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	TRENCHLESS TECHNOLOGY GUIDELINES	THIRD EDITION
	ASSOCIATED TECHNOLOGIES, TECHNIQUES AND EQUIPMENT	LAST UPDATED NOVEMBER 2008

OVERVIEW

Other sections in these Guidelines cover what might be termed the 'pure' trenchless systems involving new installation or rehabilitation of buried systems or the mapping and assessment of existing networks with minimum disruption and excavation. However, running alongside these technologies is a family of systems that may not be deemed 'purely' trenchless but that certainly have a place in the greater 'buried service industry' that might not at first be obvious.

Systems and technologies have been developed, particularly in the first years of the 21st Century, which not only almost eliminate 'traditional' excavation but also utilise existing infrastructure as their installation route. So whilst not always being a direct lay or main stream renovation system, a new utility can be installed, sometimes within an existing conduit, whilst in some cases actually renovating the original conduit at the same time. This technology can also work 'the other way around' in that in some cases where a network of pipe is in need of renovation and a lining system can be used, the liner can be designed to carry secondary ducting that has a use for other, normally cable based, services. The following summarises some of these systems.

Also, whilst the rest of these Guidelines look at the specific technologies and techniques that form the greater family of trenchless technologies, this section will also look at the Ancillary and Support Services, Accessories and Backup Equipment without which these trenchless systems would not be able to operate successfully.

The section will also look at Training Courses and Qualifications, not so much from the individual course viewpoint but more as to how they fit into the global industry.

The section will finally overview the various types of equipment that are utilised throughout the construction industry in general that have specific use or specific adaptation to trenchless technologies.

Associated Technologies link (click link to see section):
Ploughing link Narrow Trenching link Vacuum/Keyhole Excavation link

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Horizontal Environmental Wells and Contaminated Ground Remediation link
Land Drains & Ground Stabilisation Bores link
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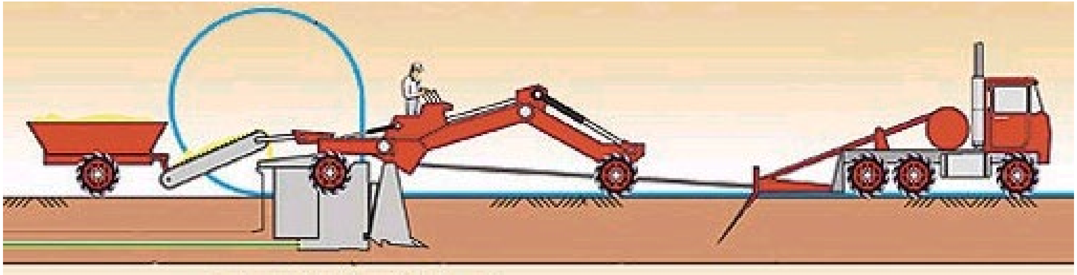
ASSOCIATED TECHNOLOGIES

PLOUGHING**:** Known as Mole Ploughing or Cable Plowing, such installations are normally found to operate best in open expanses of ground. For example a field system that needs to be crossed by an long distance overland pipeline or where roadside verges are of sufficient width to accommodate the equipment required whilst having few existing crossing services are typical. The equipment used for this is effectively, as the name suggests, a ploughing unit. In this case the unit is specially designed to open a 'furrow' at the depth required for the installation of the new pipeline, conduit or cable that is sized slightly larger than the utility diameter but no bigger so as to minimise the impact of the opening on the landscape. The new service is fed through the machine, either directly off a coil on the unit or from a coil trailer or laid-out alongside the plough run. As the plough opens up the 'furrow', the 'spoil' is moved to one side of the plough unit. The service is fed directly into the ground along the base of the 'furrow' as the plough advances, onto a trench bedding layer if the unit is designed to apply such materials. The plough design then pushes the 'spoil' back into the 'furrow' as the machine passes immediately burying the newly placed service.

In most cases, the system is used for pipes or cables that are not required to be very accurate to line and level. Therefore pipe installations are normally associated with pressure networks. The system can also only be used with pipe with sufficient flexibility to be installed in the relative tight curves required using the machines.



A schematic of the Ploughing technique.
Picture courtesy of the Drill-n-Plow Trenchless Alliance.

In some cases, as the machine passes and refills the ploughed 'furrow', very little evidence of the machine's passing can be seen.

The ploughing technique is especially suitable for easily displaceable soils where there is a favourable gradation of the soil mix so that cavities containing coarse fractions can be filled with finer fractions. Such soils include mixed-grained soils (gravel-silt, gravel-clay, sand-silt, sand-clay). The system can operate in some poorly displaceable, firmly layered soils, such as those with a compact-mass or fine-grained soils with low water porosity.

Some systems can bed pipelines in sand if required and pipes of up to 450 mm diameter can be accommodated in the right ground conditions, although 225 mm diameter are probably the most common. Installation lengths of up to 500 m in a single run can be achieved if the room is available to do such a run, with up to 5,000 m being complete in a day given the right circumstances.

As well as normal 'solid' ground conditions, the technique has also been used on riverside mudflats and in swampy areas.

A plough unit in operation.
Picture courtesy of the Drill-n-Plow Trenchless Alliance.

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Of course utilising this system also means that, in general, the need for new backfill material is eliminated, minimising both cost and the need for vehicular transport of 'imported' materials or the quarrying and processing of said material, thereby minimising the overall 'carbon footprint' of the project.

Whilst systems are available for major installation across largely open expanses there are some manufacturers that offer 'pedestrian' ploughing systems that can operate at shallow depth in more urban, limited access areas.

NARROW TRENCHING

For Trenchers and Mini Excavators and Vac Ex (see later)

Whilst obviously an excavation technique, narrow trenching has long been used as a utility installation technique to minimise environmental damage and inconvenience to traffic and people. The system, as its name suggests, relies on the use of a machine to excavate a narrow trench opening in the ground into which a pipe, conduit or cable can be placed. Not only does this minimise the time that the excavation is open but as with ploughing, though not to the same extent, minimises the requirement for the need to backfill and the logistical problems and concerns that this bring with it. Narrow trenching can be achieved in one of three ways. One particularly specialised system is the Vacuum Excavator which is dealt with in the following subsection as it also has other uses.

The first system dealt with in detail here utilises a specially designed trenching machine that is equipped, in the main, with a cutter chain or disc that can be lowered into the ground to excavate the soil. The cutter chain or wheel excavates the trench in a pre-marked position over the length required, with the depth normally being preset in the machines control system

Typical examples of Narrow trenchers and Mini Excavators. Top left a Pedestrian trencher. Top right a medium sized trencher. Bottom left a heavy duty trencher. Bottom right a mini excavator. *All pictures courtesy of The Charles Machine Works Inc (Ditch Witch).*

or manually controlled by the operator. Once cut the required service is laid into the narrow trench with any bedding material as required and back filled according to the required specification (*such specifications can vary widely from country to country and should therefore be investigated on the local level*).

These units can excavate through normal soils or paved, bituminised (tarred) or concrete surfaces provided the correct cutter picks and chain/wheel system is used on a machine designed with the capacity to cut whichever material is required.

The advantage of such a system is that whilst the machine is cutting the ground at one end of the run, the pipeline or service can be being installed in the middle of the run with the other end of the run being back filled and finished. This minimises not only the excavation size but the duration for which it is open.

Of course this type of installation does need to be planned properly and thoroughly, particularly in terms of knowing what other buried plant exists along the route. If an unknown service is hit by one of these machines it is likely to be destroyed and expensive to replace – so homework is essential!

Smaller narrow trenchers (and sometimes pedestrian ploughs) can trench between 0.3 to 1.2 m deep and are generally manually operated. Medium range machines work up to 2 m deep depending on the boom configuration. Larger heavy duty machines can work up to 2.5 m deep.

Mini-excavators can also be utilised for narrow trenching. Many, often smaller contractors, are increasingly utilising these units to give a similar installation to that achieved using trenchers, although they may be slightly more labour intensive and slower overall. The only advantage that may be applicable to the use of a mini excavator is that, if the existing buried services are not so well defined, the slower excavation operation could give the operator time to see obstacle before major damage is done.

VACUUM/KEYHOLE EXCAVATION

Vacuum Excavation, sometimes and in certain circumstances becoming known as Keyhole Excavation, is becoming a very useful technique in the buried service engineer’s portfolio in that it appears to have a variety of uses. On the one hand it could be deployed as a narrow trenching tool. It can be used to quickly excavate a small dimension trench for the placement of a buried service. On the other hand it can be used to excavate the smallest of keyhole access ‘trenches’ for the exposure of services connections to water mains. These can then be reconnected after renovation or replacement work is complete.

In Keyhole operations the vacuum excavation systems is only part of the system. Increasingly specially designed rotary drills have been developed to cut a ‘keyhole’ through the road or pathway surface when vacuum excavation cannot be used to act directly on soil surfaces. Most recently, this has been further developed so that once the keyhole has been cut, the vacuum excavation of the subsoils completed and the pipe/cable repair made, the excavated soils can be recycled to make the initial reinstatement of the keyhole excavation. Once the subsoils have been replaced the keyhole piece from the road surface can be recycled and replaced. This is done using specially designed grouts to reinstate the road/pathway fully with minimal requirement for externally produced or

Top: A specially designed drill cuts out the ‘key’ for the keyhole excavation. Middle: Vacuum excavation removes soils from the hole prior to the repair. Bottom: The ‘key’ is replaced using special grouts to complet the reinstatement of the hole.
Pictures courtesy of U Mole.

transported backfill. The operation is designed to ensure that the disruption of each individual access site is kept to an absolute minimum both in terms of the time on site and the site traffic required to support it.

Vacuum excavation systems are also becoming increasingly used as a location verification tool. It can be used to pothole at specified points on a network of pipes or cables, to 'prove' the validity of existing documentation and plans in terms of completing an 'existing' services map. (see TRC Guidelines Section 2).

More recently, the systems have also been adopted by some demolition contractors for use as site clearance tools for the removal of debris after sections of say road surface have been loosened on bridge decking.

All of this is, of course, in addition to its use for slurry and sludge removal on HDD and other site clean up works. In some cases, excess fluids must be removed from the surface to prevent environmental impact.

Other uses include: Manhole clean-out; Storm drain clean-out; Meter box cleaning; Vacuum down retention ponds; Emergency road spills; Saw mill clean-up; treatment plant cleaning and to clean up rocks and dry sand.

Top: Vacuum Excavation limits space requirements.
Bottom: Spoil is easily removed from site to a suitable disposal point.
Pictures courtesy of U Mole.

Also where narrow trenches are being used to install new pipelines vacuum excavation systems can also play a part as they can excavate a trench that is far narrower and more precise in its dimensions than is usually possible with even a small backacter. This can also allow very speedy 'one-day' excavate, pipe lay, reinstate operations to take place with minimum impact on the local surrounding provided the trench length is kept to a distance that can be completed fully in one day.

Most vacuum excavators operate in a relatively simple way. A vacuum is provided by a motor that operates an air pump, that in turn sucks air through a hose. The air then passes through filters, so that material drawn in by the fast moving airflow is deposited into a holding tank.

Dry and Wet vacuum excavation is possible depending on the situation and the equipment available. That is to say the right systems will normally accommodate either slurry/wet materials or granular materials such as soils.

For use as an excavation tool, there are two main excavation types, one with high-pressure water and one with high-pressure air. Whether water or air is utilised as the excavation medium, the process is more or less the same. A high-pressure jet (air or water) is used to break down the medium (soil etc) being removed or excavated. As the jet breaks down the material, the vacuum immediately removes the spoil into the vacuum excavation unit. The unit separates the spoil from the air stream. The used air is then vented into the atmosphere. The spoil is stored in a holding tank for disposal later, or if dry enough and reusable it can be taken from the tank to fill any excavation after the work or investigation has been completed.

The advantages of such systems are: they keep the spoil excavated to the minimum required to complete an operation, so minimising the site size required; the spoil remains in the confines of the vehicle until off-loaded at a convenient place. This avoids the need for stockpiling prior to removal at the excavation site so limiting site size requirements. The ability to operate as a keyhole excavation can help to minimise costs in terms of both waste removal and backfill requirements. Once again this may have significant impact on the site 'carbon footprint'

OTHER TECHNIQUES

In addition to the ancillary techniques described above, there are also some unusual applications of trenchless techniques. Examples of this include the Pipe Arch and some jacked structures.

PIPE ARCH AND GROUND STABILISATION TECHNIQUES

The pipe arch is a technique that has been developed to allow large bore tunnelling operations to take place beneath structures that may otherwise become unstable or have to be taken out of service should conventional tunnelling techniques be used. The pipe arch effectively creates an *insitu* support mechanism beneath the structure before any major excavation work takes place. Three trenchless techniques have so far been successfully utilised to create pipe arches in the field. These are Microtunnelling, HDD and Pipe ramming. The choice of system used depends largely on the ground type being entered, the length of the pipe arch being installed and the accuracy to which the arch must be installed. Key factors are: a) Microtunnelling is more accurate over long distances than pipe ramming but is a more complex and probably more expensive system to operate; b) HDD will enable relatively accurate bores at smaller diameter than microtunnelling but may require a lot more individual bores to make the same arch size; c) There are many other factors to be taken into account and each technique should be looked at individually, on it merits, for any given situation.

A line of pipes installed using pilot auger microtunnelling technology as the roof section of a pipe arch for an under-rail tunnel installation.
Picture courtesy of Bohrtec GmbH.

Once installed, by whichever means, the ground beneath the arch can be excavated leaving the arch as the support structure for the surrounding ground until the main tunnel support is installed. In a few cases the arch may itself be the ultimate support system so should be designed and installed with this in mind if this route is to be followed.
To create a pipe arch, whichever system is being used to make the arch, the access pits at either side of the tunnel structure required are excavated first. Then, for a microtunnelled pipe arch, a microtunnelling system is set up on the launch side of the tunnel route. The microtunneller is then used to drive a series of bores from the launch side to the reception side, installing a pipe string in the ground as it proceeds, as is usual with microtunnelling. Once this pipe is in place, the microtunneller is moved to the next launch point beside the first and the process of driving the bore is then repeated. Often the installed pipes are steel. The advantage of these pipes is that they are relatively thin walled whilst also being strong and they can be designed with an external flange running the length of the pipe. On the second and subsequent bores this flange can be made to interlock with the corresponding flange on the new pipe, so helping to guide the follow-on bores and make a physical link

between all the pipes installed. In some cases, once installed, the pipes forming the arch may be filled with concrete to give the system extra strength.

For an HDD pipe arch, an HDD rig is used in place of the microtunneller and a similar procedure followed. However in this case the final pipe installation is normally achieved at the backream/pipe pull-in stage of the HDD cycle with the pipes being installed from the reception pit side. It is also possible to use HDD to create a pipe network that can be used as the refrigeration set-up should an ice wall construction technique be employed.

An arch of borehole installed using HDD technology as part of a ground stabilisation programme prior to a major tunnel installation. *Picture courtesy of Prime Horizontal.*

For rammed installations, the first pipe is normally the most important because it is used as the guide for all the follow-on pipes in the arch, which will parallel the direction of the first one. This is because, as with many microtunnelled installations the pipes are usually linked in some way during installation. So any deviation in the first pipe direction or gradient will be reflected in all the others.

Over the years successful pipe arch constructions have become numerous but by way of example microtunnelled pipe arches have been installed beneath roads and railways that have remained open for the duration of the works through to the completed tunnel structure, as have many rammed arches. A project of this type, in the People Republic of China, won the ISTT Best Project Award for 2005.

JACKED STRUCTURES

The technique above leads on nicely to the next associated technique that of jacked structures. This technique involves the jacking into place of prefabricated, normally, box-section tunnel units or culverts. They may be installed using one of the ground stabilisation techniques indicated above, or in more stable ground conditions, they may be jacked into place as the ground excavation advances without any preliminary works.

Installing a box section under a railway embankment. In this instance using pulling rods to apply the 'jacking' force as opposed to rear positioned hydraulic jacks. *Picture courtesy of HMS Machines BV.*

Most situations where this is used comprise crossing of roads, railways or waterways which are either elevated (railway or road embankments) or are positioned such that relatively easy access is available to sink the launch pit next to the structure being crossed.

Normally the box-section, or whatever unit shape is to be jacked, is constructed in the launch pit to one side of the crossing point. This may involve significant excavation depending on the length and cross-section of the unit being jacked. The lead end of the jacked section is positioned close to the start point of the excavation and may utilise a cutting edge if the ground conditions warrant it.

As ground is removed from the face, the jacked section is moved forward into the void created. This continues until the excavation holes out on the reception side of the structure being crossed, normally into a specially prepared reception pit. Once holed, the excavation equipment and any support or ancillary equipment is removed leaving the tunnel or culvert structure in place.

Jacking can be achieved in two ways. The first and most obvious is to use a hydraulic jacking frame or cylinder arrangement to the rear of the box section to be jacked. These push the whole structure forward as required and as excavation advances.

Alternatively there have been cases where the box section is pulled towards the reception pit. This is achieved using the support of HDD technology, where holes are first bored through the crossing point below service structure. Sacrificial guide pipes may be used to line these bores to ensure they remain open. Through these guide pipes if used, pulling rods are installed through the ground and which also pass through the box section, which has been designed to use this system. Using bearing plates at the rear of the box section the pulling rods advance the box section in to the excavation by pulling through the ground structure as ground is removed.

The difference between this technique and that of microtunnelling or pipe jacking is that the box section is normally constructed to its final length/size prior to installation, as opposed to new sections being added as excavation proceeds. It also allows non-standard shapes to be installed if necessary.

FIBRE OPTICS IN SEWERS

At the turn of the millennium one of the biggest discussion points throughout the trenchless industry was the development of systems for the installation of fibre optic cables into an existing pipeline network. As pressure pipe is more difficult to access whilst in operation the main thrust of this technology development was aimed at sewer systems. The idea was to place, into an existing pipe, a network of micro-ducting which could carry fibre optic cables to any, and all, residences and businesses that were connected to the mains drainage system.

‘Inversion Lining’ technology being used to install fibre optic cabling in a lateral sewer connection for a residential or business feed. *Picture courtesy of Epros GmbH.*

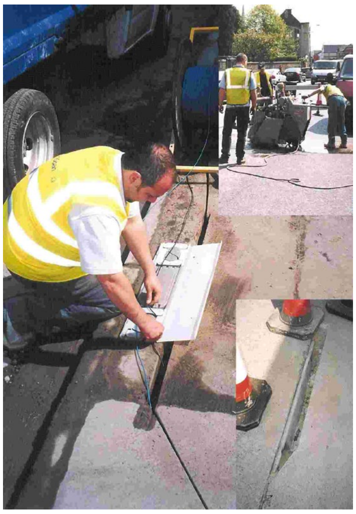
Several systems were developed in just a few short years. In the main they all comprised one of three basic types. These included Renovate with duct installation; Install duct only (using matting strips and resin); and Robotic stringing.

The first of these, Renovate with duct installation, comprised the installation of CIPP type liner which was either designed with duct arrangement built into the liner material or a system where cable was laid in such a way that the liner once installed would hold it in position against the inner wall of the host pipe. The advantage of this system was that not only did the cable supplier get its cables installed without the need to excavate, but also the pipeline owner got a renovated pipeline out of the project with the cost being taken either by the cable supplier, or with the pipeline owner getting a revenue from the cable supplier for ‘rental’ of the pipe space so helping negate the cost of the renovation.

The second option, Install duct only, used a similar installation technique to the first. But instead of ultimately getting a renovated pipe, the system purely installed a specially designed mat with the micro-ducting placed within it. A calibration hose is inverted into the host pipe to push the duct matting against the pipe wall. The duct matting has previously been impregnated with resin which, on curing, bonds the mat to the pipe wall. Once the calibration hose is removed the ducting remains in place ready to take the fibre optic cables.
The third option, Robotic installation, is generally an offshoot from robotic sewer renovation systems. These CCTV monitored, surface controlled systems comprise modified sewer renovation robots, where the sewer renovation equipment is replaced with placement and fixing systems. The fibre cable string is laid through the pipe and the robot is then passed through the pipe, picking up the cable, locating it in position against the pipe wall and establishing a form of fixing system to hold it in place. The fixing systems varied across the type of unit designed, from a drilling system that bores into the pipe wall to utilise clips that would hold the cables, to complete circumferential rings that were expanded into place once the cable was positioned. These rings are somewhat similar to expanding localised repair seal rings.
All of these systems offer the opportunity to install cable without any digging, as all access can be via existing manholes. They can offer a new revenue stream to participating sewer owners whilst given total 'house connection' capability to the cable supplier. Recent years have not seen major take up of this technology, and this to some extent seems to centre around the 'fee and who pays for what' discussion between the various representative bodies and the need to ensure that neither service will interfere with the other.

FIBRE OPTICS IN DIAMOND CUT SLITS

Again, coming back to excavation systems that could come under the 'low dig' category, this fibre optic cable installation method is essentially an excavation method, but to such a small degree it is classed as a form of trenchless technology by many.
In essence the system involves using a diamond-edged concrete saw to cut a slit in the road or pavement surface, to a prescribed depth and width. The slit cut is of a dimension that a fibre optic cable of known diameter will fit into snugly. Once the slit has been jetted to ensure it is clean so no material could damage the cable, the cable is positioned in the slit. This is then backfilled with material and sealed with a bituminised compound. The result looks on surface like a sealed joint between road or pavement sections.



Installing Fibre optic cable in a slit trench. Top right - cutting the slit. Main picture - installing the cable through a junction box design to fit into the slit. Bottom right - the finished surface.
Picture courtesy of Teraspan.

The advantages of the system are: minimal excavation, very quick cable installation and surface rehabilitation. As the slit is so small it can be cut and left for a period of time before the cable is installed if necessary, which means that cutting can take place at times of minimum traffic if required, separately from the cable installation.

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CABLE IMPREGNATION

Whilst some may argue that Cable Impregnation is simply a cable repair technique, it should be noted that it is also a trenchless technique in that it does not require the existing, damaged cable to be removed or replaced. Cable impregnation relies on the fact that many cables fail, not because of a failure in the fabric of the metal in the cable, but because of water ingress into the cable structure through microscopic cracks in the cable covering and insulation. The cable repair system injects a silicone material into the cable which ejects the water and reinforces the cable's insulation preventing further water ingress. This work is achieved through existing manholes.

Silicone inject applied to impregnate a water damaged cable.

HORIZONTAL ENVIRONMENTAL WELLS AND THE REMEDIATION OF CONTAMINATED GROUND

Whilst the basic use of drilling technology is covered in Section 3 of these Guidelines, there are very specific uses of this type of drilling that warrant special mention. The installation of Horizontal Environmental Wells using HDD technology is a particularly useful tool from two significant aspects.

Using HDD to install ground remediation drainage pipelines. Note the personnel protection used for the crew. *Picture courtesy of Mining Communications Ltd.*

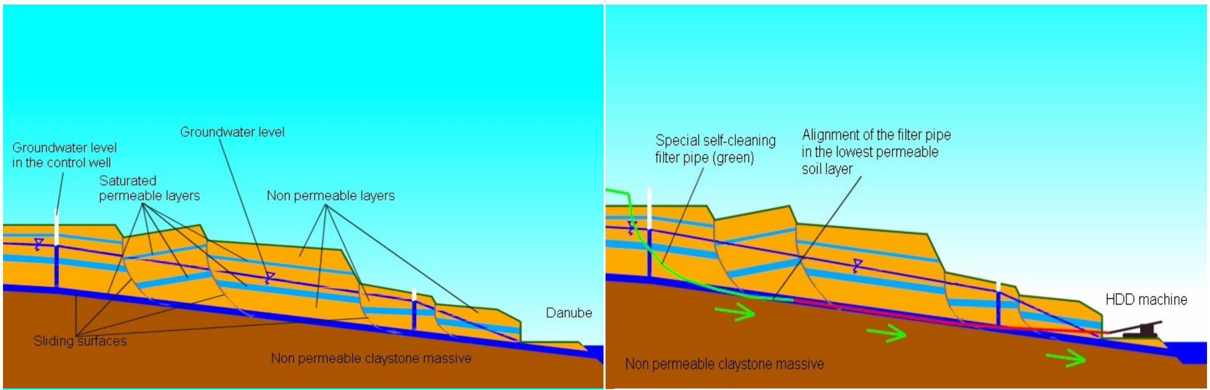
The first is the installation of land drainage systems. This utilises HDD to install a drainage pipeline in areas where water table levels are or could become a problem. The pipe is installed by the HDD unit in the normal manner but the pipe itself is perforated, to allow water to drain from the surrounding soil into the pipe. The water can then flow away. If a perforated pipe were to be installed directly using HDD this would allow drilling fluid to run into the pipe during the pipe pull-in operation. To over come this and leave the final product pipe empty, a duel pipe is normally installed during the pipe pull-in. The outer pipe is sacrificial but keeps the final drainage product pipe clear of drilling fluid. Once the pipe pull is completed the drainage pipe is anchored in place, and the outer sleeve pipe is pulled back out of the ground, leaving just the drainage pipe in place. The drainage pipe is back flushed to ensure that any drilling fluid remaining in the hole does not block the drainage pipe perforations, allowing the land drainage to commence.

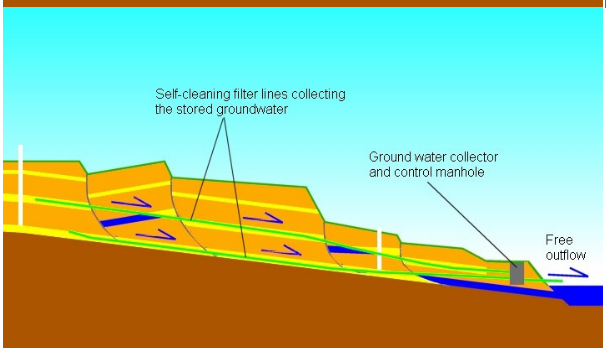
The second and more specific use of this sort of technique is installation of drainage pipes for 'contaminated' land remediation. For this technique several drainage pipe are installed beneath the area of 'contaminated' land using HDD. The contamination is removed from the ground by running the necessary 'cleaning' fluid through the ground from surface. Applying the cleaning fluid with surface sprayers or similar equipment, allows it to percolate through the contaminated soil picking up the contaminant substance as it passes. This drains into the land drainage pipes to be removed and treated. Run-off from these pipes is then connected into a sealed pipeline for transfer to a local treatment plant, normally situated at the site,

which is designed to decontaminate the out flows from these drains, removing the contamination to a place currently recognised for such disposal and leaving clean water run-off. This can be used for the treatment of contaminated landfill sites or areas of land that have, for instance, been contaminated with pesticides which need to be recovered for future agricultural use or redevelopment.
For land remediation however very strict personnel protection procedures must be observed. As the work is required to decontaminate land this implies a substance of potential danger to people and livestock. Machine operators and support crews must be adequately protected against contact with any potentially harmful substances throughout the operation, from site preparation to demobilisation. This cannot be stressed strongly enough.

INSTALLING LAND DRAINS FOR BROAD AREA DEWATERING OR GROUND STABILISATION

In similar manner to that used for the installation of remediation drainage pipes, as indicated above, this technology can also be used for the installation of perforated land drainage pipelines. Where ground water levels are such that a small rise may potentially cause flooding or ground/soil destabilisation the ability to drain excess water from the strata can be vitally important.





Top left: Unstable ground before groundwater well installation.
Top right: Installing ground water wells using HDD into permeable soil layers
Bottom: Stabilised ground conditions after HDD wells are installed with excess ground water collection and removal reducing the influence of groundwater on the local geology. *(pictures courtesy of Sycons Ltd - paper 2008 No-Dig Moscow)*

Using trenchless boring techniques, most likely horizontal directional drilling (HDD), these soils can have the land drain added beneath them without disturbing already potentially unstable conditions.
Removing additional or excess water from these soils at a point where the water's influence no longer matters (for example directly into a watercourse) will help to re-stabilise such soils so minimising the risk of future land movement.

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TRAINING COURSES AND QUALIFICATIONS

Equipment Specific Courses: Training courses are available in their multitude and each normally leads to a specific, recognised qualification of some description. To cover individual courses in this review would be impossible. However, the types of courses that are available range widely. Courses related to specific equipment are normally available through the manufacturer, or at the point of purchase. They are designed to ensure that future operators are fully aware of the equipment, its capabilities and any specific safety concerns that may arise in handling or operating it. In many cases the equipment is new to both the company purchasing it and the staff operating it. It is vital that best advantage is taken of such courses. Many failed trenchless projects have occurred because of incorrect handling or misunderstanding of the maximum capabilities of any given piece of equipment. In some cases manufacturers also offer refresher courses and upgrade courses to ensure that operatives are kept up to date with the latest developments and application of machines as well as making them fully aware of any new equipment upgrades that have been made on the latest system models. These should not only apply to particular trenchless equipment but also to any ancillary equipment that may be used within a work site in general, for example gas testing equipment, access equipment etc.

Training can be either at the manufacturer or supplier site or on the job site.
Picture courtesy of U Mole Ltd

Safety Training: Safety should be the paramount concern on any construction site whether trenchless or not. In terms of trenchless situations there are specific aspects of safety that need to be covered which do not apply to open cut contracts. Confined space working is a prime example of such a circumstance. Whilst general site safety is always a key factor on any site, working in a confined space has to take into account very specific additional concerns. The crew will be operating often some distance from the nearest access point, in a relatively small space that can limit movement. There is usually the potential for noxious or other dangerous gasses being present, and working conditions may be somewhat uncomfortable if not hazardous. Courses are available that take all of this into consideration, and can teach crews with little or no experience the basic information and requirements of working in such situations. Other courses teach experienced crews, and those requiring refresher courses, to maintain their current qualification status the latest development in working practice and equipment availability for such circumstances. Other types of course are available for a wide variety of other work situations.

Safety training is a vital part of the trenchless industry as many standard courses do not take account of the specific trenchless aspects of the work being undertaken. *Picture courtesy of Develop Training.*

Further Education and On-going Education: Some Universities and colleges now offer specific trenchless orientated further education courses, either post school or post graduate. This however is not currently the ‘norm’. Organisations including some of the ISTT’s

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Affiliated National Trenchless Societies offer training courses, seminars etc on the basics of trenchless technology so as to bring the technology to a wider audience. However many of these course are often short and of limited accessibility and places and may be very subject specific, for example a Microtunnelling course or an auger boring seminar that does not touch the wider aspects of the industry as a whole.

Generally it is becoming accepted that there is currently insufficient trenchless training available in most countries and that what is available is limited by place availability. There is also a potential problem with client companies in that in the modern world where time/revenue relationship is king, on-going career development training has a limited place with any organisation and it is deemed to be up to individuals to keep themselves up to date on developments within their industry. Conversely given the pressure placed on employees by companies, few have the time or inclination or the money to invest in such training for themselves and the industry is left with little, if any, on-the-job development of staff who, although directly required to use trenchless technology in their everyday working life, could find advantage from it if they knew more of what was available to them.

An encouraging development has been the emergence of training courses for site operators, which are run both before and in conjunction with actual contracts. The trainers have normally worked for many years in contracting and understand what is necessary.

COURSE AND QUALIFICATION COMPARISON

Almost all safety courses provide recognised National qualifications on completion that enable the now qualified trainees to work in situations previously unavailable to them.

It should be pointed out however that not all courses are recognised across national or international industries as a whole or across international borders. In some cases, there is a requirement from different companies in the same country that contracted workforces should take in-house qualifications before being allowed to work on their sites. This could mean one operative taking several different courses covering essentially the same area in order to work on the same job in different parts of one country. This applies particularly to industrial process sites.

It is therefore very important that companies offering a service to its customers should fully establish what their client qualification requirements are, what external qualifications the client company recognises within its own operations and the number of qualified personnel they require on or in any particular job site or circumstance. This can be even more important when crossing international boundaries as almost all countries have different safety standards and qualification requirements. These should be checked thoroughly before commencing any work or even before applying for a contract.

EQUIPMENT

As well a training and qualification services, the trenchless industry also relies heavily on a range of companies that provide equipment, without which it would be impossible to achieve a trenchless installation or rehabilitation, although the equipment is not directly trenchless in its nature.

The type of equipment falling into this category includes things such as pipe towing heads, cable pulls/socks, swivels and specially-designed breakaway swivels (which ensure that pulling forces on a pipe do not exceed the maximum allowable before causing damage to a pipe), drill bits, drilling and pulling rods, cutters, picks, fittings, gaskets, seals, end fittings etc. Also included in this category could be pumps, compressors, winches, cranes, trailers,

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coil trailers, cable blowers, pipe rollers, fusion welding equipment and generators. Without which many sites simply would not operate effectively or safely.

Safety equipment, such as protective clothing, breathing apparatus, harnesses, man-hoist hoist frames, gas monitors, excavation support etc is also vitally important.

The number of companies involved in this sector is impossible to contemplate within these Guidelines but without them the industry just simply would not work.

There are also some very specific pieces of equipment that can be considered as directly trenchless but which fall into the category of 'trenchless specific' because they generally have the ability to operate without the need of excavation or can actually be used for what is effectively 'keyhole' excavation when required or do a job that does not require the interruption of a service whilst they do their work.

Towing Heads have a very specific role to play in many aspects of trenchless technology. *Picture courtesy of Pipe Equipment Specialists Ltd.*

SUMMARY

1. There are available, as well as the 'pure' trenchless systems, a variety of technologies that will minimise disruption and environmental impact that could be used in circumstances where the 'pure' trenchless systems may not be applicable.
2. Each system, as with all such technologies, has its advantages and disadvantages and each should be investigated as a stand-alone system alongside trenchless technologies when considering options for work.
3. There are numerous training courses available across the globe both directly associated with trenchless equipment and it use and with other aspects of the industry such as specific safety training.
4. Qualifications are available for many aspects of the trenchless industry BUT they may not all be recognised equally either between different companies organisations or countries – when taking courses for specific qualifications it is vital that their applicability to your specific circumstance is checked before spending the time or the money to take the course and to ensure they are recognised by the client you may be looking to use it/them with.
5. It is vital that organisations requiring the use of trenchless equipment, of whatever kind, ensure that their staff is fully aware of the latest technology available and are given the support and means to access and appreciate these developments through on-going career development schemes and access to training courses as necessary.
6. Support equipment is vital to the success of any trenchless work but before choosing your support equipment check it is applicable to the trenchless systems you have and that it will operate to the required level of satisfaction you need and within the acceptability of your client's or your own operation.

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Bibliography: The Bibliography may be accessed via the TRC Home page. If none is currently available on-line, please contact ISTT – info@istt.com for further information.

Conference Papers: These may be accessed via the TRC Home page. If none are currently available on-line, please contact ISTT – info@istt.com for further information.

If there is any information that you consider to be missing from this Guideline or have seen any information that you feel is incorrect please contact ISTT directly stating the omission or incorrect item. ISTT will endeavour to correct any such omission or error subject to further investigation to validate any such claim. Email: info@istt.com

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