB- Horizontal Horizontal Auger Boring; PR- Pipe Ramming; PJ- Pipe Jacking; HDD- Horizontal Directional Drilling; MT- Microtunneling; PB- Pipe Bursting

[2] Steel-Steel Casing Pipe, RCP- Reinforced Concrete Pipe, GFRP- Glass-Fiber Reinforced Plastic Pipe, PCP- Polymer Concrete Pipe, VCP- Vitrified Clay Pipe, DIP- Ductile Iron Pipe, PVC- Polyvinyl Chloride Pipe, HDPE- High Density Polyethylene Pipe, MDPE- Mid Density Polyethylene Pipe, ACP- Asbestos Cement Pipe

[3] For new pipe of pipe bursting

[4] For host pipe of pipe bursting, including all materials breakable practically

2.2 Advantages and Limitations of Methods

This section summarizes the advantages and limitations of the various trenchless technology applications. In general, all trenchless technology applications have the common advantage of reducing the impact to the surface, and to pavement structures. Although some city ordinances consider directional drilling or microtunneling to be a disruption to the pavement structure, the surface of the pavement is generally not impacted.

Other benefits include reduced impacts to traffic, and the other costs or impacts associated with traffic congestion. Although this section includes some reference to cost and safety, they are only made as they relate to the advantages and limitations of the particular method. These will be discussed in more detail in later sections.

2.2.1 Horizontal Auger Boring

Horizontal Auger Boring has decreased risk of disrupting the surface either by subsidence or heaving, but an experienced operator is necessary to minimize the risk. Horizontal Auger Boring can be used in a wide range of soil conditions. Horizontal Auger Boring can be used to install any type of pipe or cable.

Horizontal Auger Boring is generally unsteerable, however some basic steering systems are available. It also requires entry and reception shafts. As with any trenchless technology application, a thorough site investigation is recommended, primarily to identify obstacles such as large boulders and soft ground. Horizontal Auger Boring can accommodate larger rocks, up to one-third the diameter of the casing. In Horizontal Auger Boring, the casing should be made of steel, to accommodate the steel augers turning inside the casing. Subsidence is a minor risk in Horizontal Auger Boring. There is a greater risk of heaving, however, in Horizontal Auger Boring if excessive force applied at the excavation face.

2.2.2 Pipe Ramming

Pipe ramming operation is generally much simpler to operate than other trenchless applications. Due in part to the simplicity of the methods, it is generally less expensive than other operations as well. Pipe ramming allows larger casings to be installed in a wide range of soil conditions. In open-faced pipe ramming, the casing is fully supported throughout the driving operation, does not present the risk of over excavation, and does not require fluid for the excavation.

Most state highway agencies do not consider pipe ramming in their Additional Conditions explicitly, but experience has found that many do not oppose the method. Operations in hard soils can be difficult, including the risk of deflecting the lead pipe off course due to large rocks, changing soil characteristics, or other obstructions. Rammed pipes have little to no steering control, and are used primarily for straight-line bores. Both types present the risk of damaging existing utilities, as do other methods of trenchless technology.

2.2.3 Pipe Jacking and Microtunneling

If used properly, both pipe jacking and microtunneling can have a low risk of surface disruption. Subsidence can be kept to about 1 in. Pipe jacking has been in use for over 100 years, thus providing a long history of success and much experience in the industry. Curved, steered bores are possible, although the radius of curvature depends on the equipment and the product materials.

As with most trenchless applications, pipe jacking and microtunneling require a skilled operator who can make adjustments based on almost imperceptible changes in the operation of the machines. Again, a through site investigation is essential to the success of the project. Access shafts are required at both ends of the drive. Soil characteristics can have a significant effect on the choice and application of pipe jacking systems, including the bore face excavation, which must be properly supported to prevent sudden collapse. Since the definition of pipe jacking compared to microtunneling is that workers are present in the jacked pipe, the safety of the operators is important. Pipe jacking systems require pipes that can transmit the jacking forces expected in the operation.

Typically the minimum depth of cover is 6 feet or 3 times outside diameter of installed pipe, whichever is greater. However, the actual depth of cover shall be determined by the applicant's design engineer and reviewed/approved by the MDOT Engineer/ Inspector.

In locations where the road surface is super elevated, the minimum depth of the bore shall be measured from the lowest side of the pavement surface.

2.2.4 Horizontal Directional Drilling

In general, the advantages of HDD are similar to those of the entire trenchless technology industry. HDD allows for rapid installation, and relatively large pipelines can be installed over long distances. HDD can be made accurately, and safety is greatly improved when used in conjunction with subsurface utility engineering. Line and level available is controllable. Mini-HDD equipment is portable, self-contained, and is designed to work in small, congested areas.

Limitations on HDD include the amount of space required to develop the underground access points. A relatively large area may be required for the drilling rig and associated equipment at the drill entry point. Another large area is generally required at the drill exit point, although surface-entry operations can reduce the need for access shafts. Other limitations include the possibility that the bore may collapse in some granular soils and gravels and lose its steering ability in soft soil. Ground movement must be considered, especially in midi- and maxi-HDD applications. The pressure and high flow rates of the drilling fluid can cause some excess soil to erode, which leaves a void outside the installed pipe, which may eventually collapse. Additionally, pressure may cause the drilling fluid to flow into a soil stratum as the drilling head advances, potentially causing heaving of that soil layer. Drilling fluid can also seep to the surface in shallow cover. Other limitations include excessive torque and thrust applied to the drill stem, especially in curving boreholes, which can cause drill stem failure in mini-HDD application.

2.2.5 Pipe Bursting

Advantages of pipe bursting for in-line pipe replacement include the fact that the alignment of the pipe is already established. This type of operation also provides the flexibility of maintaining or increasing the pipe capacity. Compared to open trench operations, the progress of pipe bursting can be much greater. Also, compared to other trenchless operations, there is less vibration, so damage or other impact to nearby services and structures is minimized.

A limitation of this type of operation is that with bursting of the pipe, and its expansion radically outward, existing utilities can be damaged, if they are not well-defined and located prior to commencing construction. Surface displacement can be extensive, especially in shallow applications, or in less compactable soils. Also, where unexpected conditions are encountered, such as unrecorded repair collars or adverse soil conditions, the operation may need to be stopped and excavation may be required to get past the obstruction. Another condition that generally requires additional excavation is negotiating sharp bends in the existing pipe. Additionally, excavations must be made to connect the new pipe to the existing service.

2.3 Methods not approved for Road Crossing

Thrust boring: In thrust boring, a borehole is formed by applying axial thrust to solid or closed-end push rods. This action causes local compression and displacement of soil into the surrounding soil at the front of the system. Primary characteristics of the method are that it produces no spoil and the push rods are not rotated or impacted. Thrust boring is nonsteerable.

Impact Moling: The use of a tool which comprises a percussive hammer within a suitable casing, generally of torpedo shape. The hammer may be pneumatic or hydraulic. The term is usually associated with non-steered devices without rigid attachment to the launch pit, relying upon the resistance (friction) of the ground for forward movement. During operation the soil is displaced, not removed. An unsupported bore may be formed in suitable ground, or a pipe drawn in, or pushed in, behind the impact moling tool. Cables may be drawn in. Impact moling is nonsteerable (Figure 2.3.1).

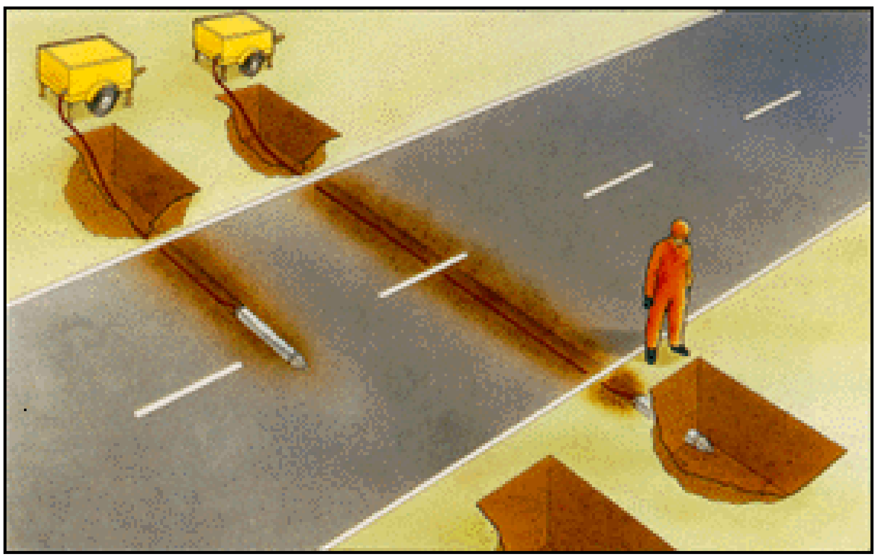

Figure 2.3.1 Impact moling

Wet/Slurry Boring: Wet boring is a technique that typically utilizes a small rotary drilling rig, a drill rod, and a drilling fluid. In a wet boring operation, a pneumatic- or hydraulic-operated drill rig simultaneously pushes and rotates hollow steel pipes through the soil from a launching pit. A cutting head or bit is attached to the lead end of the drill pipe. The drilling fluid is usually water or bentonite mud. The fluid is fed under pressure at a low rate- typically 5 to 15 gallons per minute- to the cutting bit. Spoil may be pushed back into adjacent soil if it is porous or compactable, or a mud slurry may return to the work pit through the annulus, where it is removed.

Water Jetting: A form of washing or wash boring the hole with low-pressure water, typically 60 to 100 psi in utility applications. Jetting or wash boring requires large volumes of water and is suitable only for soft materials, such as soils, loose sands, and soft clays. The erosion process of jetting often leaves irregular or washed-out hole sizes and may be difficult to control. Excessive soil erosion and overcutting issues are major problems of water jetting.

Blasting shall not be permitted under or on MDOT's right-of-way.

2.4 Potential Impacts on Pavements and Adjacent Utilities

Although trenchless technology methods of utility installation and maintenance generally impact the public and surrounding infrastructure to a lesser magnitude than utility cuts, there are some potential impacts that should be understood. Many of the trenchless methods described in these Additional Conditions have similar potential impacts, while others have unique impacts that should be considered when deciding on trenchless technology for a project:

- Bore hole collapse / subsidence.
- Access / reception pit excavation.
- Ground displacement / upheaval.
- Ground vibrations.
- Worker safety.

Loose, cohesion less, and granular soils are more susceptible to bore hole collapse if a casing is not placed immediately after excavation. Pipe jacking and Horizontal Auger Boring are most affected by this type of soil with respect to collapse or subsidence.

Pipe bursting can cause outward ground displacement along the pipe alignment. The displacement is typically localized, and their effects dissipate rapidly away from the bursting operation. Some causes for displacement or upheaval include:

- The pipe to be burst is shallow.
- The ground displacement is directed upwards.
- The new pipe diameter is significantly larger than that of the old pipe.

These displacements can also cause damage to nearby utilities if they are within two to three times the diameter of the new pipe.

Ground vibration can affect the surrounding soil and adjacent structures. This can be caused by pneumatic pipe bursting, as well as pipe ramming.