Passaic Valley Sewerage Commissioners
Water Pollution Control Facilities

# Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line

February 2009


# *Final Report*

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# Study Objective/Introduction/Project Background

## 1.1 Study Objective

The purpose of this evaluation is to review and evaluate the rehabilitation options of the existing gravity Heat Treatment Plant Supernatant Return (HTPSR) Line to convey the Sludge Decant Tanks (SDT) supernatant flow to the Supernatant Treatment Plant (STP).

## 1.2 Introduction

In the late 1970s, as part of a major plant upgrading program, the Passaic Valley Sewerage Commissioners (PVSC) placed into operation a sludge thickening/dewatering process at its Water Pollution Control Facility in Newark, N.J. The process consists of thickening raw waste activated and primary sludge's utilizing gravity thickeners, stabilization by thermal conditioning utilizing the Zimpro process, thickening in Sludge Decant Tanks and dewatering using plate and frame filter presses.

There are six Sludge Decant Tanks (SDTs). Each SDT is approximately 88-feet in diameter and has volume of approximately 1.25 million gallons (MG). The total volume of all six SDT is about 7.5 MG. Zimpro processed sludge from the Sludge Heat Treatment Facility (SHTF) is fed to the SDTs where thickened oxidized sludge is drawn from the bottom cone and pumped to the filter presses. The overflow or supernatant from the SDTs is collected and conveyed to the Supernatant Treatment Plant (STP) through the Heat Treatment Plant Supernatant Return (HTPSR) Line.

Refer to the following table for the composition makeup of the HTPSR supernatant wastewater from the Sludge Decant Tanks.

Table 1-1

Composition Makeup of the HTPSR Supernatant Wastewater [1]

| Parameter Description | Value/Range |
|---|---|
| pH | 4.2 to 5.1 |
| Temperature | 18.2 to 41.3 deg. C (64.8 to 106.4 deg. F) |
| Solids | < 1% |
| Sulfides | 8.0 mg/l |
| Chlorides | 500 mg/l |
| Acetone | 84,600 ppb (8.5 %) [2] |
| 2-Butanone | 50,765 ppm (5.08 %) |
| 2-Hexanone | 1,290 ppm (0.13 %) |
| 4-Methyl-2-Pentanone (MIBK) | 275 ppm (0.028 %) |
| Acetophenone | 1,121 ppm |
| Isophorone | N.D. (<9.3 ppm) |

(1) – Data obtained and compiled from PVSC's Operations Department sampling and email correspondence to CDM dated 7/22/2002; 8/09/2002; 8/12/2002, and 10/28/2002.

(2) – Data obtained and compiled from PVSC's Operations Department additional sampling and email correspondence to CDM dated 11/05/2007.

The HTPSR line is approximately 5,000 feet long and ranges in size from 12-inches to 16-inches from the Sludge Storage Tanks up to and including the SDTs. From the SDTs to the STP, the HTPSR lines begins as 20-inches and decreases to 18-inch at the Effluent Pumping Station. The majority of the HTPSR line is constructed of polyethylene (PE) lined ductile iron pipe. It is also believed that there are sections with a glass liner.

Refer to Figure 1-1 for an overview of the overall HTPSR Pipeline.

The pressure head developed by overflowing the weir of the SDTs provides the pressure needed to convey the supernatant to the STP. Each SDT has an 8-inch diameter line that connects and conveys the overflow into the HTPSR Line.

There are two separate parallel HTPSR Lines located within the basement of the SDTs Facility. There is the older North HTPSR Line and the newer South HTPSR Line. The old North HTPSR Line consists of 12-inch, 16-inch, and 20-inch diameter piping installed along side SDT No. 2, 4, and 6. The newer South HTPSR Line consists of 16-inch diameter piping installed along side SDT No. 1, 3, and 5. The older North HTPSR Line is the original line that was installed in the late 1970s, while the South HTPSR Line is the newer line that was recently installed in 2005.

Each SDT has the capabilities to decant into either the North or South HTPSR Lines within the SDTs Facility via the isolation gate valves located within the ground level of the three stair towers in vicinity of the SDTs. PVSC operators have to manually operate the isolation gate valves to direct and control the flow into either the North or South HTPSR Lines.

Both the North and South HTPSR Lines within the SDTs Facility connect into one common HTPSR Line prior to entering the SHTF en route to the STP.

There is a 12-inch diameter overflow pipe from the HTPSR line, located within the SDTs Facility, that is capable of diverting SDT overflow into the Sludge Storage Tanks (Tank Nos. 5 and 6) if the capacity of the HTPSR line to the STP and the Aeration Tanks is exceeded. PVSC operators have to manually operate the two knife gate valves located at the east end of the Sludge Decant Tanks to direct and control the flow from either the North or South HTPSR Lines into the overflow pipe and into the Sludge Storage Tanks. The two knife gates valves isolate the North and South HTPSR Lines located within the SDTs Facility.

There is an existing crossover (or bypass) connection, where PVSC currently has the option of splitting and diverting flow to the STP and/or to the effluent of the Primary Clarifiers. (Refer to Figure 1-2 for additional information on the existing gravity HTPSR Line crossover connection.) Any flow directed through the existing crossover and to the effluent of the Primary Clarifiers is then directed to the Aeration Tanks. The existing crossover connection, located at the west end of the Sludge Thickeners and the east end of the Effluent Facilities Utility Tunnel, ties the existing 18-inch diameter HTPSR Line into the existing 42-inch diameter Sludge Thickened Supernatant Return (STSR) Line. There are two (2) existing knife gate valves to direct and control the flow to the STP and the effluent of the Primary Clarifiers. PVSC operators have to manually operate the two knife gate valves.

There is also an STP bypass connection that exists, which allows the diversion of the supernatant directly to the STP Effluent Well, where pumps divert the supernatant directly to the head of the Aeration (Oxygenation) Tanks. The STP bypass connection piping consists of PVC materials of construction.

## 1.3 Project Background

PVSC has had capacity issues with the existing HTPSR line, limiting the ability to consistently convey supernatant from the SDTs to the STP. Supernatant has been overflowing the HTPSR line into the Sludge Storage Tanks more often than normal, indicating a reduced capacity of the HTPSR line. The flow capacity issues are likely due to solids depositing in the pipeline due to the low velocity of the supernatant within the pipeline.

PVSC has attempted to "pig" the HTPSR Line to clean it on several occasions which resulted in pieces of the PE liner being removed. Based on discussions with PVSC, the pig reportedly had gotten stuck on the liner in one area and that when the fitting was removed, the liner was "tulipped" (i.e. separated from the pipe wall at various non-continuous locations) in from the wall of the pipe.

CDM performed and prepared a Hydraulic and Corrosion Evaluation of the HTPSR Line (refer to our February 2003 Report). As part of the corrosion evaluation, the line was inspected externally and internally. During the internal inspection, the HTPSR line was found to have as much as 8-inches of deposited material at the pipe invert, which is reducing the effective capacity of the HTPSR Line. (See Photo 1-1)

The evaluation also found that the existing liner was delaminating at the ends of each section of pipe due to the minimal corrosion of the exposed ductile iron.

Photos 1-1 and 1-2 depict the deposited materials as well as the "tulipped" liner section.

**Photo 1-1 - View of Deposited Materials within Existing 18" HTPSR Line at EPS.**

**Photo 1-2 – View of PE Liner Section Removed from Existing 18" HTPSR Line at EPS.**

Recently, during the construction of the HTPSR Force Main project under Contract No. A444-B of the existing HTPSR Line were removed to accommodate the installation of the new equipment. Internal inspections of the removed sections of the 20-inch diameter pipeline revealed as much as 14-inches of deposited material at the pipe invert, reducing the effective capacity of the HTPSR Line. (See Photo 1-3)

**Left - Photo 1-3 - View of Deposited Materials within Existing 20" HTPSR Line at SDTs.**

To increase the capacity of the HTPSR conveyance system, CDM evaluated, designed, and oversaw the construction of a new redundant parallel HTPSR force main and pump station.

A previous recommendation indicated that with the redundant parallel HTPSR pump station and force main installed, the existing HTPSR gravity line could be cleaned and possibly relined or replaced without interfering the sludge processing operation.

With the new pumping station and force main, the supernatant is pumped instead of the flow being conveyed by the head developed over the weirs of the Sludge Decant Tanks.

The goal of this evaluation is to review the options for rehabilitation of the existing HTPSR Line to convey the supernatant to the STP.

Additionally, in a progress meeting held on October 23, 2007, it was discussed that a pilot study was needed to further evaluate and conclude the appropriate options for rehabilitation of the existing HTPSR Line in order to convey the supernatant to the STP.

# Section 2
# Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line

## 2.1 Description of Existing Materials of Construction of the Existing HTPSR Line

According to the original PVSC Contract 494 (Sludge Decant Tanks Project) and Contract 496B (Sludge Storage and Pump Station Project) Specifications, the materials of construction for the existing HTPSR Line is Thickness Class 53 Ductile Iron Pipe conforming to AWWA Designation C151. Additionally and as indicated within the pipe schedule, the HTPSR Line is provided with a 20-mil thickness polyethylene (PE) interior lining. The pipe schedule also indicated to furnish Glass-Lined Ductile Iron Pipe if PE Lined Pipe is not available.

According to the original specifications, the PE interior lining is a blend of high and low density polyethylene powders, compounded with carbon black, and uniformly fused and bonded to the pipe interior by high temperature process.

There are also sections of the HTPSR Line (i.e. within the SDT Facility) that are of ductile iron glass-lined construction.

Additional measures and/or field investigations would be necessary to determine the exact limits of the PE interior lined pipe and the glass-lined pipe.

## 2.2 Evaluation of the Rehabilitation Options

There are several options CDM investigated for the rehabilitation of the existing gravity HTPSR Line; however, not all of the options CDM investigated for rehabilitation can be implemented and/or considered as acceptable alternatives for this specific project, due access limitations. This evaluation discusses both the investigation options which can be considered as feasible and also describes the options that are not considered feasible for rehabilitation of the existing gravity HTPSR Line.

Various innovative technologies have been utilized recently to as far back as over fifty years in an effort to reduce the costs associated with more traditional or convenient repairs and/or replacement of existing pipelines in the wastewater industry. Some methods are limited in their applicability depending on size, shape, structural condition, hydraulic capacity, accessibility, and physical conditions of the existing pipe and process. The following outlines the rehabilitation techniques or options determined to be potentially applicable for the restoration and/or rehabilitation of the existing gravity HTPSR Line.

The rehabilitation options evaluated vary and include 'no-action'; removal and replacement; clean and television inspection; removal of existing PE liner; installation of lining system; and installation of coating system alternatives.

The following sub-sections further discuss each rehabilitation option presented in more detail.

## 2.2.1 No Action Alternative

The 'No Action' Alternative would consist of leaving the existing HTPSR Line in its current state (i.e. solid materials deposited in pipe invert along with PE liner failures).

Allowing this condition will: (1) further contribute to the build-up of solids in the pipeline; (2) further contribute continued PE liner failures; and/or (3) potentially cause a blockage. All of these conditions can either restrict flow through the pipeline and/or render the pipeline unusable until the restriction, failure, or blockage is corrected.

There is no capital costs associated with this alternative. However, due to the disruption that this could potentially cause with PVSC process operations, the 'No Action' alternative is not considered an acceptable alternative.

## 2.2.2 Removal and Replacement Alternative

The 'Removal and Replacement' Alternative consists of removal of the existing ductile iron pipeline, and the installation of a new pipeline compatible with the HTPSR fluid (i.e. 316L stainless steel) in the previous location.

Considering the site and location of the existing HTPSR line within existing facilities and the utility tunnels, demolition and replacement with a new gravity line would be challenging and costly. This alternative would also require temporary relocation of other process lines that would interfere with the removal and replacement of the HTPSR Line.

This alternative would prove to be very expensive. Based on the construction cost associated with Contract No. A444-B, allowing for material escalations, volatility of fuel costs, and other unforeseen contingencies and potential difficulties, the capital costs associated with implementing this alternative would be in excess of $10 - 12 million.

Given that the gravity HTPSR Line would serve as the back-up to the HTPSR force main, the likelihood the gravity HTPSR Line would be in operation frequently would not justify the potentially high capital costs associated with this alternative. Therefore, the 'Removal and Replacement' alternative would not be considered an economically acceptable alternative.

### 2.2.3 Clean and Television Inspection Alternative

The 'Clean and Television Inspection' Alternative would consist of cleaning via a high pressure water jet truck (commonly referred to as a 'jetter') in combination with an industrial vactor to clean deposited sediments for the existing gravity HTPSR Line. The accumulated sediment would be removed via vacuum to a truck mounted debris box for storage at a designated location on site prior to offsite disposal.

Once loose sediment has been removed, a high speed chain flail would be utilized within the existing gravity HTPSR Line to perform additional cleaning of the wall surface to remove any accumulated materials or tuberculation from the wall surface.

At the conclusion of the cleaning operation, a closed circuit color camera would be passed through the existing gravity HTPSR Line to verify the effectiveness of the cleaning operation and to determine the integrity of the pipe interior.

In evaluating this alternative, CDM discussed the project requirements with National Water Main Cleaning Company (NWMCC). They indicated that approximately eighteen 'drop-out' points along the existing gravity HTPSR Line would have to be provided to install the cleaning equipment and camera. The eighteen 'drop-out' points, for the most part, are at locations along the existing gravity HTPSR Line where there is a change in direction of the pipeline (i.e. vertical or horizontal bends and fittings). However, there would also be several locations where a straight length of pipe would need to be temporarily removed due to the longer length of the straight pipe run.

Depending on the integrity of the gravity HTPSR Line and the current accumulated condition of solid deposition materials in the pipe invert, the capital costs associated with the 'Clean and Television Inspection' alternative would be approximately $332,000. This is predicated on the amount of solid deposition materials accumulated within the pipe invert. The costs would be less if less material is found to be accumulated within the pipe invert.

Refer to Appendix A for a copy of the NWMCC's Proposal Letter dated April, 30, 2007 as well as a copy of the general site plan field notes prepared by CDM resulting from the April 10, 2007 field visit with NWMCC.

Based on the 'Hydraulic and Corrosion Evaluation of the HTPSR Line' performed by CDM (refer to our February 2003 Report), it was concluded that the existing ductile iron gravity HTPSR Line, which was inspected externally and internally, was in relatively good condition and exhibited only minimum anaerobic corrosion to the exposed ductile iron. The extent of the existing lining damage could not be quantified due to the limited data available during the inspections. This could be better quantified with a television inspection after cleaning. Additionally, a television inspection of the existing gravity HTPSR Line would identify/determine the exact limits of the PE interior lined pipe and the glass-lined pipe segments.

Therefore, based on the relatively good condition of the existing gravity ductile iron HTPSR Line from our previous report and the approximate capital costs needed to perform the work, the 'Clean and Television Inspection' alternative could be considered an acceptable alternative. But additional investigations are required to confirm the feasibility of this alternative and its estimated cost.

### 2.2.4 Existing Liner Removal Options/Alternatives

Various innovative technologies have recently been utilized to remove an existing liner from the host pipe. One of the major considerations for the evaluation is the ability to remove the existing PE liner while the existing gravity HTPSR Line is still in place (i.e. the pipe does not have to be removed from its installed place in order to remove the liner, except for changes in pipe direction). The evaluation determined that there are only two potential alternatives that could be considered to remove the existing PE liner from the existing gravity HTPSR Liner while the pipe is in place. They include high pressure removal and a modified HDD (horizontal directional drilling) approach.

#### 2.2.4.1 High Pressure Removal

The 'High Pressure Removal' option consists of the use of water pressure to successfully clean the pipe interior, to cut and hydro-demolish the polyethylene liner from the host pipe, and to provide an adequate surface preparation for operation or continued additional rehabilitation implementation measures. Water pressure needed for 'High Pressure Removal' options and/or applications can vary from 12,500 psi up to 40,000 psi.

In order to implement this alternative, CDM discussed the requirements with Montauk Services Incorporated (MSI) and Broadbent's Inc. (BI). Similar to the Clean and Television Inspection' Alternative , BI indicated that they too would need the same 'drop-out' points that NWMCC needed along the existing gravity HTPSR Line to install their cleaning, cutting, and hydro-demolition equipment. In addition, their equipment is limited to maximum pipe runs of approximately 100 to 150-feet (revised based on pilot test results). Therefore, additional 'drop-out' point locations would need to be provided.

In order to confirm the existing polyethylene liner can be removed and that BI (as well as their equipment) is capable of the removal of the polyethylene liner, BI simulated the high pressure removal by performing a bench test. During the construction of Contract No. A444-B, portions of the existing gravity HTPSR Line had to be demolished in order to accommodate the installation and connections of new piping, fittings, and valves for the new HTPSR force main. Two pieces of pipe removed from the existing gravity HTPSR Line were salvaged and turned over to BI for their bench test. The two segments included a piece of pipe with the existing polyethylene liner intact (i.e. relatively good condition) as well as a piece of pipe with the existing liner failing (i.e. visible separation in the form of bubbles or blisters).

Refer to the following photographs of the interior condition of the two pieces of pipe prior to the high pressure removal process performed by BI.

**Photo 2-1 – Piece of pipe with the existing polyethylene liner intact (Before)**

**Photo 2-2 - Piece of pipe with the existing liner failing (Before)**

Refer to the following photographs of the interior condition of the two pieces of pipe after the high pressure removal process performed by BI.

**Photo 2-3 – Piece of pipe with the existing polyethylene liner intact (After)**

**Photo 2-4 - Piece of pipe with the existing liner failing (After)**

While BI's high pressure removal equipment is capable of cutting and separating the existing PE Liner from the interior of the pipe, their equipment is not capable of actually removing the cut liner pieces from the pipeline. BI indicated additional services would be needed to remove the cut liner pieces from the pipeline. The removal of the cut liner pieces from the pipeline could be accomplished by various methods including "pigging" the line (by Montauk Services Incorporated), cleaning the line with a traditional combination high pressure water jet truck (commonly referred to as a 'jetter') with an industrial vactor to clean and remove the existing cut pieces (by National Water Main Cleaning Company) or, by passing a mechanical bucket back and forth through the pipeline to clean and remove the existing cut pieces of liner (by a General Contractor). BI indicated that a water connection (i.e. hydrant) would be needed for the high pressure removal process.

In order to successfully remove the existing polyethylene liner from the interior of the existing HTPSR, BI indicated that they utilized a water pressure of 30,000 psi for the segments of pipe where the existing liner is failing and up to 40,000 psi for the segments of pipe with the existing polyethylene liner intact.

After the existing polyethylene liner is removed, the existing HTPSR Liner would be videotaped to inspect and confirm removal as well as to identify areas where liner still needs to be removed.

Implementing the 'High Pressure Removal' option while the pipeline is in place is possible; however, the existing Victaulic coupling gaskets could potentially be damaged as a result of the high pressure process needed for the liner removal. Provisions of any design package including this option should either address some kind of pressure testing of the pipeline after the removal process is complete and/or the removal and replacement of all of the existing gaskets with new EPDM gaskets after the liner is removed.

Based on an initial cost of about $75-$80 per linear foot of pipe from Broadbents Inc to remove the PE liner, the capital costs associated with just the 'High Pressure Removal' option would be at least $375,000 to $400,000 and does not include all other related costs including general conditions, contractor OH&P, testing/inspection, etc. However, the costs were revised by Broadbents Inc. to be in the range of about $104 - $125 per linear foot of pipe based on the pilot test results. Therefore the revised capital costs associated with just the 'High Pressure Removal' option would be at least $520,000 to $625,000 and does not include all other related costs including general conditions, contractor OH&P, testing/inspection, etc. This also does not include the additional costs associated with the additional "drop-out" of pipe and fittings work from a mechanical contractor as well as the clean-up and disposal of the removed liner and the installation of the new EPDM gaskets.

The probable project capital costs associated with this alternative (Not including the 'Clean and Television Inspection' Alternative) would be approximately $2.86 million as indicated in Table 2-1.

**Table 2-1**

**Summary of the Overall Probable 'High Pressure Removal" Project Costs**

| | | |
|---|---|---|
| Mechanical Contractor – 'Drop-Out' Locations | | $150,000 |
| 'High Pressure Removal' of PE Liner | | $625,000 |
| Clean and Disposal of Removed Liner | | $250,000 |
| Mechanical Contractor – Installation of EPDM Gaskets | | $300,000 |
| **Subtotal – Direct Construction Cost** | | $1,325,000 |
| Indirect Costs – Bonds and Insurance | 7% | $93,000 |
| **Subtotal** | | $1,418,000 |
| Contractor's OH&P | 20% | $284,000 |
| **Subtotal – Construction Cost With OH&P** | | $1,702,000 |
| Construction Contingency | 40% | $681,000 |
| **Total Opinion of Probable Construction Cost** | | $2,383,000 |
| Engineering and Implementation | 20% | $477,000 |
| **Total Opinion of Probable Project Cost** | | $2,860,000 |

However, the overall probable project capital costs associated with implementing this alternative with the 'Clean and Television Inspection' Alternative would be approximately $3.58 million as indicated in Table 3-1 within Section 3.

#### 2.2.4.2 Modified HDD Technology & Similar Equipment

The 'Modified HDD Technology and Similar Equipment' option consists of the use of standard horizontal directional drilling (HDD) equipment to access (via an entrance and exit pits) the utility along with the liner stripping device to remove the failing liner. Typical access to the utility for the HDD equipment can be attained via an excavated pit, while typical access for the liner stripping device can be attained and assembled through an existing manhole.

Attached (in Appendix B) is a copy of a paper presented at the 2007 No-Dig Conference and Exhibit for the North American Society for Trenchless Technology, which was held in San Diego, California in April 2007 that discusses HDD technology.

Based on discussions with HDD Technology equipment manufacturers, CDM determined that the use of standard HDD Technology equipment would not be suitable for this application since access to the existing gravity HTPSR Line cannot be easily achieved from the ground surface with a classical HDD equipment setup. While the stripping tool is easily adaptable, the challenge is in the thrust and pullback unit or piece of equipment that resides outside of the pipe to make the tool rotate and thereby perform the needed stripping. The unit or piece of equipment has to transmit sufficient torque on average (and at peak when the stripping tool catches or gouges) to sufficiently remove the liner. Based on the existing configuration for this application, a custom smaller, mobile, and adjustable (for the height above the floor) unit or piece of equipment would be needed to ensure a rigid and safe arrangement to produce maximum results. However, according to the HDD Technology equipment manufacturers, the design and fabrication of such a custom unit or piece of equipment would be complicated with custom parts and too extensive that there just is not enough value in the job to cover and/or justify the expenses. Therefore, the 'Modified HDD Technology' alternative would not be considered a viable and/or an economically acceptable alternative.

In addition (and based on information provided to CDM from PVSC's Operations Department), CDM had further discussions with Mr. William T. Suchodolski, Engineering Manager of the Ocean County Utilities Authority (OCUA) to discuss the results of OCUA's pipeline liner removal test and project. Based on discussions with OCUA, CDM discovered that OCUA had similar issues with liner failure within their collection system. OCUA retained the services of a general contractor to utilize typical bucket machines to pull a cutting device through the pipe to remove the failed liner.

Based on discussions with OCUA, CDM determined that the use of typical bucket machines to pull a cutting device through the pipe to remove the failed liner was relatively successful with some limitations. The cutting devices utilized were not able to completely remove the entire liner down to the host pipe. OCUA estimated at best 50% of the liner was removed. Essentially, the use of typical bucket machines to pull a cutting device through the pipe only removed those portions of the liner at points of failure. After the section of the failed liner had been removed, a cured-in-place liner was installed. Based on cost information provided to CDM from OCUA for a similar liner removal project they had bid within their system, the capital costs associated with removal of the existing failing PE liner within the existing gravity HTPSR Line alternative would be in the range of $80 to $100 per LF.

Based on our discussions with the HDD Technology equipment manufacturers and with OCUA, the 'Modified HDD Technology and Similar Equipment' option would not achieve the goals needed to rehabilitate the HTPSR Line. Therefore, the 'Modified HDD Technology and Similar Equipment' option should not be considered as a feasible rehabilitation option.

## 2.2.5 Lining System Alternatives

There are several lining system alternatives on the market that can be installed in various size and shape configurations of pipes. However, for the purposes of this evaluation, CDM reviewed the feasibility of two of the most feasible lining options. They include the cured-in-place pipe and Sliplining pipe options.

### 2.2.5.1 Cured-In-Place Pipe

In order for this option to be considered, all loose sections of the existing liner would have to be removed prior to a new liner installation.

The 'Cured-In-Place Pipe' (CIPP) lining method option consists of the insertion of a resin impregnated flexible felt or fabric liner tube into the existing pipeline and thermally activating or curing the liner to make it rigid. The CIPP liner forms to the shape of the host pipeline and provides structural rehabilitation without loss in hydraulic capacity or requiring that an annular space be grouted. After the liner is completely installed, tie-in connections to the rehabilitated line must be reestablished. This can be performed either by man-entry or by using a remote cutting device in conjunction with a television camera to remove the liner from the connection opening.

Unlike the Coating System Alternative, a CIPP liner would cover the existing polyethylene liner. However, the existing gravity HTPSR Line would still have to be adequately cleaned and any loose materials and/or liner removed.

In order to install such as system; the installation materials and equipment would need to be set up at each change in direction (i.e. bend) along the existing gravity HTPSR Line to be rehabilitated. In addition, the installation of a liner would require equipment capable of maintaining a head condition of approximately 15-feet above the pipe in order to invert the liner into the pipe using water. This equipment would require headroom of approximately 15-20 feet above the pipe, which could be feasible within some of PVSC's process facilities but would not be feasible within PVSC's utility tunnels. Also, there is limited access to the utility tunnels from the surface for the equipment needed in order to install the CIPP liner system. Therefore, construction access to all of the changes in direction along the existing gravity HTPSR Line is not feasible.

In addition, the CIPP liners are not installed within the changes in direction (i.e. bends). At all changes in direction locations, another rehabilitation alternative (i.e. an epoxy coating system) would have to be implemented, thereby creating gaps in the liner installations.

Additionally, future access to all of the ductile iron pipe joints (i.e. Victaulic grooved-end joint connections) would be restricted because the CIPP liner installation would be over each joint along the straight pipe sections. Therefore, the only locations where the pipe would be able to be dismantled would be at changes in direction, unless breaks in the CIPP liner were provided at joints.

Previous failures (i.e. separation or delamination) of the existing PE liner within the existing gravity HTPSR Line can be partially attributed to the gaps created at the pipe end joint connections. Therefore, additional consideration of these areas of potential failure would be covered up, except at changes in the pipes direction or if breaks in the CIPP liner were provided at existing pipe joint locations, which would be a challenge.

Therefore, the 'Cured-In-Place Pipe' lining method option would not be considered an acceptable or viable option to rehabilitate the existing gravity HTPSR Line for reasons associated limited access to the utility tunnels to install the CIPP liner as well as limited future access to the HTPSR Line itself because of the covered pipe joints by the CIPP Liner installation.

#### 2.2.5.2 Sliplining Pipe

Similar to the 'Cured-In-Place Pipe' lining method option, in order for this option to be considered, all loose sections of the existing liner would have to be removed prior to a new slip-lined pipe installation.

The 'Sliplining' option basically consists of the insertion of a pipe liner system into the host pipe. Many different materials are used in the construction of Sliplining systems and are dependent on the required resistance to corrosion and hydraulic characteristics. Some of these materials include PVC and polyethylene.

The evaluation of the 'Sliplining' option consists of sliding sections of a pipe liner system (Fusible C-900 PVC or polyethylene) into the existing gravity HTPSR Line host pipe. New fittings would need to be provided at changes in direction to connect to the slip line lining.

The use of the Fusible C-900 PVC option was discussed with Underground Solutions Incorporated as they had indicated that they have rehabilitated buried lines with this technology. They were provided the chemical makeup of the HTPSR decant and they had indicated that PVC is not compatible. Similar to the Fusible C-900 system, CDM also discussed this application with UltraLiner only to find that their liners are also fabricated of PVC and not compatible with the makeup of the HTPSR decant.

While the use of PVC is not compatible with the makeup of the HTPSR decant, polyethylene is compatible. While U-Liner manufactures and fabricates a fold-and-form polyethylene sliplining system, CDM has been unable to discuss the potential use of their system for this application. CDM has made several attempts to reach out to them and they have been unresponsive to our many inquiries.

However, based on our understanding of the system and from the information we were able to obtain from the manufacturer's website, it can be concluded that the 'Sliplining' option is not considered an acceptable or viable option to rehabilitate the existing gravity HTPSR Line.

## 2.2.6 Coating System Alternatives

There are several coating system alternatives on the market that can be installed in various size and shape configurations of pipes. There are also numerous products on the market that are meant to be applied in-situ to coat the existing pipeline. These pipe coatings can be divided into two categories; structural coatings and non-structural coatings.

Structural pipe coatings are coatings whose main purpose is to improve the strength and structural integrity of the existing pipeline. The condition and construction of the existing gravity HTPSR Line evaluated within this report is such that a structural coating system is not considered necessary as a long-term rehabilitation option.

Non-structural pipe coatings are coatings whose main purpose is to improve the hydraulic characteristics of the pipeline and/or to protect the pipeline from corrosion or abrasion where the host pipe is determined to be in satisfactory condition.

For purposes of this evaluation, CDM reviewed the feasibility of a spray-applied epoxy coating system, given the integrity of the existing ductile iron pipe that was determined to be in relatively good condition based on the corrosion evaluation CDM performed in 2003.

Similar to the lining system alternative rehabilitation options described in Section 2.2.5 above, in order for this option to be considered, the existing liner would have to be removed and the surface of the pipe interior would have to be adequately prepared in accordance with the manufacturer's recommendations prior to the application of the spray-applied epoxy coating system.

### 2.2.6.1 Spray-Applied Epoxy Coating System

The 'Spray-Applied Epoxy Coating System' option consists of the application of an appropriate coating material to the interior of the existing gravity HTPSR Line to adequately protect the host pipe from the corrosive composition make-up of the HTPSR decant.

For purposes of the make-up of the HTPSR decant, a suitable epoxy coating system would be sufficient to provide corrosion protection to the interior of the existing gravity HTPSR Line.

CDM had discussions with two (2) spray-applied epoxy coating system installers (A&W Maintenance, Inc. and Corrosion Technology Systems). A&W Maintenance, Inc. is the epoxy coating installer who worked on PVSC's Contract No. A410 – Repair to the STSR Line. Corrosion Technology Systems is a coating system supplier and works closely with a certified installer (SP Thomas Coatings).

Based on discussions with and information provided to CDM from A&W Maintenance, the application of a 150 mils dry thickness, two step monolithic pipeline surfacing system manufactured by Warren Environmental System appears to be the appropriate application to provide the necessary corrosive protection of the existing gravity HTPSR Line. The complete pipeline surfacing system consists of surface cleaning, pre-application visual inspection, application of epoxy coating system, and post-application visual inspection. The monolithic surfacing system would consist of a unique non-toxic, 100% solids, solvent-less epoxy resin coating system which would be continuously bonded to the interior of the existing gravity HTPSR Line. The 'Clean and Television Inspection' Alternative indicated approximately eighteen 'drop-out' points along the existing gravity HTPSR Line would have to be provided to install the cleaning equipment and camera. Additional 'drop-out' point locations will most likely be required based on 250 to 300-feet long pipeline run limitations of the application process of the coating system. The 'drop-out' point locations, for the most part, are at locations along the existing gravity HTPSR Line where there is a change in direction of the pipeline (i.e. vertical or horizontal bends and fittings). However, there would also be several locations where a straight length of pipe would need to be temporarily removed due to the longer length of the straight pipe run. The capital costs associated with implementing just the application of the spray-applied epoxy coating system would be at least $2.86 million, based on the cost information provided from A&W Maintenance of $220.00 per foot for the 18-inch and $242.00 per foot for the 20-inch. The costs includes general conditions, contractor OH&P, testing/inspection, etc, but does not include other related costs associated with the 'Cleaning and Television Inspection' or the 'High Pressure Removal' of the PE Liner.

Refer to Table 2-2 for the overall probable project capital costs associated with this alternative, all other related costs [including the 'Clean and Television Inspection' and the 'High Pressure Removal' of the PE Liner], general conditions, contractor OH&P, testing/inspection, etc.

Based on discussions with and information provided to CDM from Corrosion Technology Systems and their certified installer (SP Thomas Coatings), the application of a 26 mils total dry thickness, three step pipeline surfacing system appears to be the appropriate application needed to provide the necessary corrosive protection of the existing gravity HTPSR Line. Similar to A&W Maintenance, the complete pipeline surfacing system consists of surface cleaning, pre-application visual inspection, application of epoxy coating system, and post-application visual inspection. Their surfacing system would consist of a three part application coating system, a primer coat, an intermediate coat, and a finish coat. The Primer Coat consists of their VE 550-G (Sauereisen's Vinyl Ester Glaze base coat system) at a 6 mils application thickness. Both the Intermediate and Finish Coats consist of their VE 472-G (Sauereisen's Vinyl Ester Glaze top coat system) at a 10 mils application thickness each. Similar to the previous coating system, additional 'drop-out' point locations would most likely need to be provided. SP Thomas Coatings has indicated they are limited to runs of 150-feet in length. The capital costs associated with implementing just the application of the spray-applied epoxy coating system would be about $500,000, if not more, based on the cost information provided to CDM from SP Thomas Coatings. However, additional capital costs associated with a mechanical contractor to 'drop-out' the appropriate points for access for the application of the spray-applied coating system equipment would need to be further evaluated and quantified.

While both 'Spray-Applied Epoxy Coating System' company's contacted will require additional capital costs associated with a mechanical contractor to 'drop-out the additional points for access, the additional capital costs associated with the Corrosion Technology Systems and SP Thomas Coatings system will be a least double that of the A&W Maintenance coating system based their pipe run limitations being about half.

Additionally, while both 'Spray-Applied Epoxy Coating System' company's contacted provided CDM with their recommended coating system compatible with the composition make-up of the HTPSR Supernatant, it is recommended that additional 'coupon' testing be performed to confirm the coating system company's recommendations.

Therefore, based on the relatively good condition of the existing gravity ductile iron HTPSR Line from our previous report and the successful test results of the PE Liner removal pilot tests performed by Broadbents Inc., the 'Spray-Applied Epoxy Coating System' alternative could be considered an acceptable alternative.

In a progress meeting held on October 23, 2007, it was discussed that a pilot study was needed to further evaluate and conclude the appropriate options for rehabilitation of the existing HTPSR Line in order to convey the supernatant to the STP. Refer to Appendix C regarding the summary of pilot test results associated with the HTPSR Liner Evaluation.

The overall probable project capital costs associated with just implementing this alternative, including other related costs, general conditions, contractor OH&P, testing/inspection, etc., would be approximately $6.43 million as indicated in Table 2-2. This includes the costs associated with the 'Clean and Television Inspection' and the 'High Pressure Removal' of the PE Liner.

**Table 2-2**

**Summary of the Overall Probable 'Spray-Applied Epoxy Coating System' Project Costs**

| | | |
|---|---|---|
| Cleaning and Television Inspection of HTPSR Line | | $332,000 |
| 'High Pressure Removal' of PE Liner | | $1,325,000 |
| 18-Inch Diameter Spray-Applied Coating System | | $570,900 |
| 20-Inch Diameter Spray-Applied Coating System | | $627,990 |
| Mechanical Contractor – Additional 'Drop-Outs' | | $125,000 |
| **Subtotal – Direct Construction Cost** | | $2,981,000 |
| Indirect Costs – Bonds and Insurance | 7% | $209,000 |
| **Subtotal** | | $3,190,000 |
| Contractor's OH&P | 20% | $638,000 |
| **Subtotal – Construction Cost With OH&P** | | $3,828,000 |
| Construction Contingency | 40% | $1,532,000 |
| **Total Opinion of Probable Construction Cost** | | $5,360,000 |
| Engineering and Implementation | 20% | $1,072,000 |
| **Total Opinion of Probable Project Cost** | | $6,432,000 |

## 2.2.7 Gravity to Force Main Conversion Alternative

The 'Gravity to Force Main Conversion' Alternative would consist of connecting the recently installed and operational HTPSR pumping station to the existing gravity HTPSR Line. More specifically, this alternative would consist of a connection between the HTPSR pumping station 12-inch diameter discharge header piping to the existing 20-inch diameter gravity HTPSR Line within the SDTs Facility. [Partial provisions for this potential future gravity to force main conversion connection have already been made as part of the Contract No. A444-B construction project.]

The capital cost associated with the mechanical equipment (i.e. piping, fittings, and valves) needed for the 'Gravity to Force Main Conversion' alternative would be in the range of $200,000 to $275,000. This capital cost includes estimated costs for instrumentation and/or automation modifications.

Implementing the connection and conversion of the existing gravity HTPSR Line to a force main would give PVSC with a back-up to the recently installed 12-inch diameter HTPSR force main should there ever be a problem encountered. Converting the existing gravity HTPSR Line to a force main would also allow for the pipe to see higher flow rates and therefore higher velocities within the pipe, thereby reducing the likelihood of solid deposit materials accumulating in the pipe invert.

Therefore, the 'Gravity to Force Main Conversion' alternative would be considered an acceptable alternative.

# Section 3
# Conclusions and Plans of Action

## 3.1 Conclusion and Short-Term Plan of Action

Based on the confirmed accumulation amounts of solid materials deposited within the pipe inverts, which have reduced the overall conveyance of the line, the short-term plan of action would be to have the existing gravity HTPSR Line from the Sludge Decant Tanks to the Supernatant Treatment Plant cleaned (i.e. to remove all solids build-up) and televised (i.e. to inspect the internal integrity of the pipe).

The cleaning would require portions of the existing gravity HTPSR Line to be taken out-of-service and opened at several points to allow access for the cleaning equipment to enter the line and for the removal of the built-up materials.

Following the cleaning, the closed circuit television (CCTV) inspection would be performed to confirm that the existing gravity HTPSR Line was adequately cleaned and to assess the overall condition and integrity of the polyethylene (PE) liner as well as the exposed ductile iron pipe for the full length of the existing gravity HTPSR Line.

Table 3-1 summarizes the anticipated probable costs associated with the Short-Term Plan of Action listed within this Section.

## 3.2 Long-Term Plans of Action

The following section presents the long-term plans of action for the existing gravity HTPSR Line rehabilitation methods evaluated by CDM. CDM investigated and evaluated several rehabilitation methods, including 'no-action', removal and replacement, clean and television inspection, removal of existing PE liner, installation of lining system, and installation of coating system. The evaluated rehabilitation methods are discussed in more detail in Section 2.2.

Of the viable rehabilitation methods evaluated, the following are the preliminary plans of action that CDM suggests PVSC consider for further evaluation and discussion.

However, implementation of any of the long-term plans of action still requires the implementation of the short-term plan of action described above (i.e. cleaning and television inspection).

Table 3-1 also summarizes the anticipated probable costs associated with the Long-Term Plans of Action listed within this Section.

### 3.2.1 Long-Term Plan of Action Option No. 1 – Existing Liner Removal and Coating System

Long-Term Plan of Action Option No. 1 is a combination of two rehabilitation methods presented in Section 2 of this evaluation report. They include the 'Existing Liner Removal Options/Alternatives' and the 'Coating System Alternatives' to the existing gravity HTPSR Line.

However, before Long-Term Plan of Action Option No. 1 can be implemented, the Short-Term Plan of Action will need to be implemented first to ensure that the existing gravity HTPSR Line is clean and clear of any debris and/or materials for the liner removal equipment.

Implementation of Long-Term Plan of Action Option No. 1 will eliminate the restriction of the flow path as a result of failures of the existing liner as well as to provide the necessary corrosion protection to the existing back-up gravity HTPSR Line to the HTPSR pump station and force main.

A variation to Long-Term Plan of Action Option No. 1 could be to only implement the 'Existing Liner Removal Options/Alternatives' since the existing gravity HTPSR Line is only a backup to the HTPSR pump station and force main.

Depending on whether the combination of the two rehabilitation methods presented for Long-Term Plan of Action Option No. 1 are implemented or just the one, additional considerations will need to be included in any design package prepared to address any and all of the deficient and/or deteriorating flexible coupling connections along the existing gravity HTPSR Line.

### 3.2.2 Long-Term Plan of Action Option No. 2 – Gravity to Force Main Conversion

Long-Term Plan of Action Option No. 2 is the 'Gravity to Force Main Conversion' Alternative to the existing gravity HTPSR Line.

Similar to Option No. 1, the Short-Term Plan of Action should be implemented to ensure that the existing gravity HTPSR Line is clean and clear of any debris and/or materials to avoid any potential blockages of built-up debris, materials, or failed liner sections.

The implementation of Long-Term Plan of Action Option No. 2 could eliminate the buildup of debris and/or materials within the existing gravity HTPSR Line and also provide PVSC with a redundant backup force main should the stainless steel force main be out of operation for maintenance, pipe cleaning (i.e. pigging), a pipe failure, etc.

In addition, with the plant water system connection to the wet well, the pumping system could be utilized to flush out the HTPSR Line. Depending on the implementation of Long-Term Plan of Action Option No. 2, additional considerations will need to be included in any design package prepared to address any the addition of pipe cleaning equipment (i.e. pig launchers and receiver) along the existing gravity HTPSR Line.

CDM

# Memorandum

*To:* *Sheldon Lipke, P.E., Superintendent of Plant Operations*

*From:* *Thomas A. Laustsen, P.E., BCEE and Eric Granholm, P.E.*

*Date:* *January 15, 2009 (Revised February 2, 2009)*

*Subject:* *HTPSR Liner Evaluation – Summary of Pilot Test Results*

This memorandum is a supplement to the 'Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line' draft report, dated September 2007 and will be included as an Appendix in the final report. This memorandum summarizes the pilot study work procedures, observed performances, results, and conclusions and recommendations.

In general, the pilot study work included the following:

- Mechanical work by PVSC (i.e. disassemble pipe & fittings, perform low pressure air test);
- Cleaning and Disposal of Sludge (at a specified on-site location) by National Water Main Cleaning Company (also included CCTV inspections);
- Liner Removal by Broadbent's Inc.;
- Installation of Two Different and Distinct Coating Systems (one by Warren Environment and one by Corrosion Technology Systems/SP Thomas Coatings)
- Observation of results and recommendations

## Background

As part of the HTPSR Liner Evaluation, CDM evaluated various methods to rehabilitate the interior lining system of the existing HTPSR line. The lining methods included as part of the evaluation were sliplining; a cured-in-place pipe; and coating systems. The desktop evaluation found that sliplining and a cured-in-place pipe were not feasible options because of either compatibility with the HTPSR chemical composition or installation issues without removing the existing HTPSR gravity line from the pipe support system. The evaluation concluded that a coating system is the only viable option that should be considered for this application. However, in order to properly install a coating system, the existing high density polyethylene pipe liner needs to be removed.

During the study evaluation (August 2007), two sections of pipe that had the liner were provided to a pipe cleaning company (i.e. Broadbent's Inc.) to see if the existing liner could be removed via high pressure water jetting. The results showed that the liner could be removed with high pressure jetting. However, that test was performed in a controlled environment at the pipe cleaning company's shop rather than in the field under the existing conditions.

In a progress meeting on October 23, 2007, it was discussed that a pilot study was needed to determine if the liner could effectively be removed with the pipe in its installed location. The draft evaluation report showed that costs for the cleaning and liner removal of the entire existing HTPSR line are considerable and could potentially reach $2.5 million. It was therefore considered prudent to conduct a pilot evaluation of the liner removal process on a small section (approximately 150 feet) of pipe in order to evaluate its effectiveness before proceeding to final design.

Following the progress meeting, CDM reached out to the two coating system suppliers/installers (Warren Environmental Systems and Corrosion Technology Systems). CDM had contacted these suppliers/installers during the preparation of the draft report about participating in the pilot study by installing their coating system on a small section of the cleaned pipe (approximately 75 feet for each supplier/installer). The purpose of the pilot study would be to see how well their coating system would perform under the existing field conditions. The two coating system suppliers/installers informed CDM that they were willing to participate in the pilot study and provided CDM with their costs for their participation. While both coating suppliers/installers were willing to provide their materials at no cost to PVSC, they both wanted to be reimbursed for their labor costs.

With the two coating suppliers/installers willing to participate in the pilot study, CDM reached out to the other two participants required for the pilot study, a pipeline cleaning company [National Water Main Cleaning Company] and a liner removal company [Broadbent's Inc.], about their participation in the pilot study. Both companies were willing to participate in the pilot study and provided CDM with their associated labor costs.

With the costs for pilot study approved by PVSC, CDM prepared a schedule along with the scope of each participant's responsibilities for the pilot study work.

## Schedule

The pilot study was originally scheduled to commence in May 2008, but due to unforeseen equipment issues with the newly installed HTPSR Pumping Station, the pilot study had to be postponed until the equipment issues were resolved.

In early September 2008, CDM was informed the previous equipment issues were resolved by PVSC and CDM could resume with rescheduling the pilot study work with the participants.

Based on our initial discussions with the pilot study participants, CDM anticipated it would take approximately three weeks to coordinate with PVSC, NWMCC, Broadbent's Inc. and the two coating system suppliers/installers. The following durations were initially anticipated for each of the activities:

- Pipe Dismantlement and Cleaning – Three (3) to Five (5) days
- Liner Removal – Two (2) to Three (3) Days
- Line Testing and Televising – Two Days
- Coating System Application – Two (2) to Three (3) Days per coating system

As requested by PVSC, CDM was onsite for the duration of the pilot study.

## Pilot Study

The following generally describes the pilot study work procedures, observed performance, and results for each of the participants.

### Performance

***Week of September 15th thru 19th***

Early in the week, PVSC performed the mechanical dismantling of the HTPSR pilot study piping in order for the line cleaning and sludge removal to commence.

Photographs (above) were taken at both ends of pilot study pipe prior to line cleaning and sludge removal.

On September 18th, NWMCC arrived on site with two (2) workers for the line cleaning and sludge removal. NWMCC also performed a closed-circuit television (CCTV) inspection of the pilot study pipe to document the interior condition of the pipeline prior to the liner removal process. A copy of the inspection report performed by NWMCC is attached to this memorandum.

On September 19th, PVSC performed a low pressure air test of the pilot study pipe, in the presence of a CDM representative, to document the condition of the pipeline and to see if there were any issues with any of the joints prior to the liner removal process. The pilot study pipe was pressurized (with air) to an initial pressure of 20-psi. After 15-minutes, the pressure within the pilot study pipe remained at 20-psi. Based on the fact that there was no change in air pressure over the duration of the pressure test, it was concluded that the pilot study pipe as well as the joints were in satisfactory condition to proceed to the liner removal process of the pilot study.

***Week of September 22nd thru 26th***

On Monday, September 22nd, Broadbent's Inc. arrived on site with one (1) supervisor and three (3) workers to begin the liner removal process. By noon, the equipment setup was complete and the liner removal process commenced (30-psi city water pressure at truck with 30-ksi pump pressure for liner removal). By 1:00 PM, Broadbent realized they needed another cutting tool along with a compressor, which they did not have on site.

Tuesday through Friday, Broadbent continued to have application and equipment problems with their cutting tool (i.e. getting stuck at flexible coupling; getting stuck on hanging pieces of existing liner; cutting nozzles not rotating; did not have proper equipment to "string" pipe with cable/rope to assist cutting tool moving within the existing pipe). Broadbent adjusted and readjusted their process several times to try and come up with proper procedure for liner removal.

On Thursday, Broadbent requested that NWMCC return to the site on Friday to flush the pipe and to see if any of their equipment, nozzles, and cutting tools are capable of removing the remaining liner fragments that are hanging.

On Friday, NWMCC returned to the site to flush the pipe and to use their root cutting tool to remove hanging liner fragments. NWMCC made several passes with their equipment and removed liner fragments that were hanging to within about 1-2 inches of the pipe interior. Broadbent indicated that was acceptable for them to continue with their equipment and the liner removal process.

Broadbent continued to have equipment problems (i.e. cutting tool rolled on its side at the first flexible coupling location). Broadbent continued with the liner removal process knowing their cutting tool was on its side.

By Friday, Broadbent indicated they were able to successfully removal the existing liner down to bare metal for about twenty-five (25) feet out of the 150-feet.

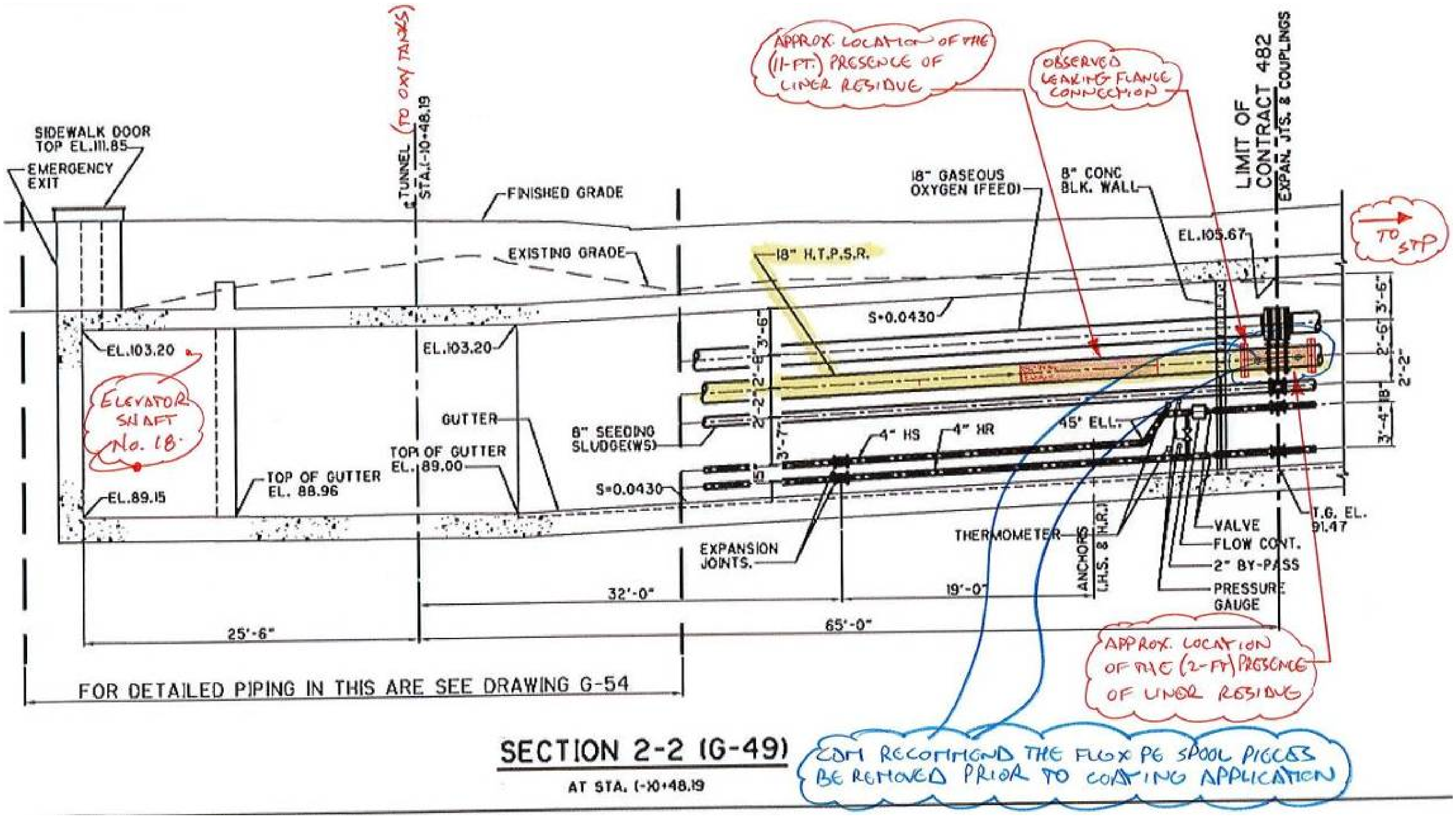
***Week of September 29th thru October 3rd***

On Monday September 29th, Broadbent returned to the site to continue with the liner removal process. By the end of the day, Broadbent indicated they were averaging about 9-feet per hour of liner removal for the 18-inch diameter HTPSR line.

On Tuesday, Broadbent continued to have equipment problems with their air hose disconnecting from the cutting tool. To reconnect the air hose required the entire cutting tool assembly be removed in order to gain access to the air hose connection.

On Wednesday, Broadbent arrived on site with their cutting tool rebuilt with a new wheel assembly. However, within the first thirty minutes of the liner removal process for the day, the aluminum-to-steel welds did not hold and broke loose leaving the cutting tool to rest on the bottom of the pipe rather than centered in the pipe.

It was also observed during the week that one of the flanged joints was leaking, most likely as a result of the high pressures from the liner removal process.




Refer to the above sketch for the location of the leaking joint.

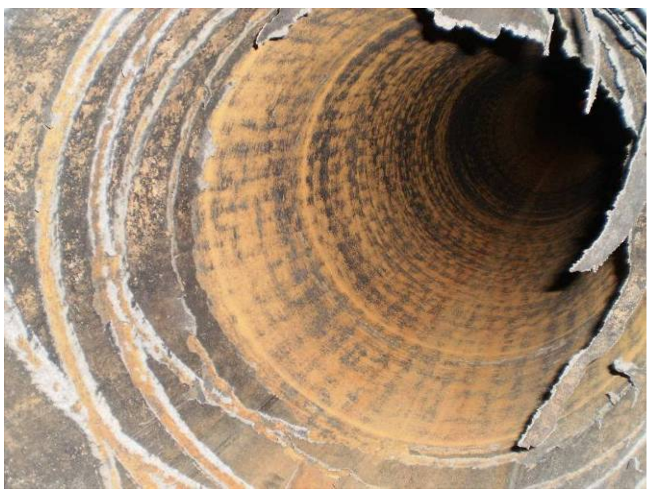
Broadbent was not on site for rest of the week.

***Week of October 6th thru 10th***

On Monday, October 6th, NWMCC and Broadbent were on site for flush and CCTV inspection. Based on the flush and CCTV inspection, Broadbent needed to perform additional liner removal. While Broadbent performed the additional liner removal, NWMCC left site for several hours and returned in the afternoon for a final flush and CCTV inspection.

After Broadbent completed the additional liner removal, NWMCC completed the final flush and CCTV inspection. The CCTV inspection revealed that the liner removal process and procedures were successful in most areas (i.e. straight pipe segments) and unsuccessful in some areas (i.e. flexible coupling location).

Out of the approximate 150 foot length of pipe that was cleaned, approximately, CDM estimates that approximately 80% of the liner was successfully removed.



The Photograph (above) shows the unsuccessful area in the vicinity of the flexible coupling located at the approximate mid-point of the pilot study area.

In order to keep the pilot study moving forward to the next step (i.e. coating system application/installation), this unsuccessful liner removal location was documented and noted. Broadbent was made aware of the issue so they can evaluate the equipment used in order to come up with a more efficient way to remove the liner at locations similar to this one (i.e. flexible couplings).

On October 6, 2008, NWMCC performed the post liner removal CCTV inspection. A copy of the inspection report performed by NWMCC is attached to this memorandum.

***Week of October 13th thru 17th***

On Monday, October 13th, SP Thomas Coatings (SPT) arrived on site to mobilize and deliver equipment for the beginning of their coating installation.

Refer to Section 2.2.6 'Coating System Alternatives' of the Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line report for the description of the SPT coating system characteristics.

On Tuesday, October 14th, SPT arrived on site with two workers with the plan to install the primer coat and the first of two top coats. SPT did not perform any additional surface preparations. SPT had pump equipment issues and could not complete the installation of the primer coat. Therefore, they left the site for the day to go back to their shop to obtain another pump. A&W Maintenance (A&W), the coating installer for Warren Environmental mobilized to the site on the same day. A&W indicated that they would be performing a muriatic acid wash of the pipe interior and needed to coordinate with NWMCC to flush the line upon completion of the acid wash. A&W was informed that this additional flush was not included within our scope of services with NWMCC and that any additional surface preparations were the responsibility of the individual coating suppliers. A&W coordinated with NWMCC.

On Wednesday, October 15th, SPT arrived on site with two workers and another pump to continue with the coating application. By early morning, SPT completed the primer coat and the first of the two top coats. The cure duration under ambient conditions between coating applications appeared to be longer than expected based on the existing conditions and they would not be able to apply all three coats in one day. Therefore, SPT had to come back the following day to apply the second of the two top coats (final coat). SPT did not apply the primer to the fitting and elbow as they did not have the proper tools and/or equipment to do so. Therefore, the fitting and elbow only received the two top coats.

Also on Wednesday, October 15th, A&W arrived on site with two workers to continue to mobilize with their equipment in preparation to install/apply their coating system.

Refer to Section 2.2.6 'Coating System Alternatives' of the Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line report for the description of the A&W coating system characteristics.

A&W performed the muriatic acid wash in the morning and NWMCC arrived in the afternoon to flush the pipeline. A&W installed a blower at one end of the pipe in order to dry the pipe interior in preparation for installation of their coating system.

On Thursday, October 16th, SPT arrived on site in the morning with two workers and installed the second and final top coat to the pipe, fitting and elbow.

The photograph to the left shows a representative view of the Final Three-Step Sauereisen Vinyl Ester Coating System installed by SP Thomas Coating.

Also on Thursday, October 16th, A&W arrived on site and started to install their coating system. However, A&W miscalculated coating material quantities and ran out of coating materials about a third of the way through their pipe line portion. When questioned about continuing where they left off, A&W indicated that would not be an issue and they would most likely start from the beginning and just apply a thin coating until they reached their marker. A&W would then slow down their process to get and maintain the desired thickness.

***Week of October 20th thru 24th***
On Tuesday, October 21th, A&W arrived on site and completed the installation/application of their coating system.

The Photographs (above) show the 1-Step 100-Percent Solids Epoxy Coating System by Warren Environmental and installed by A&W Maintenance.

In November, PVSC's pipe shop reconnected the piping in the vicinity of the flexible coupling location to repair the leaking flanged joint damaged during the liner removal process. Following the mechanical work, PVSC's pipe shop performed a low pressure air test, (not witnessed by a CDM representative.) The results of this air test revealed that a Victaulic coupling gasket had been damaged as a result of the high water pressure liner removal process.

The Four Photographs (above) show the damage to the Victaulic coupling gasket.

On December 31, 2008, NWMCC performed the final CCTV inspection. A copy of the inspection report performed by NWMCC is attached to this memorandum.

A CD of all of the CCTV inspections performed by NWMCC is attached to this memorandum. The CCTV inspections performed by NWMCC include the following:

- Post-Cleaning;
- Pre-Liner Removal;
- Post-Liner Removal;
- Final (Post Coating Systems Application).

## Additional Testing

On Wednesday, November 5th, five (5) coupons [two (2) from each coating supplier/installer plus one (1) uncoated "control"/blank] were installed within the HTPSR effluent pit to Sludge Decant Tank No. 1. Based on previous discussions, it is the intent to leave these coupons exposed to the HTPSR fluid for a minimum period of six-months, or until May 5, 2009.

In addition, also on Wednesday, November 5th, PKF Mark III, Inc. installed the accelerated pilot test connection on a section of the HTPSR force main. The accelerated pilot test connection consists of two (2) ductile iron pipe spool pieces each coated with the two (2) coating systems installed as part of the pilot study (Warren's 1-Step 100% Solids Epoxy and Sauereisen's 3-Step Vinyl Ester). Based on previous discussions, it is the intent to also leave these coated ductile iron spool pieces exposed to the HTPSR fluid for a minimum period of six-months, or until May 5, 2009.

After May 5, 2009, both the coupons and the spool pieces will be removed from exposure to the HTPSR fluid. Additional testing and observations will be performed at that time.

## Results

The performance above describes the day-to-day events of each participant included within the pilot study.

CDM evaluated alternate ways to protect the existing gaskets and still perform the liner removal process. CDM determined that the best way to protect the gaskets would be to remove the coupling housing and slide the gasket out of the way of the joint opening during the liner removal process. This way, shifting or sliding possible long lengths of pipe within the existing utility pipe racks would not be needed unless gaskets were determined during a pre-liner removal low pressure air test to have failed. Provisions within the design documents can be incorporated to inform the Contractor of these provisions in addition to a requirement to perform a pre- and post-liner removal low pressure air test. [Based on additional discussions with PVSC at our January 28, 2009 project meeting, it was determined that CDM will incorporate the replacement of all of the Victaulic joint type couplings into the design documents.]

The following is a summary of some general observations made during the study.

In addition, CDM distributed a post-pilot study questionnaire to each of the 4 participants to get their feedback, specifically regarding their own portion of the pilot study program. However, only one of the pilot study participants (Broadbent) responded.

A copy of Broadbent's response is attached to this memorandum. However, to summarize, while Broadbent acknowledges they ran into some obstacles during the pilot test, it is their opinion they satisfactorily demonstrated that ultra high water pressure is the correct energy source needed to remove the PE liner from the interior of the pipe. Broadbent informed us that the obstacles they ran into during the pilot test are correctible for them to be successful in removing the liner from the remainder of the HTPSR gravity line. Broadbent also indicated it would probably be easier and more productive if their initial maximum pipe run length was revised to 100-feet from 300-feet (as previously indicated in our draft report).

The following will focus, specifically, on the individual participants of the pilot study and discuss the results of each step of the pilot study process.

***National Water Main Cleaning Company***
NWMCC was able to perform the tasks required of them for the pilot test efficiently and effectively without any additional assistance. In fact, the equipment and tools NWMCC used to effectively remove the sludge and debris from pipeline provided additional assistance in the liner removal process. The sludge removal and cleaning process also removed portions of the liner that were already failed, loose, or hanging within the flow path.

***Broadbent's Inc.***
While the ultra-high water pressure liner removal process performed by Broadbent was effective in actually removing the PE liner on straight runs, their process was not efficient due to problems and limitations with their equipment. However, based on discussions with Broadbent, they indicated the problems and limitations they experienced during the pilot study are correctable to the point where they can provide an efficient process in order to remove the liner for the remaining portions of the HTPSR gravity line.

Some notes, observations, and limitations associated with Broadbent's liner removal procedures:

- Hanging liner fragments restrict spray-head from rotating (Possible solution: need cutting tool with air compressor to keep spray-head rotating);

- Cutting tools with wheels get stuck at flexible couplings and/or slight joint offsets (Possible solution: Provide cutting tool with sliders and/or skid rails rather than wheels to handle gaps and offsets);

- No easy way to "string" cable or rope through pipe segment scheduled for liner removal (Possible solution: provide mechanical crawler or air compressor with chute to "string" pipe segment);

- City water pressure at site hydrant about 35-psi. Broadbent's requested and indicated their equipment operates best when pressure is 60-psi. (Possible solution: provide booster pump to raise to necessary pressure).

***Warren Environment (A&W Maintenance)***

A&W was able to install their coating system efficiently and effectively for their portion of the pilot test with constant thickness results. However, implementing their coating system process will require additional surface preparation (i.e. muriatic acid wash) and flushing.

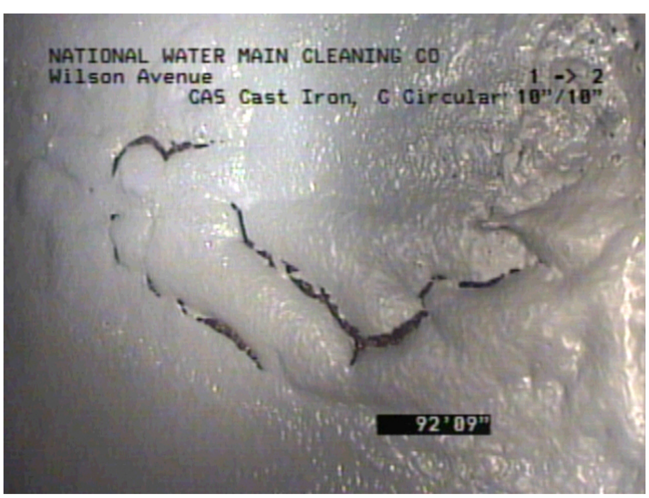
Additionally, implementing their coating system process did not effectively coat the pipe end surfaces located at Victaulic coupling joints. However, it is noted that these pipe end surfaces were not previously coated or lined with the polyethylene before the pilot study proceeded.

[Note and observation – On site CDM representative was impressed with A&W's equipment and installation process. It appears to allow for better control of the desired coating thickness over the competitor].

***Corrosion Technology Systems / SP Thomas Coatings, Inc.***

While CTS/SP was able to install their coating system process for their portion of the pilot test, their process does not appear to be conducive to provide an effective and constant thickness given the application was controlled by hand rather than mechanical equipment. Additionally, implementing their coating system process will require a much longer duration to allow for adequate curing between their three-layer applications. The pilot test also showed that their coating system process can accumulate within the invert of the pipe resulting in a possible disruption between the coating layers, which would render the coating system ineffective.

[Note and observation – The 3-step Sauereisen vinyl ester coating system appeared to accumulate within the invert of the pipe and flake between primer and top coats. Cure times under ambient conditions between coats was much longer than product data indicated which would cause for longer /additional days to the project/pilot duration]




The photograph to the left shows the disruption between the coating system layers.

## Conclusions and Recommendations

Based on our assessment of the pilot test, CDM can conclude that the existing HTPSR gravity can effectively and efficiently be cleaned of sludge and debris material for subsequent application of interior coating system. In addition, the pilot test proved that the energy from the ultra high water pressure process was effective in removing the existing polyethylene liner from the existing HTPSR gravity line down to the bare metal.

Regarding the application of the two coating systems included as part of this pilot test, CDM can conclude that A&W's coating system can be applied more effectively than CTS/SP's coating system in providing the HTPSR gravity line with adequate corrosion protection. Until the results of the accelerated pilot study and coupon testing are completed, CDM cannot comment on the amount of protection either system will provide. The coupons and accelerated pilot test piping connections are not expected to be removed until May 2009.

Therefore and until the coupons and accelerated pilot test piping can be tested and analyzed, it is our recommendation that PVSC proceed only with the cleaning and liner removal of the HTPSR gravity line.

xc: G. Kroll, CDM
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Passaic Valley Sewerage Commissioners
Water Pollution Control Facilities

**Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line**

February 2009


*Final Report*

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# Section 1
# Study Objective/Introduction/Project Background

## 1.1 Study Objective

The purpose of this evaluation is to review and evaluate the rehabilitation options of the existing gravity Heat Treatment Plant Supernatant Return (HTPSR) Line to convey the Sludge Decant Tanks (SDT) supernatant flow to the Supernatant Treatment Plant (STP).

## 1.2 Introduction

In the late 1970s, as part of a major plant upgrading program, the Passaic Valley Sewerage Commissioners (PVSC) placed into operation a sludge thickening/dewatering process at its Water Pollution Control Facility in Newark, N.J. The process consists of thickening raw waste activated and primary sludge's utilizing gravity thickeners, stabilization by thermal conditioning utilizing the Zimpro process, thickening in Sludge Decant Tanks and dewatering using plate and frame filter presses.

There are six Sludge Decant Tanks (SDTs). Each SDT is approximately 88-feet in diameter and has volume of approximately 1.25 million gallons (MG). The total volume of all six SDT is about 7.5 MG. Zimpro processed sludge from the Sludge Heat Treatment Facility (SHTF) is fed to the SDTs where thickened oxidized sludge is drawn from the bottom cone and pumped to the filter presses. The overflow or supernatant from the SDTs is collected and conveyed to the Supernatant Treatment Plant (STP) through the Heat Treatment Plant Supernatant Return (HTPSR) Line.

Refer to the following table for the composition makeup of the HTPSR supernatant wastewater from the Sludge Decant Tanks.

Table 1-1

Composition Makeup of the HTPSR Supernatant Wastewater (1)

| Parameter Description | Value/Range |
|---|---|
| pH | 4.2 to 5.1 |
| Temperature | 18.2 to 41.3 deg. C (64.8 to 106.4 deg. F) |
| Solids | < 1% |
| Sulfides | 8.0 mg/l |
| Chlorides | 500 mg/l |
| Acetone | 84,600 ppb (8.5 %) (2) |
| 2-Butanone | 50,765 ppm (5.08 %) |
| 2-Hexanone | 1,290 ppm (0.13 %) |
| 4-Methyl-2-Pentanone (MIBK) | 275 ppm (0.028 %) |
| Acetophenone | 1,121 ppm |
| Isophorone | N.D. (<9.3 ppm) |

(1) – Data obtained and compiled from PVSC's Operations Department sampling and email correspondence to CDM dated 7/22/2002; 8/09/2002; 8/12/2002, and 10/28/2002.

(2) – Data obtained and compiled from PVSC's Operations Department additional sampling and email correspondence to CDM dated 11/05/2007.

The HTPSR line is approximately 5,000 feet long and ranges in size from 12-inches to 16-inches from the Sludge Storage Tanks up to and including the SDTs. From the SDTs to the STP, the HTPSR lines begins as 20-inches and decreases to 18-inch at the Effluent Pumping Station. The majority of the HTPSR line is constructed of polyethylene (PE) lined ductile iron pipe. It is also believed that there are sections with a glass liner.

Refer to Figure 1-1 for an overview of the overall HTPSR Pipeline.

The pressure head developed by overflowing the weir of the SDTs provides the pressure needed to convey the supernatant to the STP. Each SDT has an 8-inch diameter line that connects and conveys the overflow into the HTPSR Line.

There are two separate parallel HTPSR Lines located within the basement of the SDTs Facility. There is the older North HTPSR Line and the newer South HTPSR Line. The old North HTPSR Line consists of 12-inch, 16-inch, and 20-inch diameter piping installed along side SDT No. 2, 4, and 6. The newer South HTPSR Line consists of 16-inch diameter piping installed along side SDT No. 1, 3, and 5. The older North HTPSR Line is the original line that was installed in the late 1970s, while the South HTPSR Line is the newer line that was recently installed in 2005.

Each SDT has the capabilities to decant into either the North or South HTPSR Lines within the SDTs Facility via the isolation gate valves located within the ground level of the three stair towers in vicinity of the SDTs. PVSC operators have to manually operate the isolation gate valves to direct and control the flow into either the North or South HTPSR Lines.

Both the North and South HTPSR Lines within the SDTs Facility connect into one common HTPSR Line prior to entering the SHTF en route to the STP.

There is a 12-inch diameter overflow pipe from the HTPSR line, located within the SDTs Facility, that is capable of diverting SDT overflow into the Sludge Storage Tanks (Tank Nos. 5 and 6) if the capacity of the HTPSR line to the STP and the Aeration Tanks is exceeded. PVSC operators have to manually operate the two knife gate valves located at the east end of the Sludge Decant Tanks to direct and control the flow from either the North or South HTPSR Lines into the overflow pipe and into the Sludge Storage Tanks. The two knife gates valves isolate the North and South HTPSR Lines located within the SDTs Facility.

There is an existing crossover (or bypass) connection, where PVSC currently has the option of splitting and diverting flow to the STP and/or to the effluent of the Primary Clarifiers. (Refer to Figure 1-2 for additional information on the existing gravity HTPSR Line crossover connection.) Any flow directed through the existing crossover and to the effluent of the Primary Clarifiers is then directed to the Aeration Tanks. The existing crossover connection, located at the west end of the Sludge Thickeners and the east end of the Effluent Facilities Utility Tunnel, ties the existing 18-inch diameter HTPSR Line into the existing 42-inch diameter Sludge Thickened Supernatant Return (STSR) Line. There are two (2) existing knife gate valves to direct and control the flow to the STP and the effluent of the Primary Clarifiers. PVSC operators have to manually operate the two knife gate valves.

There is also an STP bypass connection that exists, which allows the diversion of the supernatant directly to the STP Effluent Well, where pumps divert the supernatant directly to the head of the Aeration (Oxygenation) Tanks. The STP bypass connection piping consists of PVC materials of construction.

## 1.3 Project Background

PVSC has had capacity issues with the existing HTPSR line, limiting the ability to consistently convey supernatant from the SDTs to the STP. Supernatant has been overflowing the HTPSR line into the Sludge Storage Tanks more often than normal, indicating a reduced capacity of the HTPSR line. The flow capacity issues are likely due to solids depositing in the pipeline due to the low velocity of the supernatant within the pipeline.

PVSC has attempted to "pig" the HTPSR Line to clean it on several occasions which resulted in pieces of the PE liner being removed. Based on discussions with PVSC, the pig reportedly had gotten stuck on the liner in one area and that when the fitting was removed, the liner was "tulipped" (i.e. separated from the pipe wall at various non-continuous locations) in from the wall of the pipe.

CDM performed and prepared a Hydraulic and Corrosion Evaluation of the HTPSR Line (refer to our February 2003 Report). As part of the corrosion evaluation, the line was inspected externally and internally. During the internal inspection, the HTPSR line was found to have as much as 8-inches of deposited material at the pipe invert, which is reducing the effective capacity of the HTPSR Line. (See Photo 1-1)

The evaluation also found that the existing liner was delaminating at the ends of each section of pipe due to the minimal corrosion of the exposed ductile iron.

Photos 1-1 and 1-2 depict the deposited materials as well as the "tulipped" liner section.

**Photo 1-1 - View of Deposited Materials within Existing 18" HTPSR Line at EPS.**

**Photo 1-2 – View of PE Liner Section Removed from Existing 18″ HTPSR Line at EPS.**

Recently, during the construction of the HTPSR Force Main project under Contract No. A444-B of the existing HTPSR Line were removed to accommodate the installation of the new equipment. Internal inspections of the removed sections of the 20-inch diameter pipeline revealed as much as 14-inches of deposited material at the pipe invert, reducing the effective capacity of the HTPSR Line. (See Photo 1-3)

**Left - Photo 1-3 - View of Deposited Materials within Existing 20″ HTPSR Line at SDTs.**

To increase the capacity of the HTPSR conveyance system, CDM evaluated, designed, and oversaw the construction of a new redundant parallel HTPSR force main and pump station.

A previous recommendation indicated that with the redundant parallel HTPSR pump station and force main installed, the existing HTPSR gravity line could be cleaned and possibly relined or replaced without interfering the sludge processing operation.

With the new pumping station and force main, the supernatant is pumped instead of the flow being conveyed by the head developed over the weirs of the Sludge Decant Tanks.

The goal of this evaluation is to review the options for rehabilitation of the existing HTPSR Line to convey the supernatant to the STP.

Additionally, in a progress meeting held on October 23, 2007, it was discussed that a pilot study was needed to further evaluate and conclude the appropriate options for rehabilitation of the existing HTPSR Line in order to convey the supernatant to the STP.

# Section 2
# Evaluation of the Existing Heat Treatment Plant Supernatant Return (HTPSR) Line

## 2.1 Description of Existing Materials of Construction of the Existing HTPSR Line

According to the original PVSC Contract 494 (Sludge Decant Tanks Project) and Contract 496B (Sludge Storage and Pump Station Project) Specifications, the materials of construction for the existing HTPSR Line is Thickness Class 53 Ductile Iron Pipe conforming to AWWA Designation C151. Additionally and as indicated within the pipe schedule, the HTPSR Line is provided with a 20-mil thickness polyethylene (PE) interior lining. The pipe schedule also indicated to furnish Glass-Lined Ductile Iron Pipe if PE Lined Pipe is not available.

According to the original specifications, the PE interior lining is a blend of high and low density polyethylene powders, compounded with carbon black, and uniformly fused and bonded to the pipe interior by high temperature process.

There are also sections of the HTPSR Line (i.e. within the SDT Facility) that are of ductile iron glass-lined construction.

Additional measures and/or field investigations would be necessary to determine the exact limits of the PE interior lined pipe and the glass-lined pipe.

## 2.2 Evaluation of the Rehabilitation Options

There are several options CDM investigated for the rehabilitation of the existing gravity HTPSR Line; however, not all of the options CDM investigated for rehabilitation can be implemented and/or considered as acceptable alternatives for this specific project, due access limitations. This evaluation discusses both the investigation options which can be considered as feasible and also describes the options that are not considered feasible for rehabilitation of the existing gravity HTPSR Line.

Various innovative technologies have been utilized recently to as far back as over fifty years in an effort to reduce the costs associated with more traditional or convenient repairs and/or replacement of existing pipelines in the wastewater industry. Some methods are limited in their applicability depending on size, shape, structural condition, hydraulic capacity, accessibility, and physical conditions of the existing pipe and process. The following outlines the rehabilitation techniques or options determined to be potentially applicable for the restoration and/or rehabilitation of the existing gravity HTPSR Line.

The rehabilitation options evaluated vary and include 'no-action'; removal and replacement; clean and television inspection; removal of existing PE liner; installation of lining system; and installation of coating system alternatives.

The following sub-sections further discuss each rehabilitation option presented in more detail.

## 2.2.1 No Action Alternative

The 'No Action' Alternative would consist of leaving the existing HTPSR Line in its current state (i.e. solid materials deposited in pipe invert along with PE liner failures).

Allowing this condition will: (1) further contribute to the build-up of solids in the pipeline; (2) further contribute continued PE liner failures; and/or (3) potentially cause a blockage. All of these conditions can either restrict flow through the pipeline and/or render the pipeline unusable until the restriction, failure, or blockage is corrected.

There is no capital costs associated with this alternative. However, due to the disruption that this could potentially cause with PVSC process operations, the 'No Action' alternative is not considered an acceptable alternative.

## 2.2.2 Removal and Replacement Alternative

The 'Removal and Replacement' Alternative consists of removal of the existing ductile iron pipeline, and the installation of a new pipeline compatible with the HTPSR fluid (i.e. 316L stainless steel) in the previous location.

Considering the site and location of the existing HTPSR line within existing facilities and the utility tunnels, demolition and replacement with a new gravity line would be challenging and costly. This alternative would also require temporary relocation of other process lines that would interfere with the removal and replacement of the HTPSR Line.

This alternative would prove to be very expensive. Based on the construction cost associated with Contract No. A444-B, allowing for material escalations, volatility of fuel costs, and other unforeseen contingencies and potential difficulties, the capital costs associated with implementing this alternative would be in excess of $10 - 12 million.

Given that the gravity HTPSR Line would serve as  the back-up to the HTPSR force main, the likelihood the gravity HTPSR Line would be in operation frequently would not justify the potentially high capital costs associated with this alternative. Therefore, the 'Removal and Replacement' alternative would not be considered an economically acceptable alternative.

### 2.2.3 Clean and Television Inspection Alternative

The 'Clean and Television Inspection' Alternative would consist of cleaning via a high pressure water jet truck (commonly referred to as a 'jetter') in combination with an industrial vactor to clean deposited sediments for the existing gravity HTPSR Line. The accumulated sediment would be removed via vacuum to a truck mounted debris box for storage at a designated location on site prior to offsite disposal.

Once loose sediment has been removed, a high speed chain flail would be utilized within the existing gravity HTPSR Line to perform additional cleaning of the wall surface to remove any accumulated materials or tuberculation from the wall surface.

At the conclusion of the cleaning operation, a closed circuit color camera would be passed through the existing gravity HTPSR Line to verify the effectiveness of the cleaning operation and to determine the integrity of the pipe interior.

In evaluating this alternative, CDM discussed the project requirements with National Water Main Cleaning Company (NWMCC). They indicated that approximately eighteen 'drop-out' points along the existing gravity HTPSR Line would have to be provided to install the cleaning equipment and camera. The eighteen 'drop-out' points, for the most part, are at locations along the existing gravity HTPSR Line where there is a change in direction of the pipeline (i.e. vertical or horizontal bends and fittings). However, there would also be several locations where a straight length of pipe would need to be temporarily removed due to the longer length of the straight pipe run.

Depending on the integrity of the gravity HTPSR Line and the current accumulated condition of solid deposition materials in the pipe invert, the capital costs associated with the 'Clean and Television Inspection' alternative would be approximately $332,000. This is predicated on the amount of solid deposition materials accumulated within the pipe invert. The costs would be less if less material is found to be accumulated within the pipe invert.

Refer to Appendix A for a copy of the NWMCC's Proposal Letter dated April, 30, 2007 as well as a copy of the general site plan field notes prepared by CDM resulting from the April 10, 2007 field visit with NWMCC.

Based on the 'Hydraulic and Corrosion Evaluation of the HTPSR Line' performed by CDM (refer to our February 2003 Report), it was concluded that the existing ductile iron gravity HTPSR Line, which was inspected externally and internally, was in relatively good condition and exhibited only minimum anaerobic corrosion to the exposed ductile iron. The extent of the existing lining damage could not be quantified due to the limited data available during the inspections. This could be better quantified with a television inspection after cleaning. Additionally, a television inspection of the existing gravity HTPSR Line would identify/determine the exact limits of the PE interior lined pipe and the glass-lined pipe segments.

Therefore, based on the relatively good condition of the existing gravity ductile iron HTPSR Line from our previous report and the approximate capital costs needed to perform the work, the 'Clean and Television Inspection' alternative could be considered an acceptable alternative. But additional investigations are required to confirm the feasibility of this alternative and its estimated cost.

### 2.2.4 Existing Liner Removal Options/Alternatives

Various innovative technologies have recently been utilized to remove an existing liner from the host pipe. One of the major considerations for the evaluation is the ability to remove the existing PE liner while the existing gravity HTPSR Line is still in place (i.e. the pipe does not have to be removed from its installed place in order to remove the liner, except for changes in pipe direction). The evaluation determined that there are only two potential alternatives that could be considered to remove the existing PE liner from the existing gravity HTPSR Liner while the pipe is in place. They include high pressure removal and a modified HDD (horizontal directional drilling) approach.

#### 2.2.4.1 High Pressure Removal

The 'High Pressure Removal' option consists of the use of water pressure to successfully clean the pipe interior, to cut and hydro-demolish the polyethylene liner from the host pipe, and to provide an adequate surface preparation for operation or continued additional rehabilitation implementation measures. Water pressure needed for 'High Pressure Removal' options and/or applications can vary from 12,500 psi up to 40,000 psi.

In order to implement this alternative, CDM discussed the requirements with Montauk Services Incorporated (MSI) and Broadbent's Inc. (BI). Similar to the Clean and Television Inspection' Alternative , BI indicated that they too would need the same 'drop-out' points that NWMCC needed along the existing gravity HTPSR Line to install their cleaning, cutting, and hydro-demolition equipment. In addition, their equipment is limited to maximum pipe runs of approximately 100 to 150-feet (revised based on pilot test results). Therefore, additional 'drop-out' point locations would need to be provided.

In order to confirm the existing polyethylene liner can be removed and that BI (as well as their equipment) is capable of the removal of the polyethylene liner, BI simulated the high pressure removal by performing a bench test. During the construction of Contract No. A444-B, portions of the existing gravity HTPSR Line had to be demolished in order to accommodate the installation and connections of new piping, fittings, and valves for the new HTPSR force main. Two pieces of pipe removed from the existing gravity HTPSR Line were salvaged and turned over to BI for their bench test. The two segments included a piece of pipe with the existing polyethylene liner intact (i.e. relatively good condition) as well as a piece of pipe with the existing liner failing (i.e. visible separation in the form of bubbles or blisters).

Refer to the following photographs of the interior condition of the two pieces of pipe prior to the high pressure removal process performed by BI.

**Photo 2-1 – Piece of pipe with the existing polyethylene liner intact (Before)**

**Photo 2-2 - Piece of pipe with the existing liner failing (Before)**

Refer to the following photographs of the interior condition of the two pieces of pipe after the high pressure removal process performed by BI.

**Photo 2-3 – Piece of pipe with the existing polyethylene liner intact (After)**

**Photo 2-4 - Piece of pipe with the existing liner failing (After)**

While BI's high pressure removal equipment is capable of cutting and separating the existing PE Liner from the interior of the pipe, their equipment is not capable of actually removing the cut liner pieces from the pipeline. BI indicated additional services would be needed to remove the cut liner pieces from the pipeline. The removal of the cut liner pieces from the pipeline could be accomplished by various methods including "pigging" the line (by Montauk Services Incorporated), cleaning the line with a traditional combination high pressure water jet truck (commonly referred to as a 'jetter') with an industrial vactor to clean and remove the existing cut pieces (by National Water Main Cleaning Company) or, by passing a mechanical bucket back and forth through the pipeline to clean and remove the existing cut pieces of liner (by a General Contractor). BI indicated that a water connection (i.e. hydrant) would be needed for the high pressure removal process.

In order to successfully remove the existing polyethylene liner from the interior of the existing HTPSR, BI indicated that they utilized a water pressure of 30,000 psi for the segments of pipe where the existing liner is failing and up to 40,000 psi for the segments of pipe with the existing polyethylene liner intact.

After the existing polyethylene liner is removed, the existing HTPSR Liner would be videotaped to inspect and confirm removal as well as to identify areas where liner still needs to be removed.

Implementing the 'High Pressure Removal' option while the pipeline is in place is possible; however, the existing Victaulic coupling gaskets could potentially be damaged as a result of the high pressure process needed for the liner removal. Provisions of any design package including this option should either address some kind of pressure testing of the pipeline after the removal process is complete and/or the removal and replacement of all of the existing gaskets with new EPDM gaskets after the liner is removed.

Based on an initial cost of about $75-$80 per linear foot of pipe from Broadbents Inc to remove the PE liner, the capital costs associated with just the 'High Pressure Removal' option would be at least $375,000 to $400,000 and does not include all other related costs including general conditions, contractor OH&P, testing/inspection, etc. However, the costs were revised by Broadbents Inc. to be in the range of about $104 - $125 per linear foot of pipe based on the pilot test results. Therefore the revised capital costs associated with just the 'High Pressure Removal' option would be at least $520,000 to $625,000 and does not include all other related costs including general conditions, contractor OH&P, testing/inspection, etc. This also does not include the additional costs associated with the additional "drop-out" of pipe and fittings work from a mechanical contractor as well as the clean-up and disposal of the removed liner and the installation of the new EPDM gaskets.

The probable project capital costs associated with this alternative (Not including the 'Clean and Television Inspection' Alternative) would be approximately $2.86 million as indicated in Table 2-1.

**Table 2-1**

**Summary of the Overall Probable 'High Pressure Removal" Project Costs**

| | | |
|---|---|---|
| Mechanical Contractor – 'Drop-Out' Locations | | $150,000 |
| 'High Pressure Removal' of PE Liner | | $625,000 |
| Clean and Disposal of Removed Liner | | $250,000 |
| Mechanical Contractor – Installation of EPDM Gaskets | | $300,000 |
| **Subtotal – Direct Construction Cost** | | $1,325,000 |
| Indirect Costs – Bonds and Insurance | 7% | $93,000 |
| **Subtotal** | | $1,418,000 |
| Contractor's OH&P | 20% | $284,000 |
| **Subtotal – Construction Cost With OH&P** | | $1,702,000 |
| Construction Contingency | 40% | $681,000 |
| **Total Opinion of Probable Construction Cost** | | $2,383,000 |
| Engineering and Implementation | 20% | $477,000 |
| **Total Opinion of Probable Project Cost** | | $2,860,000 |

However, the overall probable project capital costs associated with implementing this alternative with the 'Clean and Television Inspection' Alternative would be approximately $3.58 million as indicated in Table 3-1 within Section 3.

### 2.2.4.2 Modified HDD Technology & Similar Equipment

The 'Modified HDD Technology and Similar Equipment' option consists of the use of standard horizontal directional drilling (HDD) equipment to access (via an entrance and exit pits) the utility along with the liner stripping device to remove the failing liner. Typical access to the utility for the HDD equipment can be attained via an excavated pit, while typical access for the liner stripping device can be attained and assembled through an existing manhole.

Attached (in Appendix B) is a copy of a paper presented at the 2007 No-Dig Conference and Exhibit for the North American Society for Trenchless Technology, which was held in San Diego, California in April 2007 that discusses HDD technology.

Based on discussions with HDD Technology equipment manufacturers, CDM determined that the use of standard HDD Technology equipment would not be suitable for this application since access to the existing gravity HTPSR Line cannot be easily achieved from the ground surface with a classical HDD equipment setup. While the stripping tool is easily adaptable, the challenge is in the thrust and pullback unit or piece of equipment that resides outside of the pipe to make the tool rotate and thereby perform the needed stripping. The unit or piece of equipment has to transmit sufficient torque on average (and at peak when the stripping tool catches or gouges) to sufficiently remove the liner. Based on the existing configuration for this application, a custom smaller, mobile, and adjustable (for the height above the floor) unit or piece of equipment would be needed to ensure a rigid and safe arrangement to produce maximum results. However, according to the HDD Technology equipment manufacturers, the design and fabrication of such a custom unit or piece of equipment would be complicated with custom parts and too extensive that there just is not enough value in the job to cover and/or justify the expenses. Therefore, the 'Modified HDD Technology' alternative would not be considered a viable and/or an economically acceptable alternative.

In addition (and based on information provided to CDM from PVSC's Operations Department), CDM had further discussions with Mr. William T. Suchodolski, Engineering Manager of the Ocean County Utilities Authority (OCUA) to discuss the results of OCUA's pipeline liner removal test and project. Based on discussions with OCUA, CDM discovered that OCUA had similar issues with liner failure within their collection system. OCUA retained the services of a general contractor to utilize typical bucket machines to pull a cutting device through the pipe to remove the failed liner.

Based on discussions with OCUA, CDM determined that the use of typical bucket machines to pull a cutting device through the pipe to remove the failed liner was relatively successful with some limitations. The cutting devices utilized were not able to completely remove the entire liner down to the host pipe. OCUA estimated at best 50% of the liner was removed. Essentially, the use of typical bucket machines to pull a cutting device through the pipe only removed those portions of the liner at points of failure. After the section of the failed liner had been removed, a cured-in-place liner was installed. Based on cost information provided to CDM from OCUA for a similar liner removal project they had bid within their system, the capital costs associated with removal of the existing failing PE liner within the existing gravity HTPSR Line alternative would be in the range of $80 to $100 per LF.

Based on our discussions with the HDD Technology equipment manufacturers and with OCUA, the 'Modified HDD Technology and Similar Equipment' option would not achieve the goals needed to rehabilitate the HTPSR Line. Therefore, the 'Modified HDD Technology and Similar Equipment' option should not be considered as a feasible rehabilitation option.

## 2.2.5 Lining System Alternatives

There are several lining system alternatives on the market that can be installed in various size and shape configurations of pipes. However, for the purposes of this evaluation, CDM reviewed the feasibility of two of the most feasible lining options. They include the cured-in-place pipe and Sliplining pipe options.

### 2.2.5.1 Cured-In-Place Pipe

In order for this option to be considered, all loose sections of the existing liner would have to be removed prior to a new liner installation.

The 'Cured-In-Place Pipe' (CIPP) lining method option consists of the insertion of a resin impregnated flexible felt or fabric liner tube into the existing pipeline and thermally activating or curing the liner to make it rigid. The CIPP liner forms to the shape of the host pipeline and provides structural rehabilitation without loss in hydraulic capacity or requiring that an annular space be grouted. After the liner is completely installed, tie-in connections to the rehabilitated line must be reestablished. This can be performed either by man-entry or by using a remote cutting device in conjunction with a television camera to remove the liner from the connection opening.

Unlike the Coating System Alternative, a CIPP liner would cover the existing polyethylene liner. However, the existing gravity HTPSR Line would still have to be adequately cleaned and any loose materials and/or liner removed.

In order to install such as system; the installation materials and equipment would need to be set up at each change in direction (i.e. bend) along the existing gravity HTPSR Line to be rehabilitated. In addition, the installation of a liner would require equipment capable of maintaining a head condition of approximately 15-feet above the pipe in order to invert the liner into the pipe using water. This equipment would require headroom of approximately 15-20 feet above the pipe, which could be feasible within some of PVSC's process facilities but would not be feasible within PVSC's utility tunnels. Also, there is limited access to the utility tunnels from the surface for the equipment needed in order to install the CIPP liner system. Therefore, construction access to all of the changes in direction along the existing gravity HTPSR Line is not feasible.

In addition, the CIPP liners are not installed within the changes in direction (i.e. bends). At all changes in direction locations, another rehabilitation alternative (i.e. an epoxy coating system) would have to be implemented, thereby creating gaps in the liner installations.

Additionally, future access to all of the ductile iron pipe joints (i.e. Victaulic grooved-end joint connections) would be restricted because the CIPP liner installation would be over each joint along the straight pipe sections. Therefore, the only locations where the pipe would be able to be dismantled would be at changes in direction, unless breaks in the CIPP liner were provided at joints.

Previous failures (i.e. separation or delamination) of the existing PE liner within the existing gravity HTPSR Line can be partially attributed to the gaps created at the pipe end joint connections. Therefore, additional consideration of these areas of potential failure would be covered up, except at changes in the pipes direction or if breaks in the CIPP liner were provided at existing pipe joint locations, which would be a challenge.

Therefore, the 'Cured-In-Place Pipe' lining method option would not be considered an acceptable or viable option to rehabilitate the existing gravity HTPSR Line for reasons associated limited access to the utility tunnels to install the CIPP liner as well as limited future access to the HTPSR Line itself because of the covered pipe joints by the CIPP Liner installation.

### 2.2.5.2 Sliplining Pipe

Similar to the 'Cured-In-Place Pipe' lining method option, in order for this option to be considered, all loose sections of the existing liner would have to be removed prior to a new slip-lined pipe installation.

The 'Sliplining' option basically consists of the insertion of a pipe liner system into the host pipe. Many different materials are used in the construction of Sliplining systems and are dependent on the required resistance to corrosion and hydraulic characteristics. Some of these materials include PVC and polyethylene.

The evaluation of the 'Sliplining' option consists of sliding sections of a pipe liner system (Fusible C-900 PVC or polyethylene) into the existing gravity HTPSR Line host pipe. New fittings would need to be provided at changes in direction to connect to the slip line lining.

The use of the Fusible C-900 PVC option was discussed with Underground Solutions Incorporated as they had indicated that they have rehabilitated buried lines with this technology. They were provided the chemical makeup of the HTPSR decant and they had indicated that PVC is not compatible. Similar to the Fusible C-900 system, CDM also discussed this application with UltraLiner only to find that their liners are also fabricated of PVC and not compatible with the makeup of the HTPSR decant.

While the use of PVC is not compatible with the makeup of the HTPSR decant, polyethylene is compatible. While U-Liner manufactures and fabricates a fold-and-form polyethylene sliplining system, CDM has been unable to discuss the potential use of their system for this application. CDM has made several attempts to reach out to them and they have been unresponsive to our many inquiries.

However, based on our understanding of the system and from the information we were able to obtain from the manufacturer's website, it can be concluded that the 'Sliplining' option is not considered an acceptable or viable option to rehabilitate the existing gravity HTPSR Line.

## 2.2.6 Coating System Alternatives

There are several coating system alternatives on the market that can be installed in various size and shape configurations of pipes. There are also numerous products on the market that are meant to be applied in-situ to coat the existing pipeline. These pipe coatings can be divided into two categories; structural coatings and non-structural coatings.

Structural pipe coatings are coatings whose main purpose is to improve the strength and structural integrity of the existing pipeline. The condition and construction of the existing gravity HTPSR Line evaluated within this report is such that a structural coating system is not considered necessary as a long-term rehabilitation option.

Non-structural pipe coatings are coatings whose main purpose is to improve the hydraulic characteristics of the pipeline and/or to protect the pipeline from corrosion or abrasion where the host pipe is determined to be in satisfactory condition.

For purposes of this evaluation, CDM reviewed the feasibility of a spray-applied epoxy coating system, given the integrity of the existing ductile iron pipe that was determined to be in relatively good condition based on the corrosion evaluation CDM performed in 2003.

Similar to the lining system alternative rehabilitation options described in Section 2.2.5 above, in order for this option to be considered, the existing liner would have to be removed and the surface of the pipe interior would have to be adequately prepared in accordance with the manufacturer's recommendations prior to the application of the spray-applied epoxy coating system.

### 2.2.6.1 Spray-Applied Epoxy Coating System

The 'Spray-Applied Epoxy Coating System' option consists of the application of an appropriate coating material to the interior of the existing gravity HTPSR Line to adequately protect the host pipe from the corrosive composition make-up of the HTPSR decant.

For purposes of the make-up of the HTPSR decant, a suitable epoxy coating system would be sufficient to provide corrosion protection to the interior of the existing gravity HTPSR Line.

CDM had discussions with two (2) spray-applied epoxy coating system installers (A&W Maintenance, Inc. and Corrosion Technology Systems). A&W Maintenance, Inc. is the epoxy coating installer who worked on PVSC's Contract No. A410 – Repair to the STSR Line. Corrosion Technology Systems is a coating system supplier and works closely with a certified installer (SP Thomas Coatings).

Based on discussions with and information provided to CDM from A&W Maintenance, the application of a 150 mils dry thickness, two step monolithic pipeline surfacing system manufactured by Warren Environmental System appears to be the appropriate application to provide the necessary corrosive protection of the existing gravity HTPSR Line. The complete pipeline surfacing system consists of surface cleaning, pre-application visual inspection, application of epoxy coating system, and post-application visual inspection. The monolithic surfacing system would consist of a unique non-toxic, 100% solids, solvent-less epoxy resin coating system which would be continuously bonded to the interior of the existing gravity HTPSR Line. The 'Clean and Television Inspection' Alternative indicated approximately eighteen 'drop-out' points along the existing gravity HTPSR Line would have to be provided to install the cleaning equipment and camera. Additional 'drop-out' point locations will most likely be required based on 250 to 300-feet long pipeline run limitations of the application process of the coating system. The 'drop-out' point locations, for the most part, are at locations along the existing gravity HTPSR Line where there is a change in direction of the pipeline (i.e. vertical or horizontal bends and fittings). However, there would also be several locations where a straight length of pipe would need to be temporarily removed due to the longer length of the straight pipe run. The capital costs associated with implementing just the application of the spray-applied epoxy coating system would be at least $2.86 million, based on the cost information provided from A&W Maintenance of $220.00 per foot for the 18-inch and $242.00 per foot for the 20-inch. The costs includes general conditions, contractor OH&P, testing/inspection, etc, but does not include other related costs associated with the 'Cleaning and Television Inspection' or the 'High Pressure Removal' of the PE Liner.

Refer to Table 2-2 for the overall probable project capital costs associated with this alternative, all other related costs [including the 'Clean and Television Inspection' and the 'High Pressure Removal' of the PE Liner], general conditions, contractor OH&P, testing/inspection, etc.

Based on discussions with and information provided to CDM from Corrosion Technology Systems and their certified installer (SP Thomas Coatings), the application of a 26 mils total dry thickness, three step pipeline surfacing system appears to be the appropriate application needed to provide the necessary corrosive protection of the existing gravity HTPSR Line. Similar to A&W Maintenance, the complete pipeline surfacing system consists of surface cleaning, pre-application visual inspection, application of epoxy coating system, and post-application visual inspection. Their surfacing system would consist of a three part application coating system, a primer coat, an intermediate coat, and a finish coat. The Primer Coat consists of their VE 550-G (Sauereisen's Vinyl Ester Glaze base coat system) at a 6 mils application thickness. Both the Intermediate and Finish Coats consist of their VE 472-G (Sauereisen's Vinyl Ester Glaze top coat system) at a 10 mils application thickness each. Similar to the previous coating system, additional 'drop-out' point locations would most likely need to be provided. SP Thomas Coatings has indicated they are limited to runs of 150-feet in length. The capital costs associated with implementing just the application of the spray-applied epoxy coating system would be about $500,000, if not more, based on the cost information provided to CDM from SP Thomas Coatings. However, additional capital costs associated with a mechanical contractor to 'drop-out' the appropriate points for access for the application of the spray-applied coating system equipment would need to be further evaluated and quantified.

While both 'Spray-Applied Epoxy Coating System' company's contacted will require additional capital costs associated with a mechanical contractor to 'drop-out the additional points for access, the additional capital costs associated with the Corrosion Technology Systems and SP Thomas Coatings system will be a least double that of the A&W Maintenance coating system based their pipe run limitations being about half.

Additionally, while both 'Spray-Applied Epoxy Coating System' company's contacted provided CDM with their recommended coating system compatible with the composition make-up of the HTPSR Supernatant, it is recommended that additional 'coupon' testing be performed to confirm the coating system company's recommendations.

Therefore, based on the relatively good condition of the existing gravity ductile iron HTPSR Line from our previous report and the successful test results of the PE Liner removal pilot tests performed by Broadbents Inc., the 'Spray-Applied Epoxy Coating System' alternative could be considered an acceptable alternative.

In a progress meeting held on October 23, 2007, it was discussed that a pilot study was needed to further evaluate and conclude the appropriate options for rehabilitation of the existing HTPSR Line in order to convey the supernatant to the STP. Refer to Appendix C regarding the summary of pilot test results associated with the HTPSR Liner Evaluation.

The overall probable project capital costs associated with just implementing this alternative, including other related costs, general conditions, contractor OH&P, testing/inspection, etc., would be approximately $6.43 million as indicated in Table 2-2. This includes the costs associated with the 'Clean and Television Inspection' and the 'High Pressure Removal' of the PE Liner.

**Table 2-2**

**Summary of the Overall Probable 'Spray-Applied Epoxy Coating System' Project Costs**

| | | |
|---|---|---|
| Cleaning and Television Inspection of HTPSR Line | | $332,000 |
| 'High Pressure Removal' of PE Liner | | $1,325,000 |
| 18-Inch Diameter Spray-Applied Coating System | | $570,900 |
| 20-Inch Diameter Spray-Applied Coating System | | $627,990 |
| Mechanical Contractor – Additional 'Drop-Outs' | | $125,000 |
| **Subtotal – Direct Construction Cost** | | $2,981,000 |
| Indirect Costs – Bonds and Insurance | 7% | $209,000 |
| **Subtotal** | | $3,190,000 |
| Contractor's OH&P | 20% | $638,000 |
| **Subtotal – Construction Cost With OH&P** | | $3,828,000 |
| Construction Contingency | 40% | $1,532,000 |
| **Total Opinion of Probable Construction Cost** | | $5,360,000 |
| Engineering and Implementation | 20% | $1,072,000 |
| **Total Opinion of Probable Project Cost** | | $6,432,000 |

## 2.2.7 Gravity to Force Main Conversion Alternative

The 'Gravity to Force Main Conversion' Alternative would consist of connecting the recently installed and operational HTPSR pumping station to the existing gravity HTPSR Line. More specifically, this alternative would consist of a connection between the HTPSR pumping station 12-inch diameter discharge header piping to the existing 20-inch diameter gravity HTPSR Line within the SDTs Facility. [Partial provisions for this potential future gravity to force main conversion connection have already been made as part of the Contract No. A444-B construction project.]

The capital cost associated with the mechanical equipment (i.e. piping, fittings, and valves) needed for the 'Gravity to Force Main Conversion' alternative would be in the range of $200,000 to $275,000. This capital cost includes estimated costs for instrumentation and/or automation modifications.

Implementing the connection and conversion of the existing gravity HTPSR Line to a force main would give PVSC with a back-up to the recently installed 12-inch diameter HTPSR force main should there ever be a problem encountered. Converting the existing gravity HTPSR Line to a force main would also allow for the pipe to see higher flow rates and therefore higher velocities within the pipe, thereby reducing the likelihood of solid deposit materials accumulating in the pipe invert.

Therefore, the 'Gravity to Force Main Conversion' alternative would be considered an acceptable alternative.

# Section 3
# Conclusions and Plans of Action

## 3.1 Conclusion and Short-Term Plan of Action

Based on the confirmed accumulation amounts of solid materials deposited within the pipe inverts, which have reduced the overall conveyance of the line, the short-term plan of action would be to have the existing gravity HTPSR Line from the Sludge Decant Tanks to the Supernatant Treatment Plant cleaned (i.e. to remove all solids build-up) and televised (i.e. to inspect the internal integrity of the pipe).

The cleaning would require portions of the existing gravity HTPSR Line to be taken out-of-service and opened at several points to allow access for the cleaning equipment to enter the line and for the removal of the built-up materials.

Following the cleaning, the closed circuit television (CCTV) inspection would be performed to confirm that the existing gravity HTPSR Line was adequately cleaned and to assess the overall condition and integrity of the polyethylene (PE) liner as well as the exposed ductile iron pipe for the full length of the existing gravity HTPSR Line.

Table 3-1 summarizes the anticipated probable costs associated with the Short-Term Plan of Action listed within this Section.

## 3.2 Long-Term Plans of Action

The following section presents the long-term plans of action for the existing gravity HTPSR Line rehabilitation methods evaluated by CDM. CDM investigated and evaluated several rehabilitation methods, including 'no-action', removal and replacement, clean and television inspection, removal of existing PE liner, installation of lining system, and installation of coating system. The evaluated rehabilitation methods are discussed in more detail in Section 2.2.

Of the viable rehabilitation methods evaluated, the following are the preliminary plans of action that CDM suggests PVSC consider for further evaluation and discussion.

However, implementation of any of the long-term plans of action still requires the implementation of the short-term plan of action described above (i.e. cleaning and television inspection).

Table 3-1 also summarizes the anticipated probable costs associated with the Long-Term Plans of Action listed within this Section.

### 3.2.1 Long-Term Plan of Action Option No. 1 – Existing Liner Removal and Coating System

Long-Term Plan of Action Option No. 1 is a combination of two rehabilitation methods presented in Section 2 of this evaluation report. They include the 'Existing Liner Removal Options/Alternatives' and the 'Coating System Alternatives' to the existing gravity HTPSR Line.

However, before Long-Term Plan of Action Option No. 1 can be implemented, the Short-Term Plan of Action will need to be implemented first to ensure that the existing gravity HTPSR Line is clean and clear of any debris and/or materials for the liner removal equipment.

Implementation of Long-Term Plan of Action Option No. 1 will eliminate the restriction of the flow path as a result of failures of the existing liner as well as to provide the necessary corrosion protection to the existing back-up gravity HTPSR Line to the HTPSR pump station and force main.

A variation to Long-Term Plan of Action Option No. 1 could be to only implement the 'Existing Liner Removal Options/Alternatives' since the existing gravity HTPSR Line is only a backup to the HTPSR pump station and force main.

Depending on whether the combination of the two rehabilitation methods presented for Long-Term Plan of Action Option No. 1 are implemented or just the one, additional considerations will need to be included in any design package prepared to address any and all of the deficient and/or deteriorating flexible coupling connections along the existing gravity HTPSR Line.

### 3.2.2 Long-Term Plan of Action Option No. 2 – Gravity to Force Main Conversion

Long-Term Plan of Action Option No. 2 is the 'Gravity to Force Main Conversion' Alternative to the existing gravity HTPSR Line.

Similar to Option No. 1, the Short-Term Plan of Action should be implemented to ensure that the existing gravity HTPSR Line is clean and clear of any debris and/or materials to avoid any potential blockages of built-up debris, materials, or failed liner sections.

The implementation of Long-Term Plan of Action Option No. 2 could eliminate the buildup of debris and/or materials within the existing gravity HTPSR Line and also provide PVSC with a redundant backup force main should the stainless steel force main be out of operation for maintenance, pipe cleaning (i.e. pigging), a pipe failure, etc.

In addition, with the plant water system connection to the wet well, the pumping system could be utilized to flush out the HTPSR Line. Depending on the implementation of Long-Term Plan of Action Option No. 2, additional considerations will need to be included in any design package prepared to address any the addition of pipe cleaning equipment (i.e. pig launchers and receiver) along the existing gravity HTPSR Line.