Trenchless 101:

PART ONE – Rehabilitation Methods

By: Tonia Jurbin, PEng (for: PW Trenchless Construction Inc.)

Acknowledgement

Much of the content for this study comes from a presentation 'Trenchless Tapas – An Introduction to Trenchless' delivered by Mr. David O'Sullivan, President of PW Trenchless Inc. of Surrey BC. David is a longtime advocate, educator and tireless crusader on trenchless technologies.

In 2007 the world-leading medical journal, *The Lancet,* asked more than 11,000 readers to vote on a list of 15 milestones going back to 1840 when the BMJ was first published. Clean water and sewage disposal or 'the sanitary revolution' topped the pole followed by the discovery of antibiotics and development of anesthesia.

It's been about 200 years since Edwin Chadwick - originally a lawyer, later a planner and by all accounts of his activities today's equivalent of a social activist, reintroduced the development of underground piping to supply clean water, and sewers to remove waste. Of course the Romans and other ancient cultures had solved this issue, however those solutions were lost and had to be re-pioneered by Chadwick and his contemporaries.

Let's reflect for a moment on how the widespread adoption of the humble underground water and sewer systems have impacted human civilization. Sanitation is credited with adding about 35 years to the life spans of most people in first world countries. Without modern sanitation it is estimated the lifespans in the developed world might drop to the mid-40's as is evidenced by the life spans of many in the developing or third world countries where effective sanitation is largely unavailable. While other countless medical advancements exist, and more are continually being discovered, people largely make it past mid-life because of sanitation.

The Greater Vancouver Regional District (GVRD) with a population of about 2.5 million operates an estimated $20 - $30 billion worth of public water, sewer and stormwater infrastructure. There are also an estimated 25,000 corrugated steel pipe (CSP) culverts under the GVRD's streets and highways. A target replacement rate for these aging systems is about 1 percent a year at an estimated cost of about $200 million, an aggressive target which is not being met. Given the importance of, and the investment in sanitation to human civilization there is a duty to maintain the utilities in the least disruptive, least expensive way that will also generate the lowest carbon emissions possible.

Trenchless methods are becoming widely accepted as rehabilitation tools for numerous reasons including:

- ✓ **minimal excavations** resulting in greatly reduced volumes of removal, transport, disposal and importing of fill. In an open cut installation or repair to reach the pipe, an excavation of at least 1.5 metres

wide by the depth of the installation over the length of the project – well, that's a considerable volume of material that has to be managed. Safety requirements for shoring, caging, or sloping the excavation walls to a safe angle for anything deeper than 4 feet is an added cost. So too does the cost increase if special waste is detected in the fill.

- ✓ **significantly less damage to all existing road surfaces**. Once an asphalt surface is cut the lifespan of that surface is reduced by 15 to 20 percent depending on the traffic loading.
- ✓ **significantly less GHG emissions** due to less removal, transport and import of fill.
- ✓ **significantly less GHG emissions due to traffic disruptions**. Assume that 1,000 cars worth about $40/hour to society are held up for 20 minutes in the morning and afternoon rush, that is a cost of $26,000 per day to society for two 20-minute delays in one location. Anyone who has driven around any large city can appreciate that there are many such disruptions costing society millions of dollars a year and generating considerable GHG emissions.

WHAT IS THE ROLE OF A PIPE?

Containment - A pipe is a tube-shaped vessel that carries either liquids or gas. The functionality of the pipe has to be designed for the fluid it is carrying. If the pipe is carrying natural gas or petroleum products it has to be a robust system, the contents must be 100 percent contained. Pipes carrying storm water do not require the same degree of rigor, water pipes not so surprisingly leak, however, in some cities 30 percent to even 50 percent of treated water is lost through leakage. Sewers in some cities like Vancouver with its famously wet autumns and winters can experience high volumes of inflow and infiltration (INI) that increases the volume of material running through these pipes. During extreme wet weather a gravity sewer can develop 'head' and act like a pipe under pressure.

Function – Are the pipes big enough to keep up with urban densification? Pipes installed 50 or even 100 years ago that are still in service cannot keep up with the increasing volumes resulting from the massive development in many Canadian cities. These pipes, even if they are still serviceable may eventually have to be twinned, replaced or upsized.

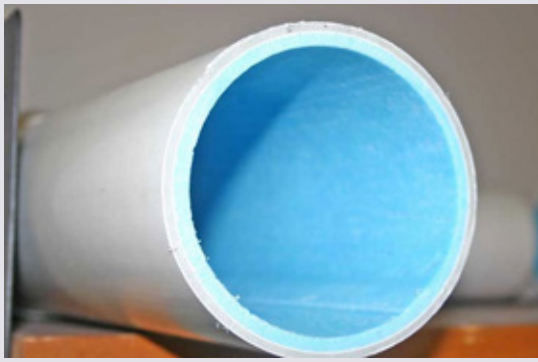
Structure – Is the structure of the pipe or the tunnel still sound? For example, is the pipe still round? Does it still have structural integrity? Most smaller diameter pipes will not likely collapse but larger pipes, especially large brick or concrete sewers and CSP culverts do deform and can collapse.

Trenchless methods can support resolving the losses caused by any one or all of these issues and result in an additional 50 to 75 possibly even up to 100 years of extended service – without digging up entire roads, parks or neighbourhoods. Some excavations usually entry, exit and service pits may be necessary depending on the rehabilitation method chosen.

Many of these older systems lie under occupied private buildings so the benefits of using trenchless rehabilitation methods cannot be overstated.

REHABILITATION METHODS

CIPP – Cast in Place Pipe - was the first method of rehabilitation introduced in the early 1970s in the UK and is still one of the most widely used rehabilitation

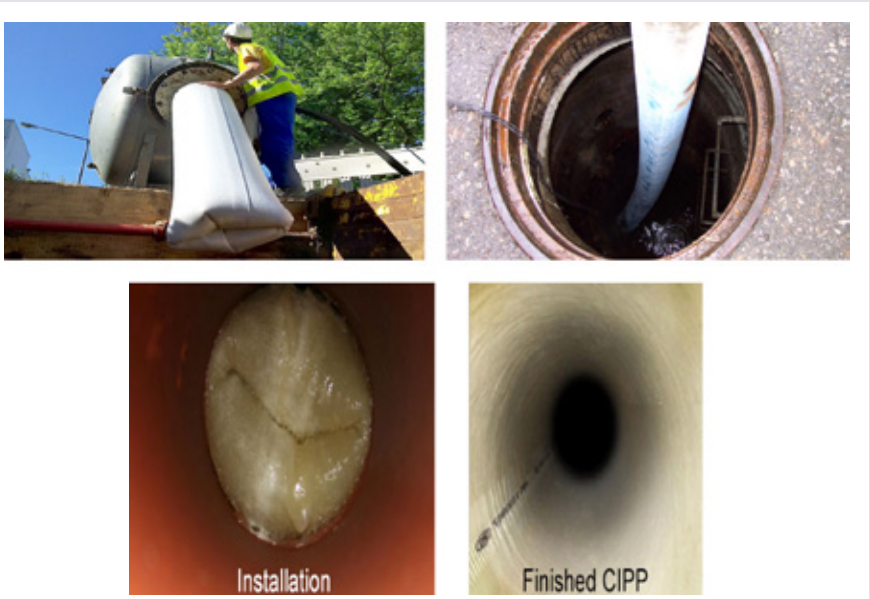


Finished CIPP liner inside PVC pipe

methods. CIPP is a close fit liner, typically a resin impregnated felt or fiberglass liner is fed into the host pipe then expanded using water or air pressure and the resins cured using hot water, steam or UV light. In doing so the resin impregnated liner gets pushed into the damaged host pipe filling the cracks, spanning holes and taking the shape of the host pipe.

CIPP decreases the cross-sectional area of the host pipe however the flow may not decrease significantly and under the right circumstances could increase slightly as the roughness of the existing pipe surface is smoothed out thereby decreasing the coefficient of roughness Mannings "n", resulting in a higher flow rate. The major advantages of CIPP are:

- low-cost trenchless solution
- is suitable for horizontal and vertical rehabilitation



CIPP offers a long term (50 years+) structural repair

Glass Reinforced Plastic (GRP) segments are becoming more widely used for sliplining

- provides an effective seal against infiltration and exfiltration
- offers an enduring (50 years or more) structural repair to the host pipe
- the liners are highly resistant to oils, caustic chemicals and high temperatures
- suitable for most pipe materials
- has been widely accepted around the world
- can be completed in the same day (with a boil water advisory for up to 4 days)

Spray on Centrifuge Products – Also a close fit solution, spray on Spray-In-Place Liner (SIPL) products can be used to augment the strength of pipes and of course stop leaks, depending on the structural condition of the host pipe. This can also be done in a day, also with a boil water advisory for up to 4 days. SIPL can add up to 50 years of service to a pipe.

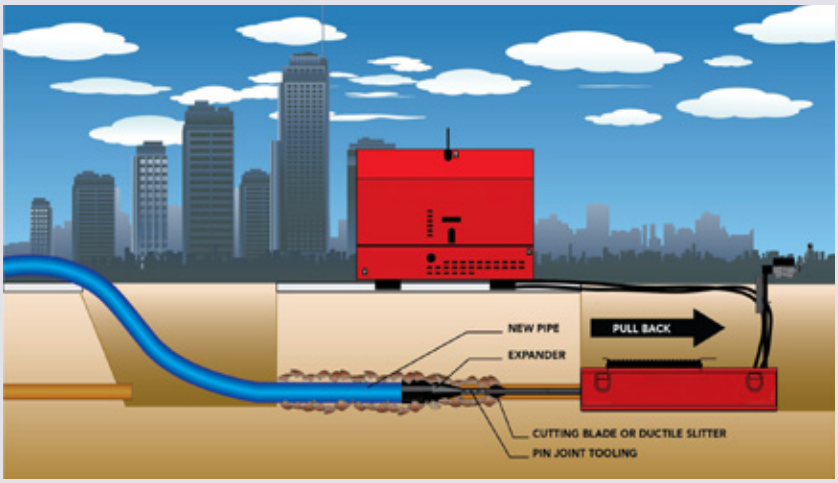
Sliplining – is a method in which a manufactured liner is slipped into an existing host. This is not a close fit solution and in sliplining there is a loss of the inside diameter, or the cross-sectional area of the pipe. The pipes being rehabilitated could be wood stave or old brick sewer tunnels that might be deformed but not yet failed structures and the liner size will be limited to a little smaller than the smallest constriction within the host pipe. The annulus between the host and the manufactured liner is usually grouted. A pipe can be sliplined with a variety of material, typically PVC, HDPE and Glass Reinforced Plastic (GRP) is becoming more widely used.

The GRP liners that are manufactured in Dubai have a durable core of fiberglass with a 1.5mm thick smooth corrosion resistant inner lining, and a typical wall thickness of 25 to 35mm. A bonded graded aggregate is applied to the GRP liner exterior to enhance adhesion to the annual grout. Like all sliplining projects, the result is a smaller diameter pipe with improved hydraulics and enough structural integrity to give a host pipe at least 50 more years of service.

During a large diameter sanitary sewer rehabilitation project the biggest cost is often the bypass, up to 75 percent of the project and there is always some environmental risk. However live flow sliplining offers a cheaper solution as sliplining can be done on a live system without a bypass if it is well planned and additional health and safety measures are taken to protect the crew and the environment.

Pipe Bursting – is used when the pipe that needs to be rehabilitated also needs to be upsized. Typically, a pipe can be upsized by 2 or 3 sizes, possibly more depending on a number of factors including the density or confinement of

SIPL is versatile and can add structural strength of pipes



Pipe bursting has a unique ability to upsize pipe capacity

Typical pipe bursting setup

the soil around the existing pipe. During pipe bursting, a bursting head is put into the existing pipe at an entry pit and has a new conduit pipe attached to it that is pulled through the space that the bursting head creates. Care must be taken with metal pipes in that the pipe being split can retain some of its spring or 'memory' and revert to its original state Pipe bursting has successfully burst many kilometers of pipes in BC in the last 25 years for rehabilitation and upsizing sewer mainlines.

Large CSP culverts are worth a special mention because they are so numerous and can be very large - ranging from about 300mm to large enough for 2 lanes of traffic to travel through, and culverts generally daylight at both ends. They have some unique challenges with concentrated abrasive bed loads, large deposits of sediment which in some cases completely

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Pipe bursting has wide application - from residential services to mainlines

Large CSP Culverts have unique challenges and are rehabilitated in a number of ways

> *"Sanitation is credited with adding about 35 years to the spans."*

block the culvert that can threaten nearby infrastructure, and erosion of the structural fill around the culvert. Culverts are most of the time also considered to be fish bearing so environmental constraints have to be managed in the rehabilitation design.

Culverts are rehabilitated in a number of ways depending on where the corrosion is concentrated or where more support for the total structure is needed. Spray on products for large culverts might be applied directly to the culvert, or if the host pipe needs reinforcement, re-bar can be installed and shotcrete applied, concrete floors can be installed where the bottom of the culvert is corroded. Any number of different products can be used in different combinations. The methods and products chosen will be unique to every situation. When restoring CSP pipes it is likely the bedding or supporting material will also need attention.

DIRECT COST COMPARISON

For most projects the costs of trenchless verses open cut are competitive, especially so as the depth of the pipe gets deeper, or, the ground above the service requires special consideration as in the case of pipes installed in now environmentally or culturally sensitive areas, or where older services are under occupied buildings.

The City of Langley, BC uses comparison bidding, trenchless methods are resulting in about 25 percent less cost than open cut. The City of Nanaimo has been adopting new technologies ranging in everything from trenchless methods

to Artificial Intelligence for years. Their position is that trenchless will always be considered where it makes sense to do so and they have realized about 40 percent savings on many projects where the bids were open to both trenchless and open cut contracts.

It's advisable to always invite tenders using both methods. Asset owners typically realize savings averaging 30 percent. Pipe bursting tenders come in about 25 percent lower, CIPP about 40 percent lower, and Horizontal Directional Drilling (not described in this piece) about 40 percent lower than open cut.

The best pearl of wisdom offered by senior management at PW Trenchless Inc. out of Surrey BC is to invite an experienced trenchless contractor to have a high-level look at your project. The final decision on rehabilitation method(s) is going to be unique for every project depending on many variables. Owners must have a good understanding of what the desired outcomes are. Are you simply trying to contain the fluid by plugging up a few leaks and cracks, or do you need to transport more product by upsizing your pipes? Is your pipe severely corroded, deformed or missing large chunks of material and in great need of restoring structural integrity, or all of the above? The project owner needs to fully understand and identify what their system needs in terms of flow, velocity, capacity, reliability, tolerance for failure etc.

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Once the goal of the project is understood the project constraints need careful identification and consideration. Examining the variables with a specialist contractor will help point to the best rehabilitation method. The technologies described above are only a high-level look at the many variations of trenchless rehabilitation, each has variations and adjustments that can be carried out to meet a specific challenge.

Key points the project designer must consider: are there multiple services, bends or differing diameters of pipe? Can you afford to lose some cross-sectional area? Is the pipe to be rehabilitated eventually going to be twinned to increase capacity overall and therefore some loss of capacity in the existing host is allowable? Are there environmental constraints? Are there temperature constraints for the product or for the method being proposed? What are the access and lay down requirements for the methods under consideration? Is there adequate on-site storage? Can the work be done without costly, risky and time-consuming bypass work. Are the pipes in a congested utility corridor with multiple nearby conflicts with other infrastructure that cannot be disturbed by undermining, vibration or contact? Is the nearby public supportive or protesting the project and why? Are there first nations or archeological issues? How will these issues be managed?

Always start with what your system is and what it is that you are trying to rehabilitate or improve and let your trenchless contractor provide input to support you while you develop a solution that will likely be less expensive, less disruptive to the public and generate less GHG emissions.

> *"Pipe Bursting is used when the pipe that needs to be rehabilitated also needs to be upsized."*

ABOUT THE AUTHOR:

PW Trenchless Construction Inc. *is an experienced General Contractor established in January 2000, specializing in both trenchless and traditional open cut utility construction methodologies. The company has pioneered trenchless technologies in BC throughout its history and stands apart from other trenchless contractors in the local marketplace by completing all civil works for trenchless projects in-house, using own equipment and forces.*

PART TWO – NEW INSTALLATION METHODS** will be published in the **NASTT-BC Y-DIG 2025** edition, circulated to all delegates at the joint **NASTT/ISTT NO-DIG NORTH SHOW** October 27 – 30 Vancouver Convention Centre, Vancouver BC*