UAA Senior Design Project

Design Study Report
ARRC Yard Rehab - Water

Prepared for:
Municipality of Anchorage
Anchorage Water & Wastewater Utility
3000 Arctic Boulevard
Anchorage, Alaska 99503

Prepared by:
Seawolf Engineering
Civil Engineering Program
University of Alaska Anchorage
3211 Providence Drive, ENGR 201
Anchorage, AK 99508

Dustin Broek, Jarrod Nelson, Chad Ringler, Timothy Saner, Kyle Tee

April 12, 2014

Table of Contents

Preface

UAA College of Engineering
UNIVERSITY of ALASKA ANCHORAGE

DEPARTMENT OF CIVIL ENGINEERING
3211 Providence Dr.
Anchorage, Alaska 99508
Tel 907-786-6195* Fax 907-786-6107
1 9

April 16, 2014

Subject: "Design Study Report: ARRC Yard Rehab – Water"

The subject report is the product of a group of students enrolled in their capstone "senior design" project for credit in CE A438 Design of Civil Engineering Systems, a required course for completion of the Bachelor of Science Civil Engineering degree at UAA. The team of senior civil engineering students engaged in this project included:

Dustin Broek
Jarrod Nelson
Chad Ringler
Timothy Saner
Kyle Tee

The project was sponsored by the Municipality of Anchorage Water and Wastewater Utility (AWWU) and James Armstrong, PE, an AWWU engineer and project manager, provided mentorship and many hours of patient and kindly guidance to the student team throughout their semester-long efforts. UAA and the Department of Civil Engineering are deeply grateful for this outstanding educational support by the Municipality, AWWU, and Mr. Armstrong.

The project report summarizes investigations and designs by students undertaken at UAA direction as part of their degree requirements. While UAA intends that the work provide a public service, this is an educational endeavor and may include errors, omissions, or misstatements. Final decisions regarding improvements to the public infrastructure discussed in the students' report should be made on the basis of recommendations by fully qualified and licensed engineers.

Sincerely,

Orson P. Smith

Orson P. Smith, PE, Ph.D.
Professor and Chair, Civil Engineering Department

1.1 Executive Summary

The Alaska Railroad's fueling and maintenance yard has approximately 2000 linear feet of aging cast iron pipe (CIP) that is in need of repair or replacement. The existing pipe has been prone to breakage due to an extended service life and extensive corrosion.. Originally placed in the 1940's through the 1970's, the pipe is an essential for fire protection to multiple buildings in the yard. The Anchorage Water and Wastewater Utility (AWWU) has been tasked with the rehabilitation of the pipe system, and it has been challenged to the Seawolf Engineering senior design team to propose alternate designs for the project.

The Seawolf Engineering assignment is a student project assigned as part of a Senior Design Civil Engineering course at UAA. The inherent limitations in both timeframe and finished product from this program must be recognized. This Design Study Report (DSR) is meant purely as an academic exercise and not for construction purposes.

Five alternate designs were initially proposed for rehabilitation of the pipe system. These designs were evaluated using a set of criteria developed by the engineering team, determining which design would meet the needs of the project scope, and of the client. The criteria developed to evaluate the alternates included: ease of maintenance, reliability, safety, minimal impact to services, and cost. This set of criteria were used to evaluate each design.

When developing alternative pipe locations for the project, one of the biggest challenges was determining a pipe route that minimized disruption of service to the railroad. The existing location of 10" CIP is routed beneath multiple sections of railway track and in between buildings. The existing pipe would have to be either rehabilitated, removed, or abandoned. Trenchless drilling techniques were proposed as an alternative to typical trenching for removal and replacement of the pipe. It was found to be expensive to use as a primary drilling source, as well as hindered by physical constraints of the rail yard. Trenching the existing pipe would involve removal of track at multiple locations, and would cause the greatest disruption to the railroad's operations. A design including trenchless technology for installing pipe under track sections, and conventional trenching a new pipe loop into the fueling yard is recommended.

This design study report recommends an alternate route alignment for a new 10” water line to be installed in the Alaska Railroad fueling yard. It will begin at the west side entrance of the maintenance yard, travels north-east to the north-west corner and past the maintenance shop. Once past the shop the pipe system will travel south-east away from the railroad tracks exiting the shop and continue towards the junction in the south-east corner, terminating at the main line. This design will keep the original transmission loop design, allowing flow from either side of the main line. A mix of open trenching and auger-boring would be utilized for pipe placement. In the event of a pipe break or maintenance requirement, valve vaults will be placed throughout the system to allow AWWU to shutoff water supply and conduct any needed repairs.

The Alaska Department of Environmental Conservation (ADEC) was consulted to help determine guidelines that would need to be followed regarding soil handling and dewatering of possible contaminated materials. Environmental reports were analyzed and showed a soil hydrocarbon contamination level in the area that does not exceed maximum limits that would require complete soil remediation. Dewatering would be done with settlement tanks with discharged water passing through charcoal filters before being pumped into the sanitary sewer system in the yard. 10” PVC pipe were selected as a preferred choice for this project. For sections passing underneath the tracks, auger-boring would be utilized with galvanic protected iron pipe incasing the water lines per the 2009 American Railway Engineering and Maintenance-of-Way Association (AREMA) Railway Engineering manual’s specifications.

Bore hole data was provided by the Municipality of Anchorage to give an understanding of the types of soils that would be encountered while trenching the pipe and how soil composition might affect the overall cost of the project. The data also gave information on possible corrosion effects that would help determine the type of pipe material that would be ultimately used.

2.1 Introduction

The full project Request For Proposal (RFP) included the following description of the project, copied from the Municipality of Anchorage's RFP was "to rehabilitate nearly 2,000 linear feet of 10" cast iron main, valves, service connections, fire hydrants and other miscellaneous parts of the system. The purpose of this RFP will include but not be limited to, soils exploration and reporting, surveying, construction plan and specifications for trenchless pipeline rehabilitation, soliciting and responding to input from stakeholders. Tasks under this contract may include, but are not necessarily limited to, the following:

1. Review all existing reports, records, construction methods and material requirements; identify any constraints for construction methods and materials; present construction methods and material options not previously considered.
2. Trenchless construction and materials are proposed; ensure that the team has experience in design and construction of trenchless technology.
3. Focus on costs of installation & long term maintenance, longevity and reliability.
4. Obtaining existing geotechnical data, conduct new geotechnical explorations, report and provide recommendations that included at a minimum:
    a. gradation results of select samples from borings with soil classification
    b. visual soil classifications during sampling and post sampling
    c. penetration values
    d. pavement structural section recommendation
    e. ground water levels at time of boring, two weeks post boring, in May and during the first two weeks of September
    f. estimate ground water flows at 10' below ground surface based on soil classification and static water level
    g. vicinity and boring log maps
    h. contaminated site map with 1 mile and 2 mile radii shown
    i. screen for petroleum contamination and test contaminated soils to ensure compatibility of the soils to the rehabilitation material

j. other information and recommendations as needed to achieve standard level of care and meets the needs of AWWU” (*Municipality of Anchorage RFP 2013-P011*)

3.1 Project Scope and Approach

The Seawolf Engineering Team, having been awarded this project by AWWU, agreed to complete the following deliverables by April 2014.

- Review existing plans, studies, geotechnical data, technical memoranda and record drawings;
- Develop alternative analysis methodology and perform a preliminary corridor / alternatives analysis to develop a list of at least three feasible alternatives;
- Analyze other utility record drawings and grid sheets to determine utility conflicts with the alternative routes;
- Review hydraulic modeling data and provide a recommendation on material and sizing of the pipe to be constructed;
- Prepare a Design Study Report that will include a recommended route alignment and piping material recommendation.
- The DSR shall include a rough order of magnitude (ROM) cost estimate

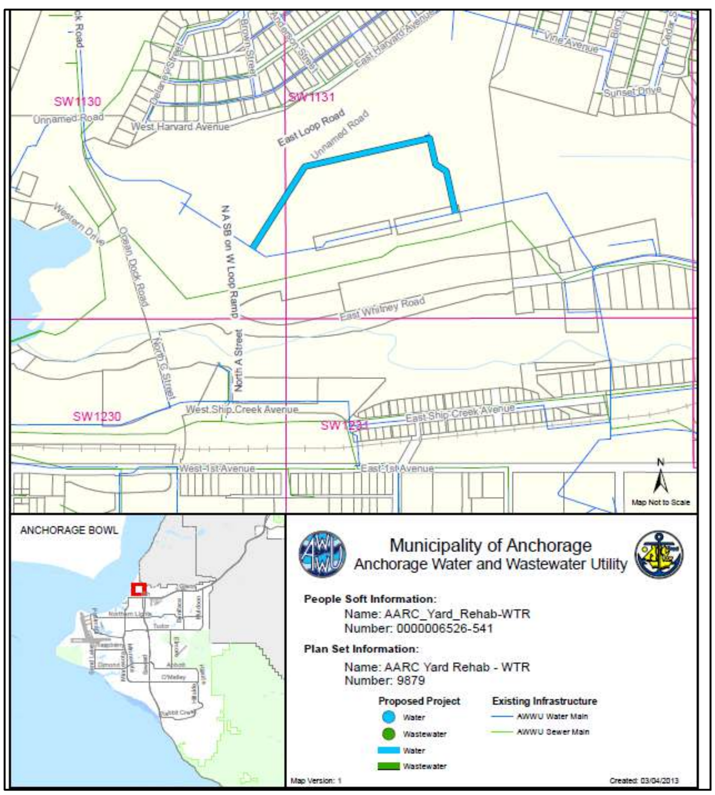


Figure 1 - Project Location

4.1 Geotechnical Issues Considered

The piping location is somewhat restricted due to track placement, building locations and other structure conflicts. Alternatives are discussed for the elimination of the loop design and for removing existing pipe routes underneath the locomotive fueling station.

The goal of the study was to provide information and data for the route selection process for each alternative. The information was intended to expose any possible issues that would arise during the installation of pipe along each possible routing, as well as any issues that could jeopardize the longevity and structural integrity of the pipe. To investigate the potential topics a variety of resources were used including the MOA soils laboratory data library and Google earth. T he ADEC website provided contaminated soil locations and specific information for locations within the project area.

4.1.1 Geotechnical Procedure

Since the alternative piping locations are within a similar location, some of the topics was deemed negligible. The primary distinguishing factor that separated the alternatives were the soil geology and the likelihood of contamination issues in those locations. To gather the appropriate information, Google Earth data as well as a site visit allowed the best analysis for possible piping routes.

To compare the environmental issues along each route, ADEC's online database was used. ADEC provides a map of Anchorage that shows every known contaminated soil site. The amount and severity of contaminated sites were totaled for each route. The route with the least amount of known contaminated sites was deemed the best alternative in terms of environmental impact.

5.1 Environmental Concerns

The project area is contained within the grounds of the Alaska Railroad fueling and maintenance yard near the port of Anchorage. This is a known fuel contaminated site according to ADEC, and will continued to be used for the servicing and fueling of the AKRR locomotives. Procedures for discharging water and reclamation of soil in fuel contaminated sites will be followed according to guidelines set by the ADEC. Soil and water sampling and testing to be conducted by an independent environmental testing laboratory prior to the start of construction.

5.1.1 Contaminated Soil

Soil exceeding maximum contamination levels listed by the ADEC for fuel contaminated sites will require thermal treatment and disposal. This process can be either done on site or the soil transported to a processing facility. Per AREMA specifications, soil from a contaminated site can be reused untreated if it is to be placed back into the site, with the only stipulation being that the top two feet of any trenched section is backfilled with thermally treated soil.

5.1.2 Dewatering

Dewatering will be accomplished in a three step process: sedimentation, filtration, and discharge. Collected water will be pumped into sedimentation tanks and detained for an amount of time to be determined by the engineer. After sedimentation, the collected water will be passed through a charcoal filtration unit before final discharge into the sanitary sewer system. Water exceeding fuel contamination levels listed by the ADEC will be placed in sealed drums and disposed of at an approved facility.

5.1.3 Permits

The following permits will be required for the proposed project:

- ADEC contaminated soil transportation permit
- ADEC disposal and discharge of contaminated water permit
- AWWU wastewater discharge permit

6.1 Piping Alternatives

One aspect of this project that presents a unique challenge is the location of the project site. The existing water pipe that is to be replaced or rehabilitated is under the Alaska Rail Road's largest train station. Two major concerns led our group to evaluate trenchless technology as an option in this project. The first is that this train station is the busiest location of the Alaska Rail Road and that any disruption of their operations using traditional techniques could be a major financial loss for the rail road. The second is that the disruption of existing track would cause a difficult and expensive task to rebuild and realign them.

Trenchless technology has been around as early as WWII but has only recently experienced rapid expansion in both technology and application. Trenchless techniques involve different methods of subsurface construction without the need for digging continuous open-cut trenches, or at least limited need. It is primarily utilized for the installation, replacement or rehabilitation of water-waste water pipes, utility conduits and pipelines.

There are two main categories for trenchless techniques, trenchless construction and trenchless rehabilitation. Construction involves the installation of new infrastructure using techniques that drill, ram or ream a pipe into place. Rehabilitation involves techniques that repair or replace existing infrastructure. Under these two categories of trenchless technology there are numerous methods. Figure 2 lists the most common techniques.

To fully understand the advantages and disadvantages of the different trenchless techniques the following methods were explored due to equipment availability in Alaska and their use in past projects. The methods are pipe bursting, cured in-place pipe, slip lining, horizontal directional drilling, auger boring, pipe ramming and micro tunneling.

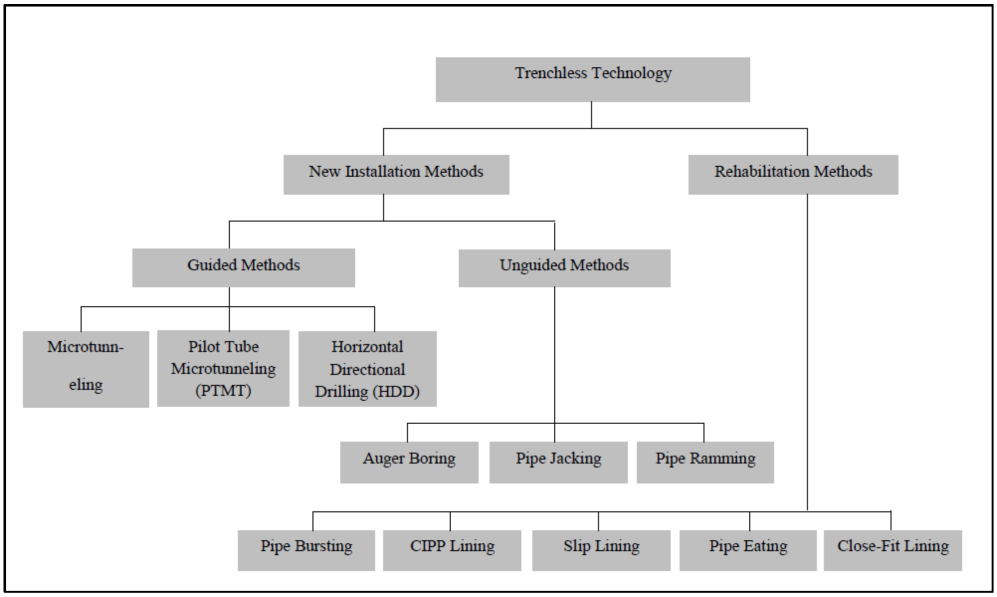


Figure 2: Family of Trenchless Technologies (Gottipati)

6.1.1 Pipe Bursting

Pipe bursting is a rehabilitation method by which an existing pipe is destroyed and replaced by a new pipe. This is illustrated in Figure 3. Pipe bursting is most frequently used on cast iron and ductile iron pipes, but in some cases can also be used on PVC and HDPE. The rehabilitation starts with digging the entry pit at one end of the old existing pipe. The pit only has to be large enough to accommodate the ground burst winch. Once the winch is in place the cable is run the length of the existing pipe to an exit pit.

The exit pit is where the new pipe will be pulled back through the existing pipe, so it must be large enough to handle the insertion of the pipe. At the exit pit an expander is attached to the cable and attached to the expander is the new pipe. The expander is pulled back through the old pipe to the entrance pit and shatters the existing pipe as it advances. Once the expander is pulled all the way back to the entrance pit the old pipe has been destroyed and the new pipe is in its place.

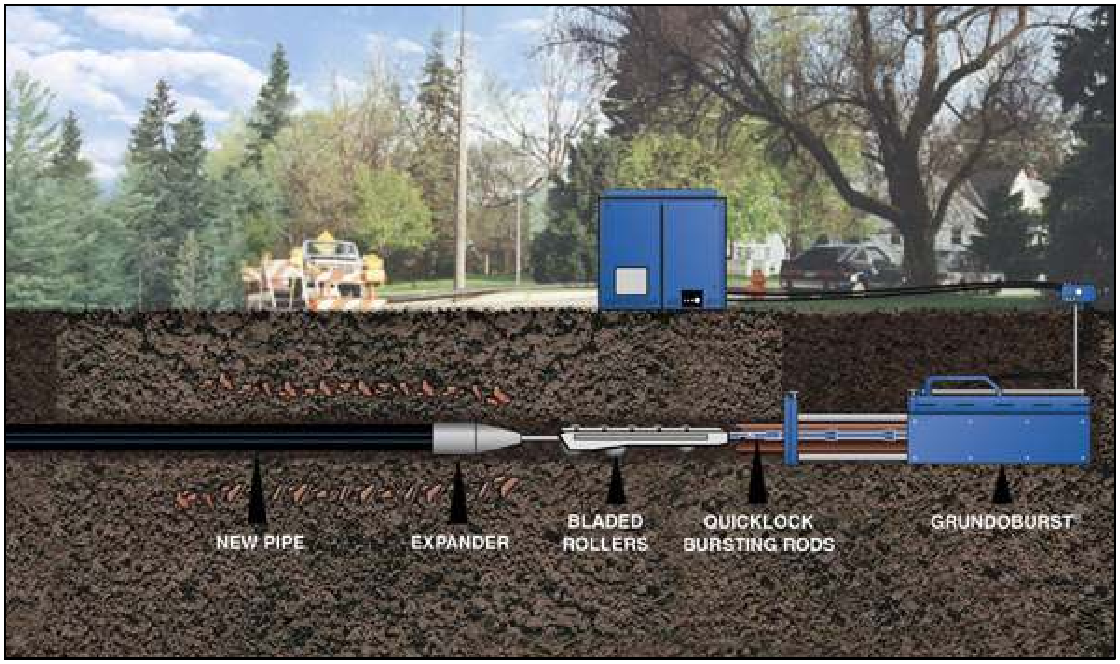


Figure 3: Pipe Bursting

The length of pipe that can be rehabilitated at one time is limited to the winch's pulling force. Generally, no more than 1000 feet of pipe can be burst at a time. Pipe bursting is the only rehabilitation method that can replace an existing pipe with a larger diameter new pipe. Pipe bursting is also not inhibited by a high water table which could be a major factor in this project.

6.1.2 Cured In-Place Pipe (CIPP)

CIPP is another rehabilitation method that lines the inside of an existing pipe with a woven liner and epoxy resin, and it can be used to line any type of pipe. Once it is cured the lining is structural sound and can support the surrounding forces. The rehabilitation begins with establishing access to the existing pipe. The woven liner is

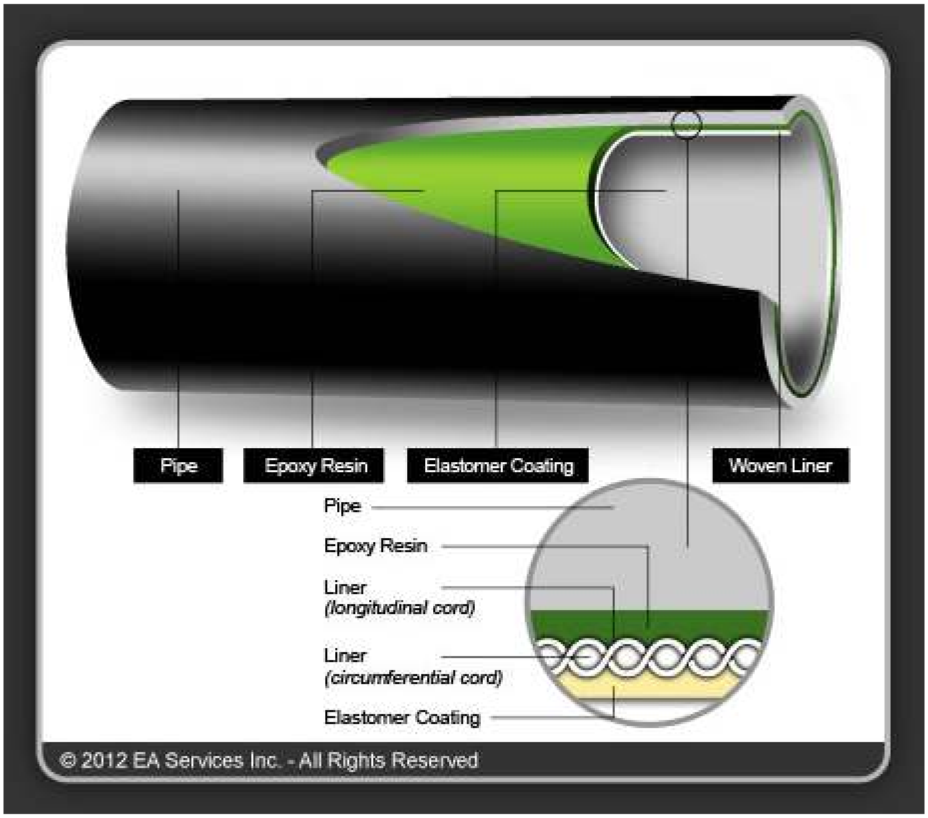


Figure 4 - CIPP Cross-section.

then placed at the entrance of the pipe and is usually inverted before installation. There are two common methods for installing the liner. Either water or air is pumped into the liner at the entrance of the pipe. The inverted liner will roll itself down the pipe flipping the right-side out to meet the surface of the old pipe. Once the liner is in place one of two methods is used to cure it. One method is to use hot water to cure the new liner. The second method is to use an infrared snake device

to move through the liner and cure it from the inside.

CIPP is a great method for limiting the cost of excavation and installation, although there are drawn backs. To date the woven liner has not been sufficiently tested at resisting certain types of chemicals, specifically hydrocarbons. Since a large portion of the water line runs under a fuel station this is a major consideration. Also, the use of the liner will make the inner diameter of the existing pipe smaller. This will restrict flow and could be a problem for proper fire flow rates.

6.1.3 Slip lining

Slip lining is another rehabilitation method. It is similar to CIPP in that it lines the inside of an existing pipe. Instead of using a woven liner, slip lining uses a smaller pipe to slide into the existing pipe. Each side of pipe is enclosed, and a grout with the consistency of water is pumped

Figure 5 - CIPP Installation

Figure 6: Slip lining – before (L) and after (R)

between the liner and the old pipe to seal any gaps and hold the liner in place.

Slip liners present a similar challenge as CIPP in that its net effect will be a smaller diameter pipe. Also, slip liners are generally used for larger size pipes. Water table can also be a problem for the proper installation of the liner and curing of the grout. The last consideration is that a slip liner requires a large work space to slide it into the existing pipe.

6.1.4 Horizontal Directional Drilling (HDD)

HDD is the first new pipe construction method that was evaluated. This method uses a highly steerable drill shaft to bore out a hole from an entrance point to an exit. No entrance pit or exit pit is needed. Once the drill bit exits the sub terrain it is taken off and replaced with a reamer. Behind the reamer the new pipe is attached and then the whole

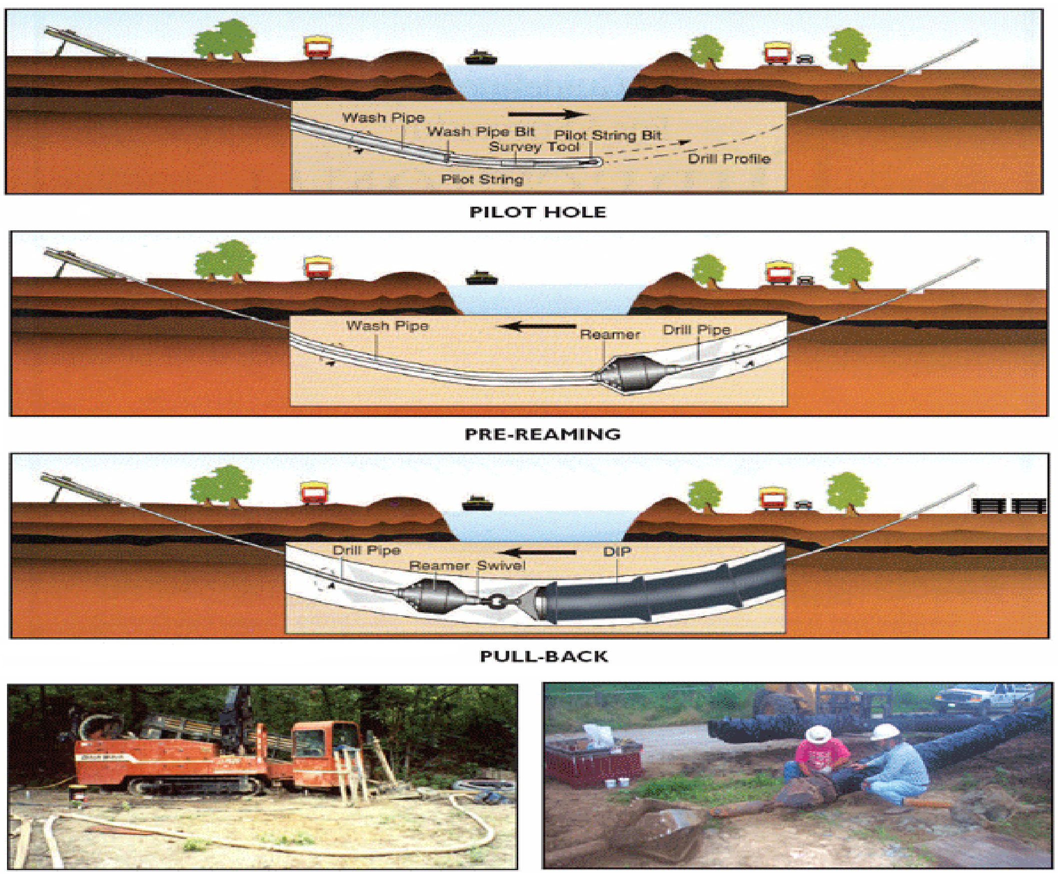


Figure 7: Horizontal Directional Drilling

assembly is pulled back through the hole.

HDD has a lot of great advantages for trenchless new construction. However, its use for tunneling under rail road tracks is no allowed according to the AREMA. Use of this method can create a larger tunnel than needed and disturb the surrounding soil. This will make the track susceptible to settling and cause great risk of train derailment.

6.1.5 Auger Boring

Auger boring is another new construction method. This method requires the excavation of an entrance pit to the depth of the new pipe and as long as needed to accommodate boring equipment plus a section of new pipe. Depending on whether 20 foot or 40 foot sections are used the pit most be approximately 40 feet or 60 feet long. The boring equipment is then placed on tracks within the pit and must be leveled to the

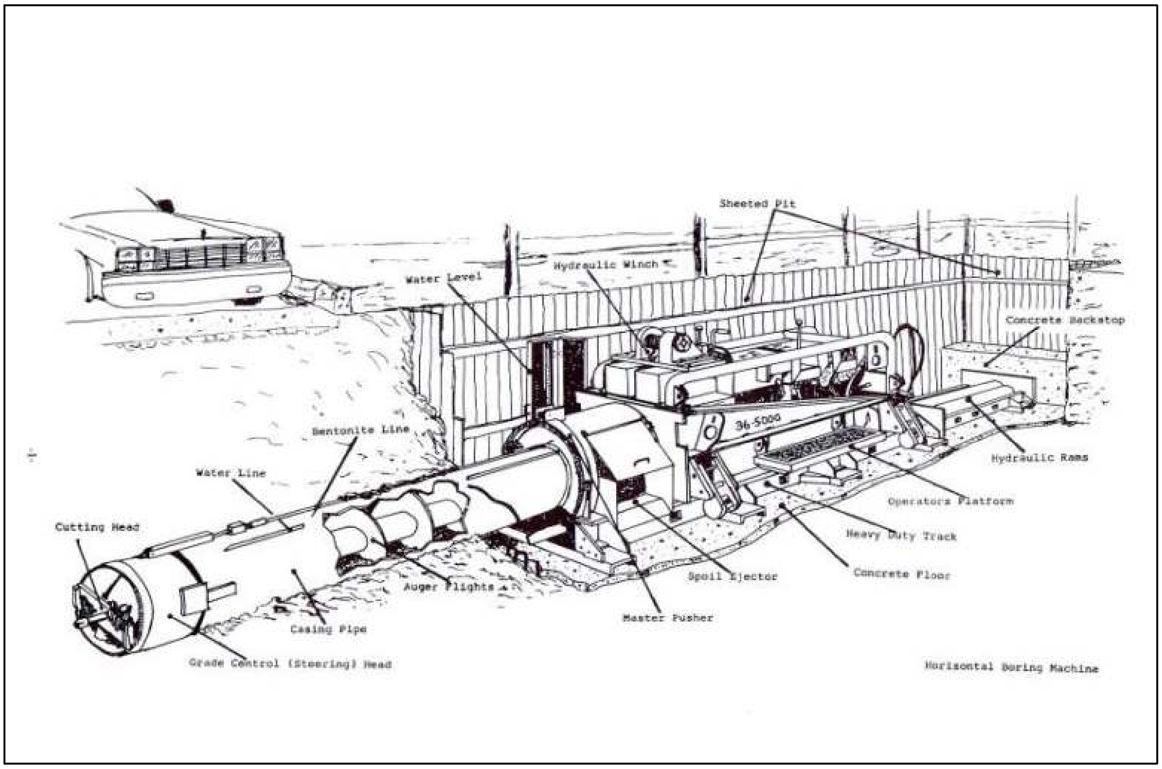


Figure 8: Auger Boring

new pipe's alignment. The first section of pipe is lowered by crane into the pit with the auger bore drill bit inside of the pit. The bit is then attached to the bore equipment and the drilling begins. As the auger bore drills into the soil it pushes the new pipe into place. Once the pipe has been drilled into the soil the drill shaft is detached and the bore is slide back on its rails. Another section of pipe is lowered with a drill shaft extension inside of it. The pipe sections are welded together and the boring continues.

Auger boring is a method that is effective under rail road tracks. It has a limited ability for directional steering that minimizes diversions. The tight fit of the pipe boring minimizes the risk of settlement. A 24 inch pipe should be the smallest diameter pipe used for auger boring. This allows a person to enter the pipe and jack hammer any obstructions if needed. A high water table can lower the effectiveness of boring, and therefore dewatering must be considered for high water table areas.

6.1.6 Pipe Ramming

Pipe Ramming is also a method of new pipe construction with similarities to auger boring. An entrance pit is dug to accommodate the new pipe as well as a pneumatic compressor that will ram the pipe into place. The pipe is aligned within the work pit and is hammered into place with compressed air.

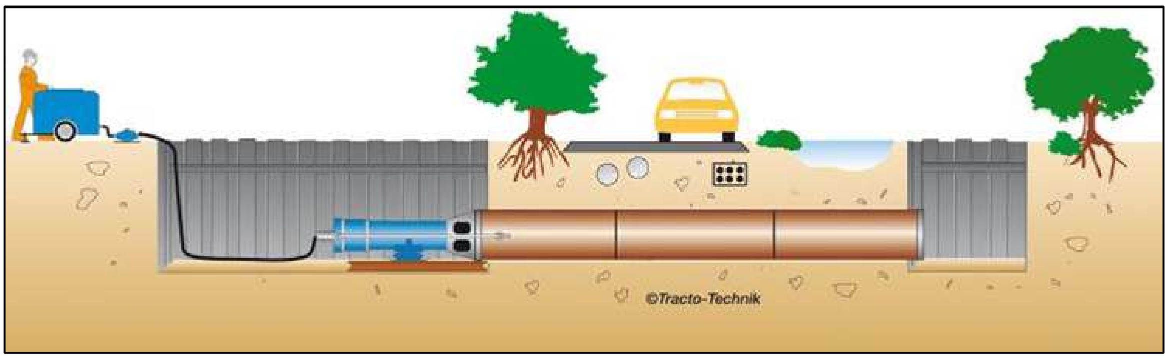


Figure 9: Pipe Ramming

Pipe ramming is less effective in areas with high water tables and it is also a method that cannot be steered. When aligning the pipe it must be oriented exactly how it is to be placed. If the pipe encounters an obstruction during the installation it is very difficult to correct or remove.

6.1.7 Micro Tunneling

Micro Tunneling is a new pipe construction method that is similar to auger boring, however the primary difference is that a lubricate solution is used on the drill bit to produce a slurry out of the tailings. The slurry is pumped out of the excavated pit into a holding tank. Micro tunneling is highly steerable and is used for large diameter pipes. Due to the fact the micro tunneling is mainly used for large diameter sewer pipes, it is less applicable to this project. Micro tunneling is not generally done in Alaska and therefore the equipment would need to be rented from the lower 48 states, increasing the cost of the project greatly.

Figure 10: Micro Tunneling

When evaluating the different construction and rehabilitation techniques it becomes evident that some methods would not be feasible or effective for this project. Using the criteria of limited work space, high water table, equipment availability and risk of rail track settlement the trenchless options can be narrowed down to two methods, pipe bursting and auger boring. The following section examines the best use of trenchless technology in each of the alternatives being considered.

7.1 Pipe Material & Corrosion Protection

The following is an overview of corrosion protection with respect to our various alternatives. This section also provides a brief summary of the current status of the pipe based on the findings of the UAA Corrosion Lab and a lab study done on similar cast iron pipe.

Pipe Status – Outer Diameter

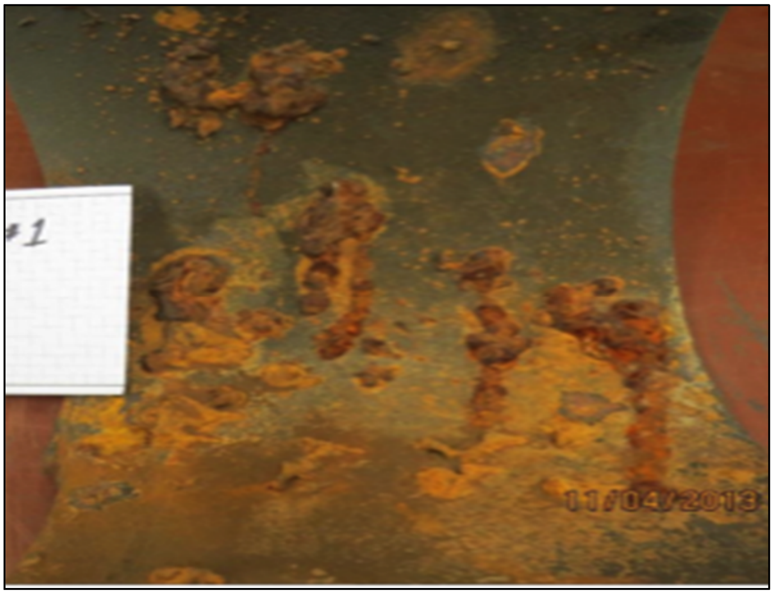
Installation of the pipe was in the 1940's and 1950's and used cast iron (gray iron). *Figure 11* show examples of a similar pipe near the project location that was also

Figure 11 – Condition of Similar Pipe (UAA Corrosion Lab)

installed during the same time frame. Pit depth in the outer diameter of the walls reached depths of over 0.14 inches with an average depth of about 0.1 inches. These pit depths are spurred from the obvious corrosion taking place. With thinner walls comes more potential for a failure of the water line.

Pipe Status – Inner Diameter

As seen in Figure 12, corrosion in the form of tuberculation is creating substantial pit depths on the inner diameter walls. UAA's Corrosion Lab has stated these depths to be on the magnitudes of 0.26 inches with an average pit depth of 0.193 inches when comparing multiple pipes from the area. These depths of corrosion, teamed with the corrosion from



the outer diameter, greatly affected our decision in what type of material to use.

Lab)

8.1 Cathodic Protection Methodology

The considerations for protection against corrosion for this project were as follows:

1) Varying Pipe Material (PVC, DIP, HDPE, etc…)
2) Cathodic Protection
3) Interior Cement Lining
4) Polyethylene Wrap
5) Polyurethane Coating

Certain pipe materials can be used to avoid buildup of tuberculation and provide "natural" defense against corrosion - materials such as PVC and HDPE offer this type of protection. However, usage of these materials might not be permitted in soils with high Volatile Organic Compounds (VOCs). (*Further discussions regarding environmental concerns with regards to pipe material are discussed in the environmental section of this DSR*.)

Table 1 - Break Rates by Pipe Type (AWWU Master Plan 2012)

Pipe Variable	Break Rate by Pipe Type			
	All Pipe	Ductile Iron Pipe	Cast Iron Pipe	Asbestos Cement Pipe
Base Break Rate	0.07	0.04	0.19	0.06
Pipe Diameter				
Diameter – 4 inches	0.00	0.00	0.00	0.00
Diameter – 6 inches	0.13	0.05	0.24	0.07
Diameter – 8 inches	0.06	0.03	0.19	0.06
Diameter – 10 inches	0.07	0.02	0.17	0.04
Diameter – 12 inches	0.04	0.03	0.08	0.00
Diameter – 14 inches	0.15	0.00	0.00	0.15
Diameter – 16 inches	0.04	0.03	0.05	0.00
Diameter – 18 inches	0.04	0.04	0.00	0.00
Diameter – 20 inches	0.00	0.00	0.00	0.00
Corrosivity of Soil				
Good Soil	0.05	0.02	0.11	0.06
Bad Soil (Any)	0.11	0.05	0.30	0.08
Installation Period				
New Bad Install Era (1965-1972)	0.20	0.13	0.23	0.10
Not Bad Install	0.04	0.03	0.12	0.06

Per AWWU's Design and Construction Manual (DCM - page 59), HDPE pipe was no longer investigated due to the pipe's location in contaminated soils. PVC pipe has been shown to be less susceptible to VOCs and thus was chosen over HDPE pipe for further consideration towards overall pipe selection.

Additionally, materials like Cast Iron and Ductile Iron were considered. However, cathodic protection and/or polyethylene wrap must be used to protect against corrosion for these

materials. When comparing Ductile Iron versus Cast Iron many variances can be seen. First, as depicted in Table 1, the break rate of Ductile Iron Pipe per mile is less than that of Cast Iron pipe. Lower break rates mean less maintenance and thus lower cost associated with using this type of pipe.

Not only does Ductile Iron outperform Gray Iron in break rates, but it also outperforms in terms of corrosive protection. Figure 13 shows a plot of outer diameter pit depth (due to corrosion) for Ductile Iron vs. Gray Iron in two different types of soils. This study was done without usage of any corrosion protection mechanism. After reviewing these results, only PVC and Ductile Iron Pipe were further considered for use on this project.

Figure 13 - Ductile Iron vs. Cast Iron in Corrosive Soils

9.1 Pipe Material Selection

Significant contrast between PVC and Ductile Iron is associated with the cost of corrosion protection for each material. To protect Ductile Iron, the methods researched for this project consisted of using an interior cement lining and exterior wall protection

Figure 14 - Interior Cement Lining Depiction

such as cathodic protection, polyethylene wrapping and polyurethane coatings. *Figure 15* depicts the application of an interior cement lining. Using an interior cement lining has shown that it does not increase friction losses when water flows through the pipe. The Hazen-Williams flow coefficient actually remains around 140 (ductile iron piping has a Hazen-Williams flow coefficient of 140). The lower the flow coefficient number, the higher the flow loss due to friction (as comparison, Cast Iron has a flow coefficient between 113-83).

To protect the exterior from corrosion, polyethylene (PE) wrapping was considered, but per AWWU's Design Criteria Manual (DCM), a PE wrapping (or barrier) may not be used if the "lines are periodically or consistently submerged in water." For this project the lines will be periodically or consistently submerged in water and thus a PE barrier cannot be used. Thus, the pipe must have a Corrosion Protection (CP) system.

For this CP system (per 20.10.06 Standardized Corrosion Protection, AWWU DCM):

1) Anodes must be installed at a regular interval of 18 feet on 16 inch or smaller diameter ductile iron pipe
2) Electrical continuity must be installed and tested
3) Epoxy coating must be specified for all fittings
4) A tightly bonded coating must be installed around the pipe

For non-metallic materials such as PVC, CP and protective coatings are not required on the pipe besides at metallic fittings. This simple fact saves tremendous cost associated with not having to install the CP system described for the Ductile Iron above. Due to this, PVC was chosen as the pipe material for this project.

The specific PVC recommended for this project is **DR-18 (235 PSI) PVC Pipe** and the specifications pertaining to this pipe choice are as follows:

- Nominal Pipe Size = 10 inches
- Pipe Outer Diameter = 11.1 inches
- Weight = 13.82 lbs/ft
- Color = Blue
- Must come in 20ft sections and conform to American Water Works Association (AWWA) C900 specifications

10.1 Fire Flow Requirements

Fire Flow is the required flow output in a specficed location. We estimated that the buildings located at the Alaska Railroad Corporation yard to be Building Type II, B. This was determined through Guide for Determination of Needed Fire Flow. From Figure 16 we determined that the building in the location were all metal.

After determining the building type then fire flow requirements were determined. In Figure 16 it shows the fire flow requirements and flow duration required for a fire area. This figure is from the International Fire Code with Municipality of Anchorage's amendments. The fire area for Building 26: Diesel Repair Shop is estimated to be 74,000 ft^2. For this building it would require a fire flow of 3,000 gpm and a flow duration of 3 hours. According to data from the Alaska Railroad, the required fire flows can be achieved with the current system that is in place, but at one of the fire hydrant location it

Figure 15: Construction Types,<http://www.isomitigation.com/downloads/ppc3001.pdf>

FIRE AREA (square feet)					FIRE FLOW [illegible] minute)[b]	FLOW DURATION [illegible]
0-12,000	0-7,000	0-4,700	0-3,200	0-2,000	1,000	
12,001-16,500	7,001-9,500	4,701-6,500	3,201-4,400	2,001-2,700	1,250	
16,510-38,700	9,501-21,800	6,501-12,900	4,401-9,800	2,701-6,200	2,000	
38,701-48,300	21,801-24,200	12,901-17,400	9,801-12,600	6,201-7,700	2,250	2
48,301-59,000	24,201-33,200	17,401-21,300	12,601-15,400	7,701-9,400	2,500	
59,001-70,900	33,201-39,700	21,301-25,500	15,401-18,400	9,401-11,300	2,750	
70,901-83,700	39,701-47,100	25,501-30,100	18,400-21,800	11,301-13,400	3,000	
83,701-97,700	47,101-54,900	30,101-35,200	21,801-25,900	13,401-15,600	3,250	
97,701-112,700	54,901-63,400	35,201-40,600	25,901-29,300	15,601-18,000	3,500	3
112,701-128,700	63,401-72,400	40,601-46,400	29,301-33,500	18,001-20,600	3,750	
128,701-145,900	72,401-82,100	46,401-52,500	33,501-37,900	20,601-23,300	4,000	
145,901-164,200	82,101-92,400	52,501-59,100	37,901-42,700	23,301-23,600	4,250	
164,201-183,400	92,401-103,100	59,101-66,000	42,701-47,700	23,601-29,300	4,500	
183,401-203,700	103,101-114,600	66,001-73,300	47,701-53,000	29,301-32,600	4,750	
203,701-225,200	114,601-126,700	73,301-81,100	53,001-58,600	32,601-36,000	5,000	
225,201-247,700	126,701-139,400	81,101-89,200	58,601-65,400	36,001-39,600	5,250	
247,701-271,200	139,401-152,600	89,201-97,700	65,401-70,600	39,601-43,400	5,500	
271,201-295,900	152,601-166,500	97,701-106,500	70,601-77,000	43,401-47,400	5,750	
295,901-Greater	166,501-Greater	106,501-115,800	77,001-83,700	47,401-51,500	6,000	4
----	----	115,801-125,500	83,701-90,600	51,501-55,700	6,250	
----	----	125,501-135,500	90,601-97,900	55,701-60,200	6,500	
----	----	135,501-145,800	97,901-106,800	60,201-64,800	6,750	
----	----	145,801-156,700	106,801-113,200	64,801-69,600	7,000	
----	----	156,701-167,900	113,201-121,300	69,601-74,600	7,250	
----	----	167,901-179,400	121,301-129,600	74,601-79,800	7,500	
----	----	179,401-191,400	129,601-138,300	79,801-85,100	7,750	
----	----	191,401-Greater	138,301-Greater	85,101-Greater	8,000	

(Note: The first three lines in the table have been edited by local amendment.)

For SI: 1 square foot = 0.0929 m^2, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa.

Figure 16: INTERNATIONAL FIRE CODE EXTRACT: APPENDIX B, TABLE B105.1 WITH MOA AMENDMENTS

only provides 2910 gpm due to the loop under the fueling station being valved off. This strongly suggests that a loop system be put in place to ensure the fire flow required, but this also does not exclude our alternatives that designs for spurs.

11.1 Conflicts by Utility

- *Water*

Water facilities along the proposed route are owned and operated by AWWU. According to the DCM, a burial depth of 10 feet to top of pipe is assumed. Building service connections and fire flow strongly dictated route selection.

- *Wastewater*

Wastewater utilities along the route are owned and operated by AWWU. The DCM calls for a minimum depth of cover of 8 feet. Since groundwater flow is on a regional basis rather than on the specific sites, preparation for groundwater discharge into the Storm Sewer has been considered.

- *Electric Facilities*

Electric facilities along this route are owned by ML&P, and any potential conflict with these lines need to be located and protected during construction phases. Conflicts include overhead lines, underground lines, electric poles, vaults, underground switch cabinets, and transformers.

- *Natural Gas*

Enstar owns natural gas lines along the proposed route. These lines are underground facilities and should be located and protected during construction.

12.1 Construction Issues

According to the DCPM the standard depth of bury is ten (10') feet from the top of the pipe up to a maximum of twelve (12') feet. If the pipe has less cover than the standard depth of bury, insulation may be required to ensure adequate freeze protection. Waivers may be required in certain circumstances when a standard specification cannot be reasonably met. Pipe installation along the main streets will most likely require only a trench design. This may be used if the sides are sloped to an angle not steeper than one and one half horizontal to one vertical as shown in Figure 17. A trench box could also be used in narrow corridors. The flow of traffic in the area will be impacted during the installation of the new water main. In some cases entire streets are expected to be closed for a period of time due to a narrow right of way. An effective traffic control plan will be imperative to efficiently and safely re-route traffic around the construction zones.

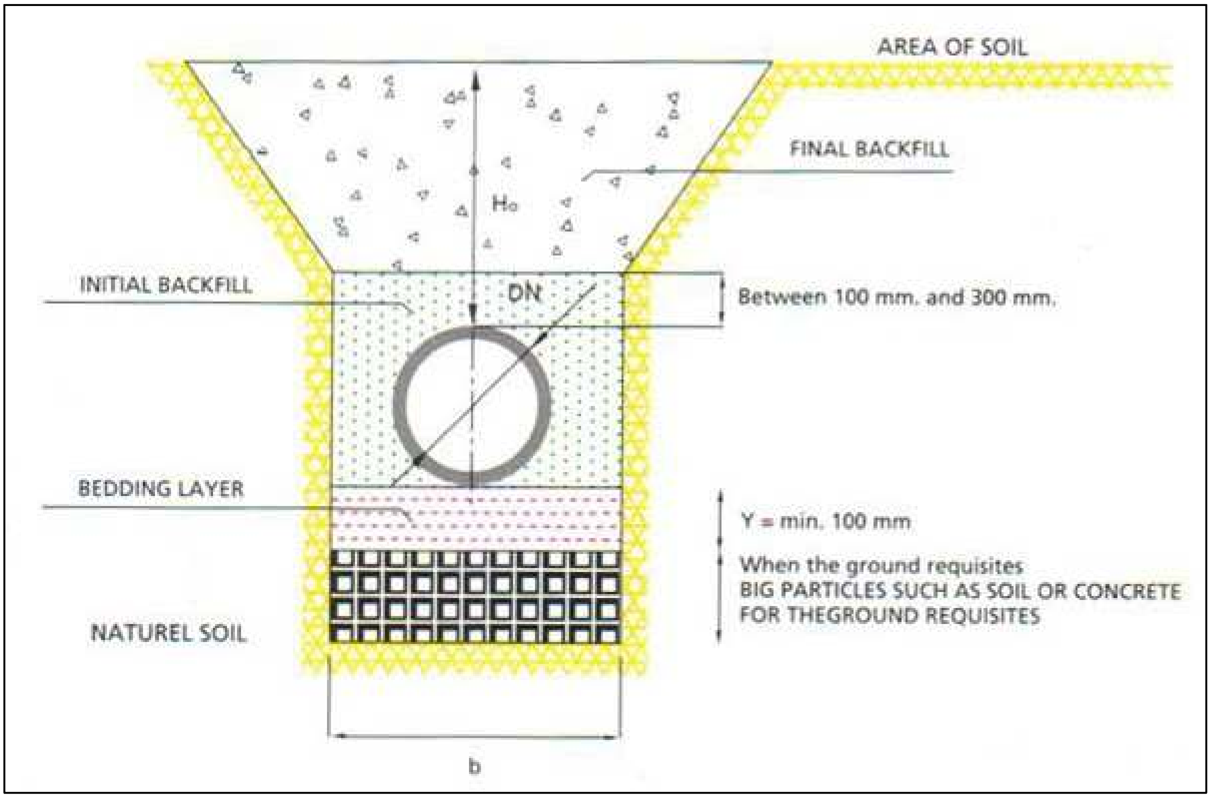


Figure 17: Typical Trench Cross-Section

13.1 Cost Estimate

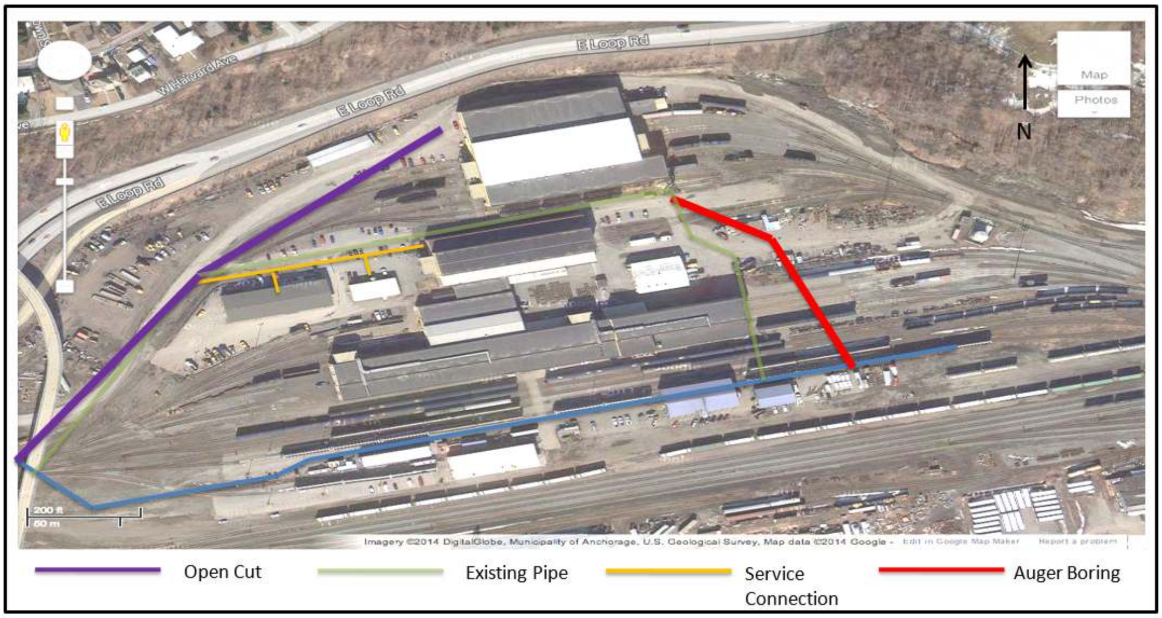
The cost estimate was challenged with primarily three tasks: identifying the appropriate construction cost line items, establishing an average cost per unit, and coming up with a reasonable quantity for each of the line items. For the line items, the team investigated other similar projects and consulted with various engineers and suppliers. The municipality's average bid-tab sheets provided the most accurate per unit cost estimates. In addition, for those line items that were not included in the bid tabs, suppliers and professional engineers were consulted. The team then had to determine the quantities for each of the line items by making some reasonable assumptions.

14.1 Piping Alternatives

In the rail yard there are several factors that result in severe limitations on re-piping, rerouting or minimal disruptions during construction. The following sections discuss the potential piping routes and the final alternative chosen.

14.1.1 Alternative 1: Spur

The spur alternative uses both open-cut trenching and auger boring methods to install the 10" PVC pipe. Open-cut trenching will be used for approximately 1140 feet of the installation along the western service road and will account for the west spur. Auger boring



will be used for approximately 770 feet of the eastern installation under numerous tracks in the rail yard operation center. This will be the east spur.

The spur is the only dead-end alterative considered in this project, since it does not complete the previously existing service loop of the original alignment. This approach greatly reduces the complexity of installing new pipe close to the maintenance shop and in between the office buildings. The spur will reduce operational impact on the rail yard during construction and decrease the risk of disturbing the existing tracks in between the buildings.

The drawback of the spur alternative is the loss of redundant water flow from two directions. This can prove to be a vital flaw during a major fire in which a large amount of water is taken from the surrounding hydrants. Through modeling techniques of fire flow conducted by AWWU's planning department this consideration proved to be true. The modeled fire flow was below the required 5000 GPM and 20 psi. This eliminated the spur alternative as a viable option for this project. This alternative was estimated at $5.04 million.

14.1.2 Alternative 2 - Big Loop

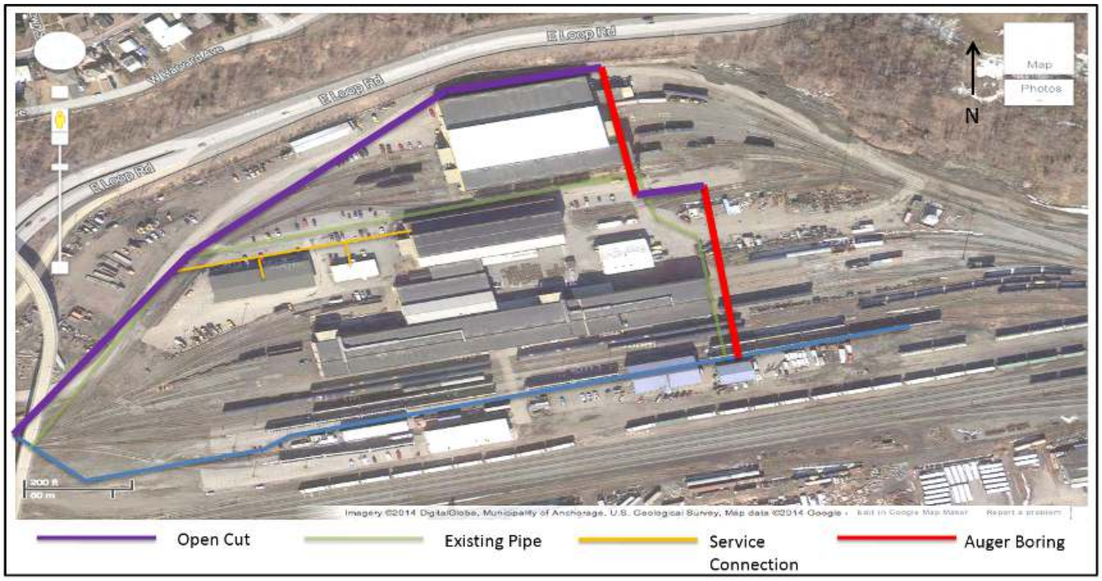
Alternative 2 proposed alignment has the 10" transmission line starting at the south west corner of the rail yard, and loops around the fueling and maintenance building, passing underneath the section of track in the south-east corner of the yard. This design uses open trenching for 2400 LF of pipe, and trenchless auger boring techniques for 350 LF of pipe placement underneath tracks and service connections to the surrounding buildings.

The alignment was designed as a redundant loop connecting to the main water transmission line at two points, while placing the longest section of the pipe network away from the buildings and from underneath the largest grouping of railway tracks.

This would allow for greater ease of construction and maintenance.

Using flow analysis from AWWU's planning department, modeling showed that the required fire flow of 5000 GPM at 20psi was met for this design. Comparison of this alternative, using the criteria developed by the Seawolf Engineering group, shows that this design met all criteria with an estimated cost of $5.75 million dollars for design and construction. Alternative 2 was chosen as the recommended design to proceed with further investigation for construction.

14.1.3 Alternative 3 – Small Loop



This alternative was considered a smaller version of the "Big Loop" alternative stated previously. This alternative was considered to investigate the potential benefits of using less open cut and more trenchless technology to place the pipe. This alternative requires 1676 feet of open cut (*the 2nd most of any alternative*) and about 770 feet of auger boring (*3rd most of any alternative*). However, the cost of using a higher amount of trenchless technology than the "Big Loop" alternative raised the cost to $5.72 million, making it the second most expensive alternative investigated for this project.

Complications also arise when investigating the construction constraints associated with this alternative. Placing the pits in the necessary locations to use auger boring will adversely affect the operations of the railroad. Additionally, when connecting the proposed 10" line to the 16" main, there is insufficient space for a proper trenchless pit to be dug in the area. For these reasons, Alternative 3 was no longer considered.

14.1.4 Alternative 4 – Pipe Bursting

Pipe Bursting has a proposed design that remediates the existing alignment using trenchless pipe bursting techniques. Placement of a new 10" PCV water line will be pulled into the alignment behind the bursting equipment. The entire 2000 LF water transmission line and service connections will remain in the current position.

This design continues to use a loop, connected at two points along the main water line giving flow redundancy for fire protection. Alternative 4, with the current

pipe layout meets fire flow requirements of 5000 GPM at 20 psi as per AWWU water flow modeling.

While meeting the requirements of fire protection, as well as having the lowest estimated cost of construction at $4.10 million, the design did not address the initial problem of difficult maintenance, and disruption of service to the railroad during repair or construction of the water line. Due to not meeting this criteria, alternative 4 was eliminated from further consideration as a possible recommendation.

14.1.5 Alternative 5 – "Government Hill"

The Government Hill alternative is similar to the Small Loop alternative but with a line running from Government Hill system area. Along with the Small Loop alternative, the goals in designing it was to move the water line away its current route that runs under the buildings and to minimize the amount of railroad tracks the line passes under. This alternative was created with the prediction of not having enough flow from the 16 inch water mainline.

This alternative was not chosen because it did not meet all of our design criteria. The major criteria it did not meet are the impact to services, ease of maintenance and cost. For impact to services, this option would impact the services to the railroad yard equal to or more than the Small Loop alternative. By adding an additional work pit in the railroad yard it would be causing unnecessary disturbance to the railroad yard's normal activities. The amount of maintenance the Government Hill alternative would require would be much more than the Small Loop's amount, primarily due to the addition of this extra line.

Costs for this alternative is the highest of the five alternatives at a cost estimated to be $6.18 million. The difference from Government Hill alternative and our chosen Big Loop

alternative is about $0.50 million. The pros of the Big Loop alternative outweighed the justification to spend $0.50 million to the project. Overall the Small Loop alternative was ranked higher than Government Hill alternative, but the Big Loop alternative was chosen over these alternatives. More in depth analysis would be required to justify connecting the two systems. As of this report it is determined that there is no need to connect the waterlines from railroad yard to Government Hill.

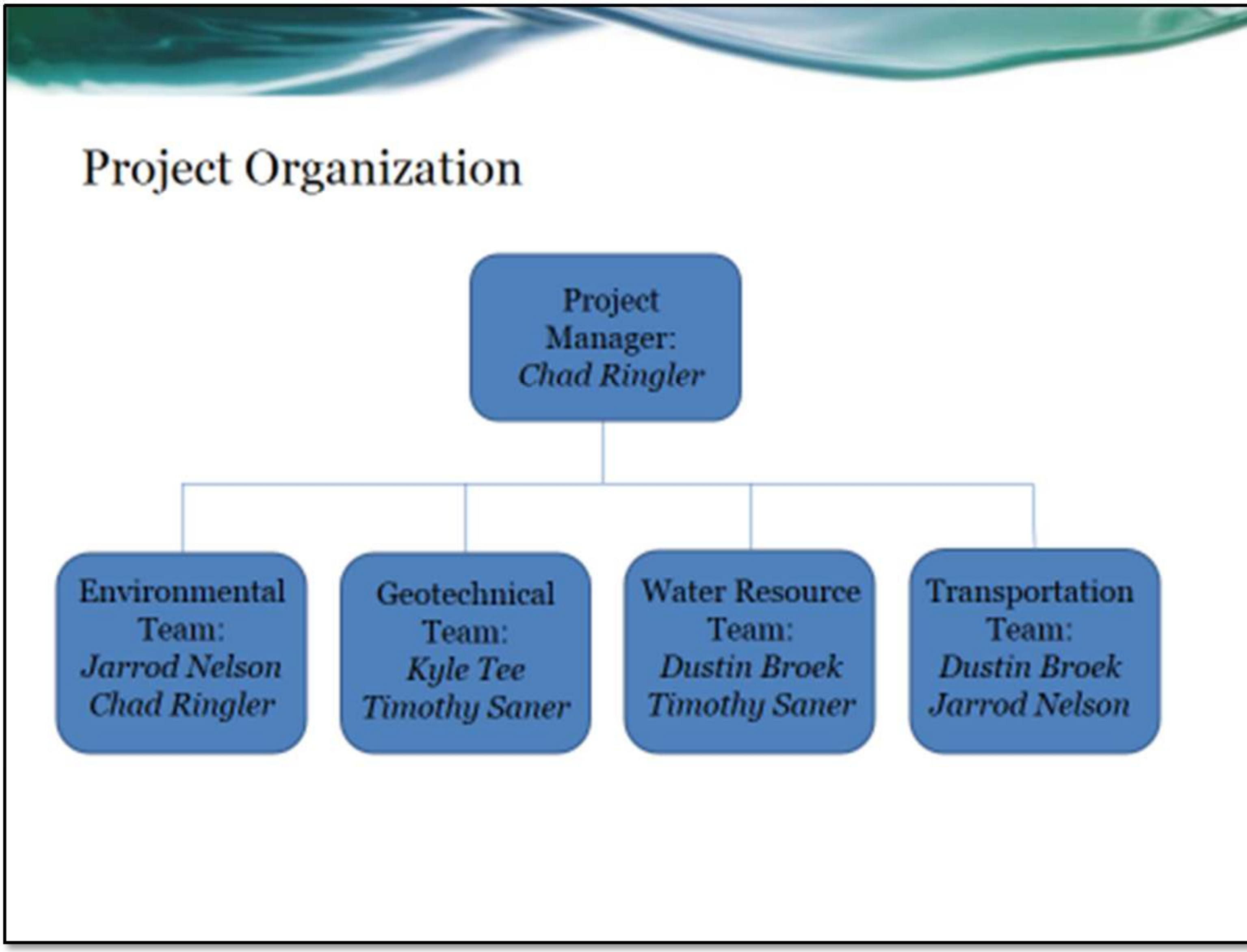
15.1 Conclusion

The alternative route alignment recommended by this study is the "Big Loop" 10-inch diameter transmission line that loops around the maintenance and fueling yard, passing underneath the section of track in the south-east corner of the yard. This alternative was evaluated and chosen, using the criteria developed by the Seawolf Engineering group, which included: ease of maintenance, reliability, safety, minimize impact to services, and cost.

This alignment, while longer than others alternatives proposed, has the least amount of disruption to railroad service, but it also places the water line in areas that could be easily maintained as needed. Open trenching is to be utilized for the largest sections of the water transmission lines, while auger boring techniques used for sections of pipe to be laid beneath railroad tracks. Each pipe section laid under tracks would need to be cased with iron pipe as required per the AREMA manual, and have the required galvanic protection detailed in this design study report.

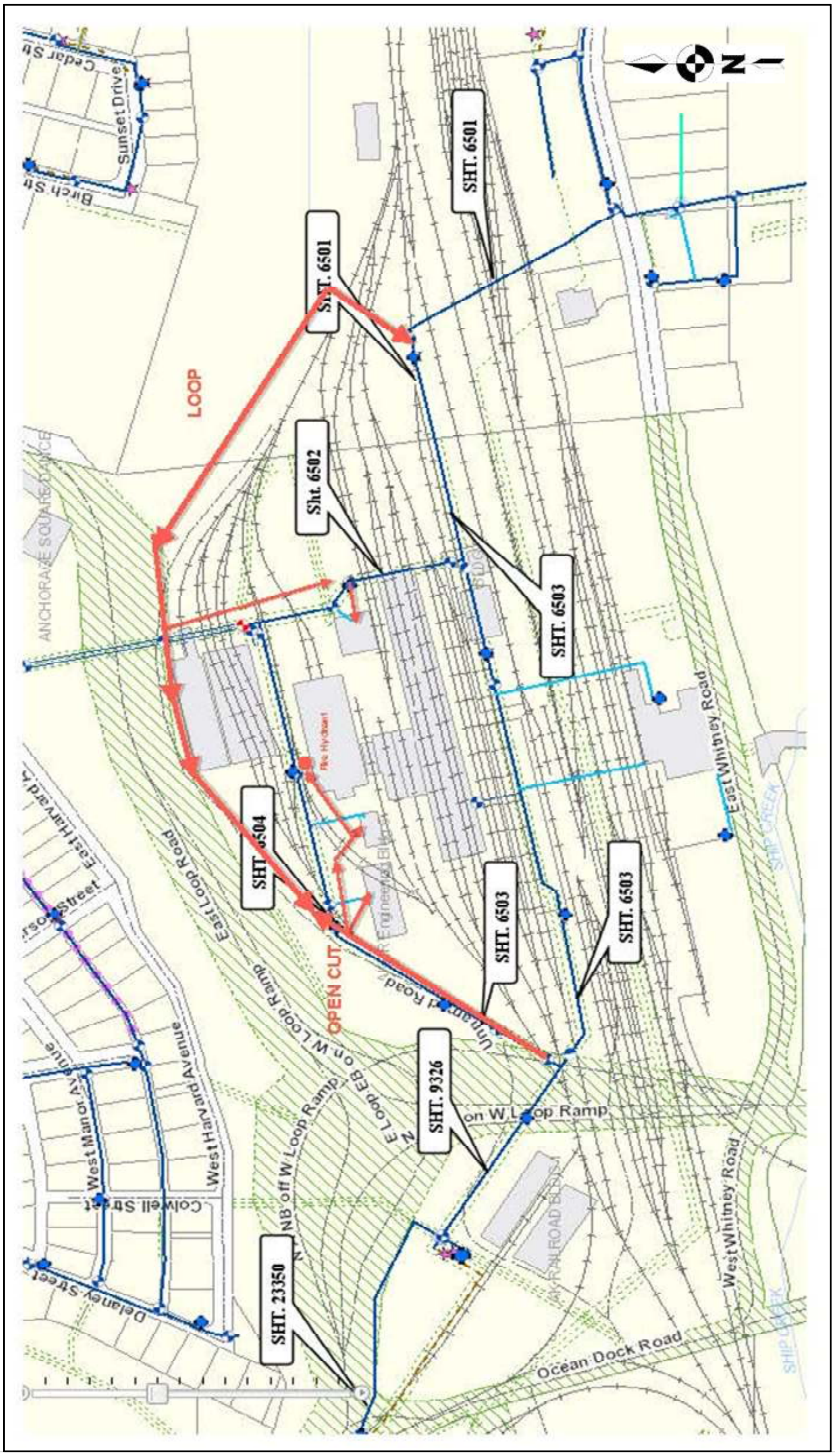
After comparing the pipe material options, PVC pipe was selected for its strength, durability, ease of installation and maintenance, as well as cost. It is an ideal material for the low levels of contaminated soil found in the maintenance and fuel yard. Sizing was determined from cost and fire flow analysis.

Appendix A


Project Organization
Project Manager: Chad Ringler
Environmental Team: Jarrod Nelson Chad Ringler
Geotechnical Team: Kyle Tee Timothy Saner
Water Resource Team: Dustin Broek Timothy Saner
Transportation Team: Dustin Broek Jarrod Nelson

Appendix B

Aerial Map of Alternative Route Selection



Appendix C

Bibliography

1. Municipality of Anchorage – Request for Proposal RFP 2013-P011 "AARC YARD REHAB-WATER", 2013.
2. Gottipati, Vamseedhar. (December 2011). "Pilot Tube Microtunneling: Profile of an Emerging Industry." *Retrieved from* www.repository.asu.edu (March 2014).

Appendix D – Cost Estimate

					Alt A (Spur)		Alt B (Big Loop)		Alt C
Item	Spec. No.	Work Description	Units	Unit Price	Est. Qty	Total Price	Est. Qty	Total Price	Est.
		Storm Water Pollution Prevention Plan (Type II)	LS	$40,000.00	1	$40,000.00	1	$40,000.00	1
		Remove Asphalt (12-feet wide)	SY	$3.00	1,515	$4,546.40	3,133	$9,398.80	2,23
		Dewatering	LS	$25,000.00	1	$25,000.00	1	$25,000.00	1
		Trench Excavation and Backfill (various depths)	LF	$154.00	1,137	$175,036.40	2,350	$361,853.80	1,67
		Bedding Material (Class E)*	TON	$30.00	543	$16,299.39	1,123	$33,695.83	801
		Foundation Fill Backfill (Type VI)**	TON	$30.00	235	$7,040.00	235	$7,040.00	235
		Leveling Course***	TON	$34.00	74	$2,519.04	153	$5,207.63	109
		Pipe Insulation Board (R-20)	SF	$5.00	1,903	$9,515.50	2,690	$13,450.00	2,44
		Disposal of Unusable or Surplus Material	CY	$22.00	63	$1,389.18	131	$2,871.86	93
		Contaminated Soil/Water Preparation and Documentation	LS	$25,000.00	1	$25,000.00	1	$25,000.00	1
		Contaminated Soil Stockpile Area Maintenance	LS	$28,000.00	1	$28,000.00	1	$28,000.00	1
		Contaminated Soil Disposal	TON	$150.00	700	$105,000.00	1,400	$210,000.00	900
		RCRA Regulated Soil	TON	$275.00	100	$27,500.00	100	$27,500.00	100
		Water Treatment Disposal Sanitary Sewer	LS	$45,000.00	1	$45,000.00	1	$45,000.00	1
		Contaminated Water Disposal Offsite	GAL	$4.00	10,000	$40,000.00	10,000	$40,000.00	10,0
		A.C Pavement (Class E) (4-in depth x 12-ft wide)	TON	$119.00	253	$30,056.76	522	$62,136.51	372
		Furnish and Install 10-inch C900 PVC Water Main	LF	$224.00	1,903	$426,294.40	2,690	$602,560.00	2,44
		Furnish and Install 2-inch Water Service Line	LF	$208.00	340	$70,720.00	340	$70,720.00	340
		Furnish and Install Fire Hydrant Assembly (Single Pumper)	EA	$11,900.00	5	$59,500.00	5	$59,500.00	5
		Temporary Water System	LS	$20,000.00	1	$20,000.00	1	$20,000.00	1
		Abandon Pipeline in Place with flowable grout	CY	$350.00	26	$9,233.68	26	$9,233.68	26
		Remove and Salvage Existing Fire Hydrant	EA	$1,000.00	5	$5,000.00	5	$5,000.00	5
		Furnish and Install Anode	EA	$522.00	43	$22,228.50	19	$9,918.00	43
		Furnish and Install Cathodic Protection	L.S.	$92,000.00	1	$92,000.00	1	$92,000.00	1
		Construction Survey Measurement	LS	$18,000.00	1	$18,000.00	1	$18,000.00	1
		Remove and Reset Fence	LF	$50.00	1,000	$50,000.00	1,000	$50,000.00	1,00
		Traffic Maintenance	LS	$41,000.00	1	$41,000.00	1	$41,000.00	1
		Utility Coordination	LS	$85,000.00	1	$85,000.00	1	$85,000.00	1
		Water System Removal	LS	$15,300.00	1	$15,300.00	1	$15,300.00	1
		Furnish and Install Pipe Bursting (10-inch PVC DR-18)	LF	$214.00		$0.00		$0.00	
		Furnish and Install Auger Bore Castin (24-inch casing)	LF	$600.00	767	$459,900.00	340	$204,180.00	767
		Work Pit Excavation Auger Bore (60'x6') and Backfill	EA	$18,480.00	1	$18,480.00	1	$18,480.00	1