COMPARING THE COSTS – TRENCHLESS VERSUS TRADITIONAL METHODS

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ABSTRACT

As communities and regulators place increasing demand on maintaining and improving infrastructure in cost effective and socially acceptable ways, there is an increasing trend in the development and usage of trenchless technologies to provide the best solutions.

Since 1993, the growth of trenchless technology in Australasia has steadily increased in most industries, with the telecommunication and gas utilities the most significant sector to take advantage of the technology. The potential use and application of trenchless technology in the rehabilitation or renewal of water services in Australasia is staggering, with an estimated 96,000 km of sewer and sewer pressure mains that are approaching or exceeding their design life. As more work has been undertaken and more industry players have become involved, unit costs have generally decreased and proven track records have been established with a wider embrace of trenchless technologies. Recent studies by the Australasian Society for Trenchless Technology (ASTT) have shown there are more than 60 proprietary products and methodologies for trenchless repair and renovation of pipelines, and they are used by more than 70 utilities in Australia and New Zealand.

Fully trenchless or partially trenchless, (where some excavation is required) technologies offer many benefits as a methodology for rehabilitating or renewing pipelines that mitigate some of the social and environmental impacts and often some of the cost of open cut excavations. Competition for space in service corridors, the intensification of urban and residential developments, the risk to the public and contractors, and the impact on property owners and the community environment in a growing number of cases limit the options for open excavation.

This paper discusses the comparisons of cost and the factors that impact on a project, the environment and society that should be considered when selecting the appropriate pipeline construction methodology.

KEYWORDS

Trenchless technology, open cut, rehabilitation, cost comparison, social cost, emissions, environment

1 INTRODUCTION

At the International Society for Trenchless Technology, (ISTT) No-Dig Conference in Perth Western Australia in 2000, the ‘State of the Industry Report on Trenchless Technologies in Australia’ was presented to the delegation and had shown that the growth of trenchless technology had steadily increased since 1993, with the telecommunication and gas utility sectors the most significant users of trenchless technology. This growth trend has continued over the past decade, and although not indicated by the data in Figure 1, the water and wastewater industry has been the driving force behind a wide range of the trenchless technologies that are available.

The potential use and application of trenchless technology in rehabilitation or renewal of water services in Australasia is staggering with an estimated 96,000km of sewer and sewer pressure mains approaching or exceeding their design life. This situation is akin to other western nations; the American Society of Civil Engineers (ASCE) estimates that it will cost $US1.3 trillion over the next five years to maintain current underground infrastructure systems (R. Mohammed et al. Oct 2008).

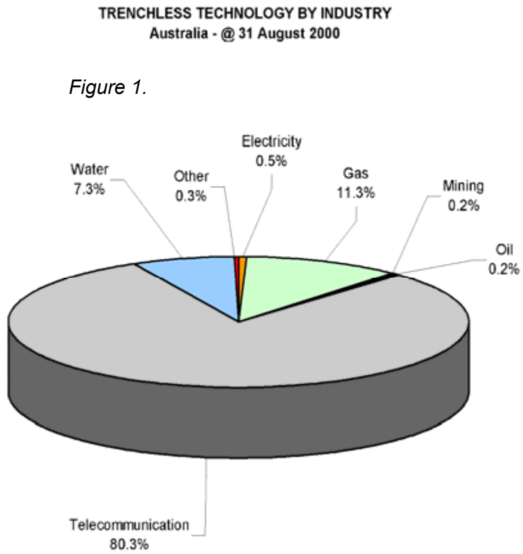


Figure 1.

Rehabilitation of sewers in the United States has been a major Growth area in the last 20 years. 1835km of sewer was rehabilitated using Trenchless Technology in 1998, (0.4% of total asset length) then equal to the amount of Open Cut Replacement. By 2001, this had risen to 4319km of trenchless rehabilitation (0.9% – 1% of total asset length) an investment of $US4.5 billion (WERF 2004).

Growth in the use of trenchless technologies comes as communities become more aware of the impact of infrastructure development and renewals on our social and ecological environments, and as the ageing pipelines in our built up and congested urban areas require replacement. Trenchless Technology is recognized as an environmentally and socially acceptable method of construction, particularly in comparison with traditional open excavation alternatives, but comparing the costs between trenchless and open cut methodologies on a dollar to dollar basis can be difficult and inaccurate when we consider the total cost to the community. The amount of money paid for installation or renewal of water and wastewater pipelines by local authorities does not represent the total cost to society, broader consideration of all costs, project and social cost, should be given when selecting the best method for constructing or renewing piped infrastructure

2 COMPARING COST

The question, "What is the cost of trenchless construction or renewal projects relative to conventional open-cut methods?" is the most frequently raised question by potential trenchless users, but unfortunately it is also the most difficult to answer. The cost of both open cut and Trenchless methodologies are affected by many factors, such as the location of the pipeline, its depth, size and also the local availability of the various trenchless technology methodologies.

The cost of a pipeline construction or renewal project can be divided into several components, as described in Figure 2. The costs fall broadly into the costs paid by the utility, as direct and indirect construction costs, and those paid for by society at large, termed social costs, that are as a result of the project being undertaken.

This paper will compare the costs of trenchless and traditional open excavation methodologies by considering both cost centres; direct and indirect costs and the social costs.

Cost category	Cost PAID by	Examples	
DIRECT	OWNER	CONTRACTOR COSTS	D1
		ENGINEERING	D2
		BIDDING COSTS	D3
		CONTRACT MANAGEMENT	D4
INDIRECT		COMPENSATION CLAIMS CUSTOMERS	I1
		COMPENSATION FOR CONTINGENT DAMAGE TO PROPERTY	I2
SOCIAL QUANTIFIABLE	SOCIETY	TRAFFIC DELAY	S1
		BUSINESS DISRUPTION	S2
		ACCIDENT COSTS	S3
		POLLUTION	S4
SOCIAL NON QUANTIFIABLE		ENVIRONMENTAL IMPACT	S5
		QUALITY (OF LIFE)	S6

Figure 2. – component of the total cost of a pipeline rehabilitation or renewal project

2.1 DIRECT & IN-DIRECT COSTS

The Direct and In-Direct costs are those most often associated as the “Project Costs” or “Construction Costs”, which are usually relatively straight forward to estimate using standard estimating methods, and are greatly represented proportionally by the construction cost fees tendered by contractors.

The cost of any particular rehabilitation or renewal method, open-cut or a trenchless method varies significantly dependant on the site conditions. The variability of costs and uncertainty of what cost items are included or not included in project estimates, makes comparing the cost between open-cut and trenchless methods difficult, and there is little recent published data available.

A recent (2008) published case study comparing the potential cost of open excavation versus pipe bursting to replace the sewer network in the City of Troy, Michigan in the United States concluded that the trenchless method of renewal if implemented would be 25% less expensive than open excavation (R. Mohammed et al. 2008). The study had a number of caveats and areas for further research; sewer laterals, and lateral connections had not been considered as part of the comparison study, or the possible affects of ground condition variability.

Other, less recent published comparisons may also be considered:

- Public Works Technical Bulletin published by the U.S Army Corps of Engineers on the Application of Trenchless Technology at Army Installation in 1999, compared the cost of Open Excavation and Trenchless Technology rehabilitation methods utilizing 1991 USEPA (United States Environmental Protection Agency) values. Table 1 summarizes this comparative data.

Pipe Diameter	Open Cut $US/Lf	Trenchless $US/Lf
12	80	55 - 115
20	125	60 - 155
48	290	160 - 330
72	460	260 - 500
100	690	370 - 800

Table 1. Summary of cost comparisons of replacement methods per linear foot installed (PWTB 420-49-10 February 1999)

  This comparison places the cost of the open-cut method inside the range of costs for various trenchless technology methods. There are also a number of caveats with this particular data; The report does not delineate the basis of cost for the open cut, depth or ground conditions, dewatering required etc, and there are several trenchless methodologies considered in this comparison, some of which are not available for some pipe diameters. The trenchless technology options included cement based coatings, slip lining, grouting and CIPP lining. Some of these methodologies may not be available or suit the particular situation. Interpretation of data indicates that Trenchless Technology may provide savings of up to 79% of the cost of open cut installation method.

- The Louisiana Technical Institute (LATECH) has produced reports that present all of the data from bids, (successful & unsuccessful) on U.S. municipal pipelines, by plotting each bid against the diameter of the pipe, for each type of technology. The data represented in the fig 3 below is presented as a ratio between the unit cost of the various technologies and the cost of Open-cut. This method of comparison is a powerful method as opposed to more theoretical case study comparisons, as the data is based on actual tender prices. Figure 3 would indicate that in 2003 Trenchless Technology installation and rehabilitation methods provided significant savings over open cut, of up to 75%, particularly in the smaller pipe diameter ranges.

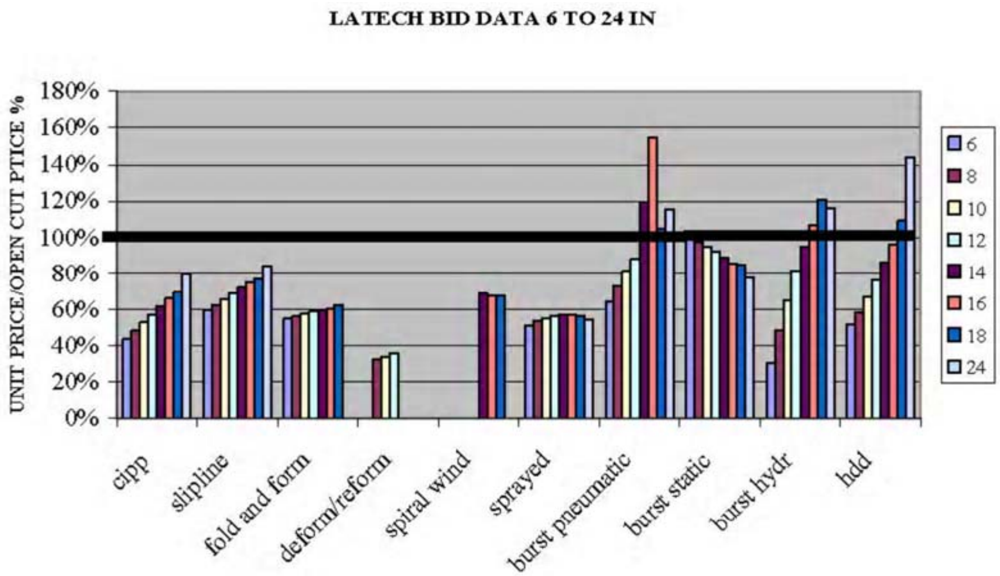
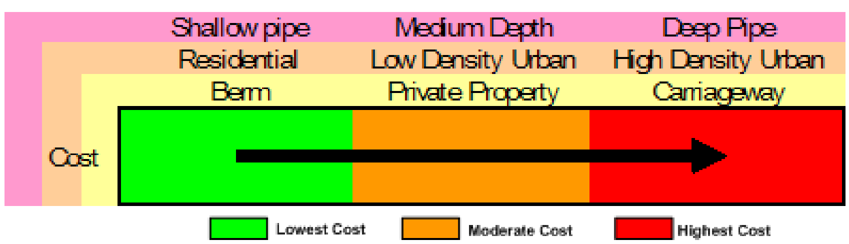


Figure 3. – Louisiana Tech analysis of all bids related to municipal pipelines in the United States (2003)

Approximately 70% of the cost of open excavation construction is simply excavating and replacing the ground dug up during the process (R. Mohammed et al. 2008). However, it does not always necessarily translate that trenchless technology is one third the cost of open excavation. In some cases the cost of construction using trenchless technology exceeds that of open excavation particularly in Greenfield and shallow conditions. Trenchless technologies do however have a tendency to become better priced than the open cut options in higher density urban areas, where access, traffic control and the cost of reinstatement of surfaces become more expensive per meter of pipe, and where pipe depths are greater requiring expensive shoring and significant increases in excavation resources.

Figure 4. – Cost of open cut excavation increase with depth and location



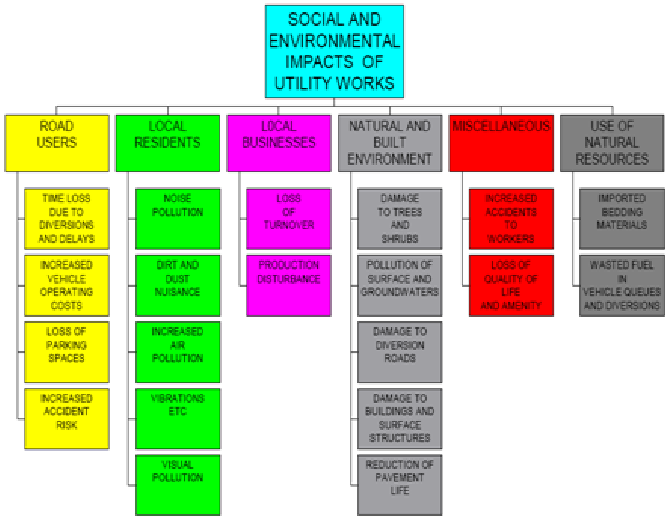
Factors effecting the cost of trenchless technology is the level of competition or the availability to access trenchless options in some areas of the country. New Zealand is a relatively young trenchless market and has traditionally had fewer contractors with the capability to offer the trenchless technology options, but in recent years this has been changing. Two trends are emerging:

i. In New Zealand trenchless technology is becoming better priced over time, as cost of materials and technology becomes more competitive
ii. Trenchless technology is becoming better priced in comparison with open cut as the cost of reinstatement of surfaces and supply of backfill material and disposal of waste material becomes more expensive.

2.2 SOCIAL COSTS

It has long been accepted that open excavation is capable of causing major disruption to commerce and the general public. Therefore a key advantage of “trenchless” construction methods is the ability to install new and rehabilitate existing underground assets with limited disruption to traffic and business activities, reduced damage to existing paved surfaces, fewer adverse environmental impacts and less disruption to normal life patterns of the people living, working and shopping around the construction zone. The equivalent monetary values of these disruptions are called ‘social costs’ – the costs associated with the construction works that are paid for by the community at large, and not realized as a cost that is included in the tendered contract price.

Figure 5. – Factors of Social and Environmental impacts resulting from Utility works



Although the existence of social costs have been recognized by utilities as part of undertaking a pipeline construction project, they are rarely accounted for within project estimates during the planning stages because they are difficult to estimate using standard estimating methods.

An estimate of the social costs for open cut projects outside of Australasia have varied from 6% to 78% of the direct and indirect costs of the project trenchless social costs on the other hand have been estimated as much lower at only 3% (Mc Kim, R. A.,1997, Michelson, K., 2005, J Pucker et al. 2006).

Social costs vary for individual projects dependant on the location and particular circumstances of each project.

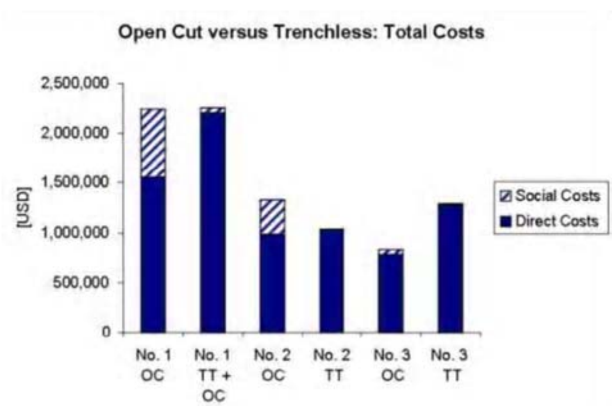


Figure 6. – Total Costs for the 3 case studies including Social Costs

Figure 6, represents 3 case studies of estimated cost comparisons for trenchless construction and open cut installation methods, with the inclusion of social costs (J. Pucker et al. 2006). Both case studies 1 & 2 took place in a high-density city area in the United States of America, where as case study 3 was located in a residential Greenfield subdivision. Figure 7 shows the relative contribution of social cost categories and direct costs to the total open-cut project costs for all 3 case studies.

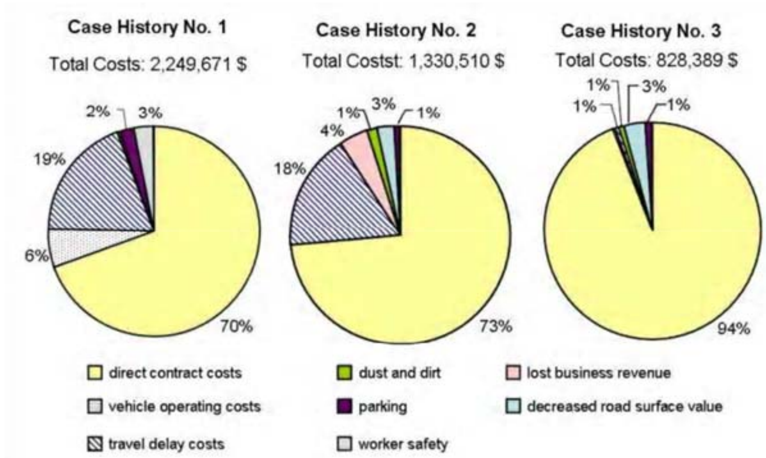


Figure 7. – Relative contribution of the different categories of social cost and direct cost for cost studies

These case studies illustrate the effect of social costs on the total project cost when comparing the different methodologies for selection. In higher density urban environments the affect of social costs have a greater effect on the cost of the project, than it does in lower population or Greenfield situations.

J. Pucker et al. (2006) put forward that "a potential rule of thumb is to first calculate the traffic delay costs. If they are less than 10% of the direct costs, social costs could potentially be ignored. If they are more than 25% of the direct costs, social costs are significant and should be taken into account during the construction projects planning, design and bid evaluation stages".

Table 2 below provides some indication of the minimum and maximum unit rate social costs per meter of placed pipe and day of construction (based on US dollars converted to NZ dollars & metric units) based on the case studies (J. Pucker et al. 2006).

Table 2. – Maximum & Minimum unit rates for social cost from case studies (J. Pucker et al. 2006)

Social Cost Category	**Minimum [$/m]**	**Maximum [$/m]**	**Minimum [$/day]**	**Maximum [$/day]**
vehicle operating costs	9	271	26	1,973
travel delay costs	13	940	41	6,435
dust & dirt	13	66	55	136
parking meter revenue	26	39	83	217
decreased road surface value	66	144	227	318
noise pollution costs	-26	2.10	-66	7

J. Pucker et al. (2006) case studies focused on traffic related social costs, but more consideration needs to be given to green house gas emissions resulting not only from the traffic disruption/diversion but from the construction activities themselves. The British Columbia chapter of the NASTT, (North American Society of Trenchless Technology) commissioned a report on the amount of green house gas emissions from trenchless pipeline construction methods, and found that Trenchless construction methods resulted in 78% to 100% lower green house gas emissions than open cut pipeline installation methods (K. Pemberton, March 2009). the main difference is the large differential in the energy used to remove and replace the material above the utility; The difference in material to be removed between trenchless and open cut to allow installation of the pipe is 53 times or 5,300% (K. Pemberton, March 2009).

In the paper "Minimizing Environmental Impact through Trenchless Construction" (Ariaratnam et al. 2008) it was also concluded in the case study that the expected reduction in green house gas emissions by use of HDD was around 97%. Table 3, from this paper compares the emissions of open-cut versus those HDD for their described case study.

Pollutants	Emission Factor (Diesel)	Open-Cut Emissions	HDD Emissions
	(lb/hp-hr)	(lb)	(lb)
NO_x	0.031	127.00	3.62
CO	6.68E-03	27.40	0.78
So_x	2.05E-03	8.40	0.24
PM-10	2.20E-03	9.00	0.26
CO_2	1.15	4712.70	134.38
Aldehydes	4.63E-04	1.90	0.05
TOC			
Exhaust	2.47E-03	10.10	0.29
Evaporative	0.00	0.00	0.00
Crankcase	4.41E-05	0.20	0.01
Refueling	0.00	0.00	0.00

Table 3. Comparison of emissions from the equipment used in each construction method in the typical project considered (Ariaratnam et al. 2008).

Another important Social Cost factor that should also be considered in a comparison, is the visual impact on the environment. Trenchless technology projects have a far smaller impact on the project zone, not only reducing the disruption that may be caused but also the stress and effect on the lifestyle of the inhabiting community particularly during large and long duration projects.

Figure 8. The footprint of the Rehabilitation of No.3 Trunk Sewer in Hastings, 628m of 1.8m diameter using Interflow's Rotoloc spiral wound lining technology.

Social costs will not always be significant, particularly in low density residential areas, but in situations where the impact of social costs to the community and environment are potentially substantial, the inclusion of social costs in calculation of the project costs should be considered when comparing Open-cut and Trenchless construction methodologies.

3 CONCLUSIONS

There is plenty of evidence that in many cases Trenchless Technology is a significantly cheaper and more socially acceptable method of construction when compared to open-cut pipeline installation.

The cost of Trenchless Rehabilitation in New Zealand is decreasing as the market becomes more mature and development of technology acts to reduce the unit rates. At the same time, the cost of open cut repairs and replacement become more expensive as the cost of fuels, disposal of waste and environmental and social impacts increase.

Global warming and an increased awareness of the environment demands that we adopt methods that will help to reduce carbon emissions. Trenchless Technology produces 97% less emissions than open-cut pipeline construction. When considering pipe replacement or repair methods the full cost, including social costs, should be taken into account as part of the Life Cycle costing to ensure that the best method with the overall lowest total cost is selected. Increasingly, trenchless methodologies will provide that result.

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