APPENDIX C – OUTFALL CONDITION ASSESSMENT 2015-2018 UPDATE – FINAL SUMMARY REPORT (REV. 1)

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The City of Winnipeg

Outfall Condition Assessment 2015 -2018 Update Final Summary Report (Rev. 1)

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January 2019

Project Number: 60431277

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Dear Mr. Bortoluzzi:

Regarding: Outfall Condition Assessment
2015 -2018 Update
Final Summary Report (Rev. 1)

We are pleased to submit four (4) hard copies and one (1) pdf of the Final Summary Report (Rev 1) for the above project.

We thank you for the opportunity to work on this very interesting assignment.

Sincerely,
AECOM Canada Ltd.

Andy Nagy, P. Eng.
Conveyance Area Market Sector Leader
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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
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Table of Contents

List of Figures

List of Tables

Appendices

1. Introduction

1.1 General Overview

The City of Winnipeg has a sewer system that services a population of over 710,000 people (as of 2017). The sewer system includes 3844 km of sewer that is comprised of 1026 km of combined sewer (CS), 1448 km of separate wastewater sewers (WWS), 1183 km of land drainage sewer (LDS) and 187 km of storm relief sewers (SRS). The network is serviced by 362 outfalls in a variety of service modes from land drainage, Combined Sewer Overflow (CSO), Relief Sewers, and Emergency wet weather overflows (WWO's) from a number of wastewater pumping stations.

Since 1998, the Sewer Condition Assessment Program has inspected 100% of the combined sewers, 100% of separate wastewater sewers over 30 years old (95% of the entire inventory), and a small percentage of land drainage and relief sewers. Sewers were assessed using Water Research Council (WRc) sewer condition assessment protocol[1] and the defect-to-treatment rationalization outlined in the City's 1997 Sewer Management Study[2]. While sewer outfalls have been assessed for many years, there were not assessed under the same program nor using the same or similar criteria as the sewer systems they serve.

From 1980 through 1996, outfalls were assessed opportunistically, with a relatively small number of outfalls inspected annually, usually at a rate of 1 to 2 per year. Inspection was by man entry methods where possible. No standardised condition assessment method was documented for the era and no formal prioritization of the inventory was made to inspect it in a systematic manner or prioritized upgrading requirements within the City's SMS. Consequently, the overall condition of the inventory was not well understood and the City desired to conduct a thorough condition assessment program to fully understand the level of investment necessary to sustain the asset and determine the best technological approach to extend the life of these critical assets.

The first comprehensive inventory and overall assessment program was undertaken between 1996 and 1998. While comprehensive, the condition assessment protocol used was more of a qualitative than quantitative based system. For example, it did not utilize the WRc protocol that the City had adopted for assessing the collection system. At the time, rehabilitation prioritization was largely based on condition considerations alone, as opposed to being risk-based (i.e. combined consideration of failure probability and consequence), with an arbitrary 5-year rehab planning horizon for the inventory.

Strategic re-inspection of portions of the inventory were carried out in 2005 and 2006 to reinitiate the annual upgrading program. However, by 2014 the City recognized the need to undertake a new comprehensive condition assessment program that incorporated a more holistic risk-based approach to the management of outfall assets.

This included:

- The introduction of quantitative assessment standards for outfall pipes aligned with the analytical methods used in collection system assessment, based on clearly defined WRc condition assessment protocol.
- Integration of geotechnical based upgrading requirements with overall pipe upgrading requirements to assess the outfalls as a unique asset class considering both observed pipe condition and outside factors such as slope stability that could alter pipe condition rapidly and independent of observations normally inferred from internal CCTV inspections.

[1] *UK Water Industry, Engineering and Operations Committee, Manual of Sewer Condition Classification", WRc Publication (1993).*

[2] *UMA Engineering, "Sewer Management Study - Technical Memoranda For Sewer Condition Assessment, Sewer Rehabilitation Design, And Sewer Maintenance Management For The City Of Winnipeg" for the WWD, July 2001*

- Application of risk-based concepts (i.e. consideration of both probability and consequence of failure) to develop a transparent prioritization methodology for a longer-term outfall rehabilitation program, and assist in development of the business case to define the appropriate funding level.
- Consideration of the appropriate set of condition assessment tools to access portions of the inventory only partially inspected or never inspected under previous programs due to seasonal or permanent submergence of the outfall.
- Rationalization of the appropriate suite of rehabilitation technologies and O&M activities to upgrade and sustain the inventory.

1.2 Program Assessment and Analytical Approach

Outfalls are very challenging pipes to assess; often with complex access logistics such as standing water due to their outlet elevation relative to the river level (e.g. partially or fully submerged); and/or high debris levels that prohibit conventional visual inspection techniques which is compounded with no pre-emptive cleaning program. Further, as the outfalls all discharge to river courses with varying degrees of slope stability; geotechnical considerations can cause pipe degradation independent and in addition to normal pipe deterioration mechanisms.

This project saw unique challenges relative to debris and access logistics where a high risk of survey abandonment was likely due to limited access, debris, or other obstructions that would impede full inspection. A unique approach to assess outfall condition in an integrated manner was undertaken where the program involved carefully matching the correct internal inspection technique to the prevailing pipe situation (e.g. CCTV only, SONAR, full multi-sensor platform) and overlaying this knowledge with a geotechnical assessment to fully understand failure risk and assess upgrading requirements for each outfall. The use of risk based assessment concepts to provide clarity on short and long-term inspection and upgrading priorities was also incorporated into the assessment approach.

The condition assessment process, as noted within the Technical Memorandum - Outfall Condition Assessment Methodology (Appendix A), was subdivided into two programs relative to the outfall pipes elevation to the river level that would likely be encountered. This produced two pipe assessment schemes:

- traditional closed-circuit television (CCTV) for fully exposed outfall pipework
- Multi-Sensor Inspection (MSI) Platform inspection technologies for partial to fully submerged pipe environments.

Structural and service related defects observed in the outfall pipe inspections coded to WRc 3rd Edition Standards[3]. Inspected coding provided internal structural condition grades which were combined with WRc service ratings to provide an overall understanding of the pipes structural (probability of structural failure) and service condition (defects that impair the sewer's ability to perform its intended service function and that can initiate further deterioration over time). These observations were combined with two geotechnical slope condition ratings as follows:

- Slope Condition Grade(SCG) – an indication of overall slope stability in terms of its ability to engage the outfall pipe, and
- Erosion condition grades (ECG) – an indication of the toe erosion potential of the slope which could lead to or initiate larger slope failures

SCG ratings as noted above were directly analogous to the pipe's structural condition and they related to the structural stability of the overall slope that could engage the pipe, while the ECG ratings were analogous to the pipes service ratings as if left un-addressed, they could compromise the entire slope over time.

All condition grades were based on a common assessment of condition state where:

- 1 = new asset or no defects present
- 2 = defects present but the short term potential for further deterioration is low

[3] *UK Water Industry, "Manual of Sewer Condition Classification, 3rd Edition, August 1993*

- 3 = defects present and the short term deterioration was highly likely
- 4 = defects present of such a nature that a random event could initiate failure
- 5 = defects present to the degree that failure had occurred or was incipient

Capital treatment expenditures were estimated for all condition grades of 3 or higher with the exception of pipe service grades as the City's Sewer Management System (SMS) has no current work streams to address pipe service-related defects. The grades also facilitated gaining some direct insight into rehabilitation timing based on the following considerations:

- Condition Grade of 1 or 2 only required re-inspection commensurate with the outfall's failure consequence
- Condition Grade 3 included defects and deterioration processes that were reflective of typically needing treatment in 5 to 15 years or more
- Condition Grade 4 included defects and deterioration processes that were reflective of typically needing treatment in 3 to 5 years or more
- Condition Grade 5 included defects and deterioration processes that were reflective of needing treatment immediately or in some cases up to about 3 years prior to incipient failure conditions transitioning to an ultimate failure

The prioritization process for implementation of re-inspection and/or implementation rehabilitation measures for sewers alone has generally been a modified worst-first approach proceeding with Condition (SPG 5) then to infrastructure in progressively better condition (SPG 4 and 3). Overall prioritization is also driven by consequences of failure or criticality of individual sewers or outfalls, whereby higher failure consequence pipes are preferentially fixed before proceeding to lower consequence pipes. The criticality model for sewer infrastructure in Winnipeg is a classic WRc risk model[4]. It includes three broad categories of sewers, Category A (most critical – failure cannot be effectively handled with normal operations), B (medium criticality – failure would strain existing operations, and C (least critical – failure can reasonably be managed by normal operations). Within each grouping, the consequence of failure is further prioritized by an Overall Cost Factor (OCF), which can be used to provide further discretization relating to the consequences of specific sewer elements failing.

While the programming of sewers other than outfalls is relatively straightforward using the above approach, the programming of outfalls is more complex. The combined consideration of the pipe's condition in conjunction with the slope's condition needs additional business case examination due to the large magnitude of slope remediation versus pipe repairs alone. A proposed framework for this program integration and business case development is presented herein.

[4] *Water Research Centre (WRc), "Sewerage Rehabilitation Manual, Volume I, 4th Edition", 2001*

2. Overview of Outfall Inventory

The outfall inventory consists predominantly of Land Drainage pipe (62%) but includes Combined Sewer Overflow's (CSO) (15%), Relief Sewers (14%), and emergency Wet Weather Overflow (WWO) elements (9%). 53% of the inventory is larger than 1000 mm and 47% ranges from 200 mm to 900 mm. Approximately 70% of the inventory is constructed of Corrugated Steel Pipe (CSP), 18% concrete and the remainder of a wide variety of other materials from thermoplastics to wood stave pipe.

The distribution of cohorts and attributes for the outfall entities are presented in Figure 1 through Figure 6. The material types under the Outfall inspection program consisted mainly of corrugated metal and steel pipe (60%), Concrete (32%) and PVC (2%). The remaining 6% is comprised of HDPE, Steel, Asbestos Cement, wood-stave, vitrified clay, steel etc.

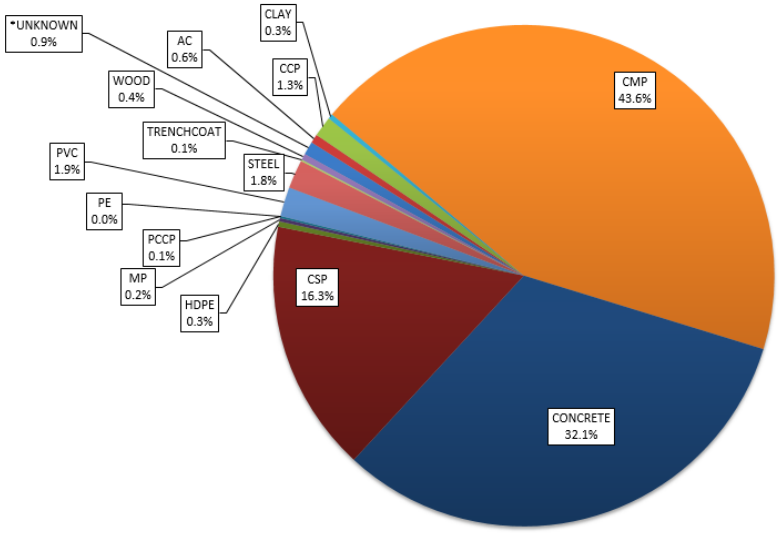

Figure 1: Outfall Predominant Pipe Material

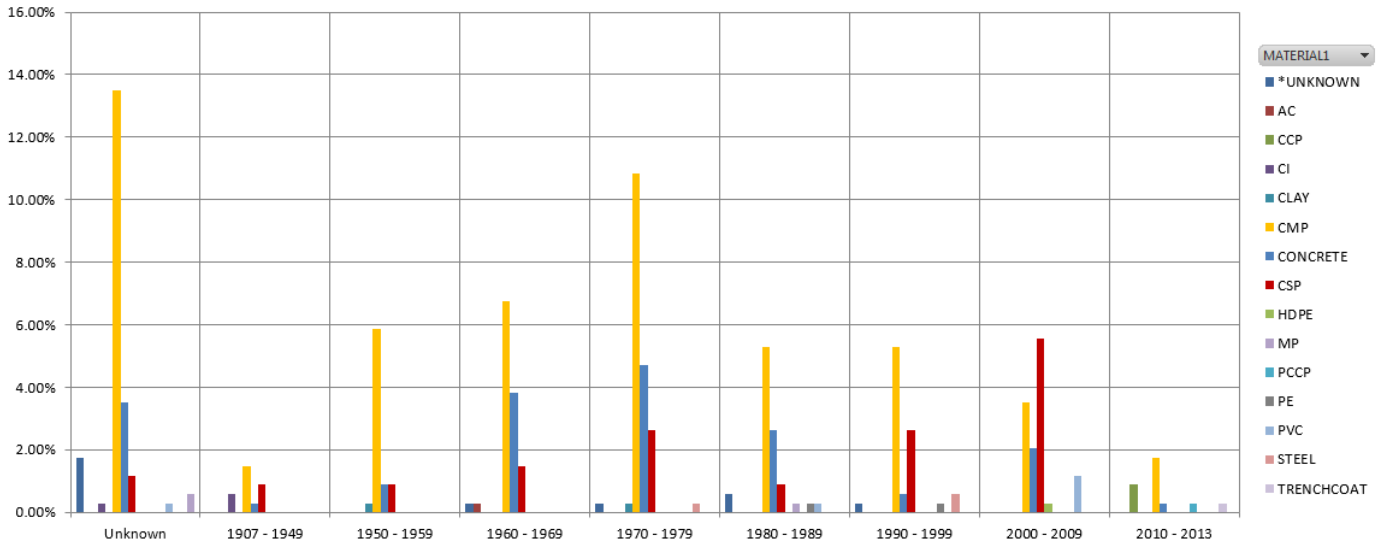

Figure 2: Outfall Predominant Material and Age

Figure 2 also denotes what percentage of total outfall pipe length was constructed with each material type decade. Note that CSP and CMP both represent the same essential pipe material, corrugated metal pipe, which is referenced in GIS as CMP (Corrugated Metal Pipe) and CSP (Corrugated Steel Pipe). Both CSP/CMP and concrete have been widely used over time with very little concrete pipe installed in outfall service after the year 2000.

The pipe size (Figure 3) is presented based on the height attribute within the City of Winnipeg Sewer Management System (SMS). As shown in Figure 3, small diameter pipes (<=900mm) account for 47% of the inventory while larger diameter (heights >900mm) account for 51% of the inventory while the remaining 2% account for egg shaped sewers. The largest pipe within the inspection program was the 3700mm storm sewer CSP/CMP adjacent to the Roland flood pump station.

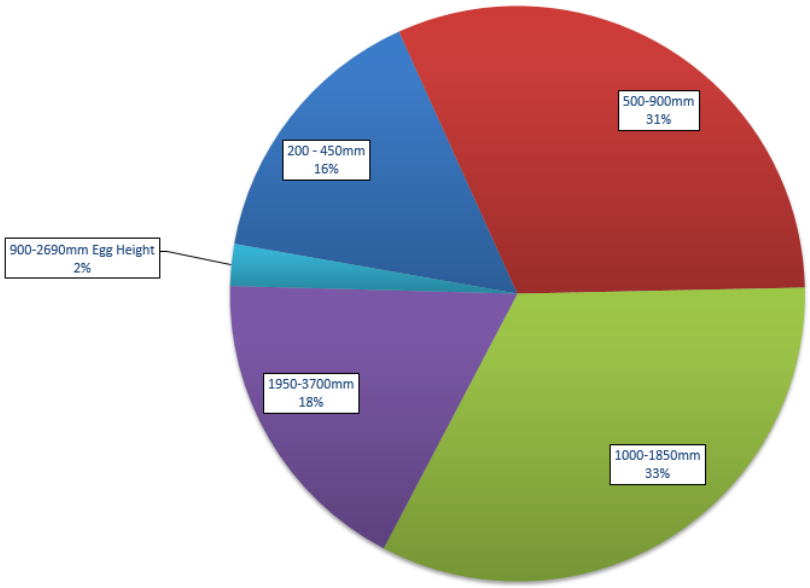

Figure 3: Outfall Diameter (Height for Egg)

Table 1: Flow Type and Diameter Relationship

Main Size (Height)	CS	LDS	SRS	WWS	Grand Total
200-450mm	1.6%	10.7%	0.9%	2.3%	15.5%
500-900mm	2.5%	22.1%	3.3%	3.5%	31.4%
1000-1850mm	4.7%	22.2%	5.5%	0.7%	33.1%
1950-3700mm	4.3%	6.5%	4.3%	2.5%	17.6%
900-2690mm Egg Height	1.9%	0.5%	0.0%	0.1%	2.4%
Grand Total	**15.0%**	**62.0%**	**14.0%**	**9.0%**	**100.0%**

The location and distribution of the pipes based on age is shown in Figure 4. The largest fraction of the outfall inspected were constructed in the 1970's which accounts for 19% of the inspected total. 21% of pipe do not have a date of installation attributed in SMS and were assigned with the systems default 1/1/1860 installation date nor can we, by association, infer possible installation dates to the surrounding district network as many outfall pipes re-constructed over time but are not classified in either SMS or the City's GIS in that manner. While it is known that many of the original outfall pipes in older areas were wood stave pipes and other materials, it is not known what dates the re-constructions took place. About 3% of the inspected total is greater than 68 years old, while the most recent installations after 2010 account for 3% of the inventory as well.

The Category attribute in SMS is also termed the Criticality and is a reflection of the consequences of failure in each Control Structure to pipe end reach of entity. In the WRc Risk model, that Criticality is based on consequences of failure that are prioritized in terms of an Overall Cost Factor (OCF). Sewers and outfalls with an OCF of greater than 6.0 have the highest consequences of failure and are classified as Category A sewers, while sewers and outfalls with an OCF from 3.0 to 5.9 are classified as Category B sewers and sewers or outfalls with an OCF less than 3.0 are classified as Category C sewers. A number of outfalls in inventory were not assigned a criticality, however, during this project due to missing data. The inspection package was comprised of 41% of Category A outfalls at 119 locations having a distance of 7613m, 45% of Category B outfalls at 161 locations and a length of 8375m and 8% of Category C outfalls having a total distance of 1434m at 43 locations. 6% (1030m) at 26 outfall locations have an unknown criticality. The unknown outfalls include both aged and newly constructed sewers for all flow types that have not yet been classified for criticality due to missing GIS attributes.

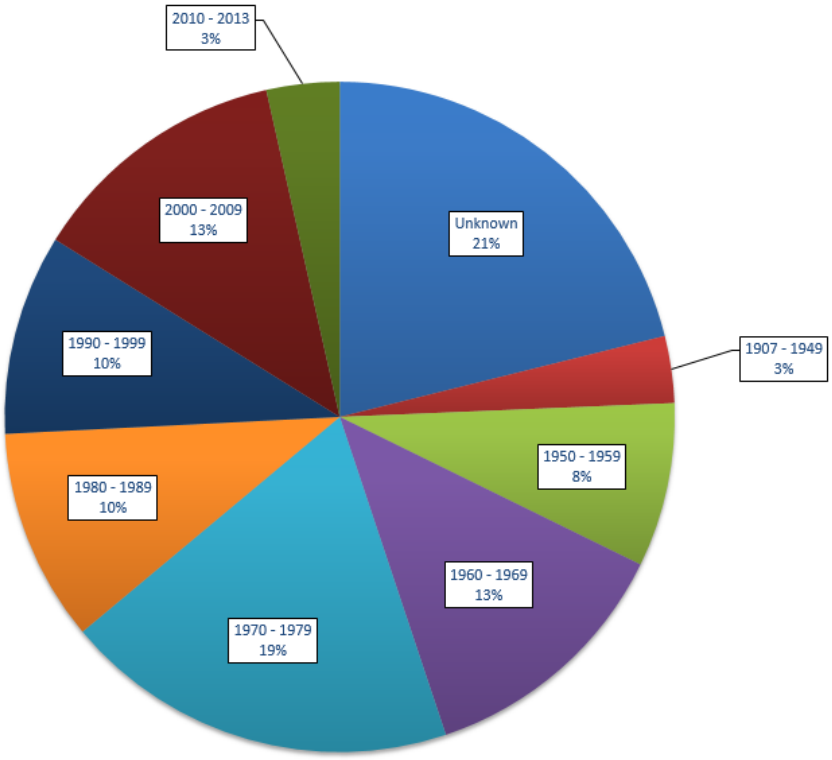

Figure 4: Installation Date by Decade (>1950)

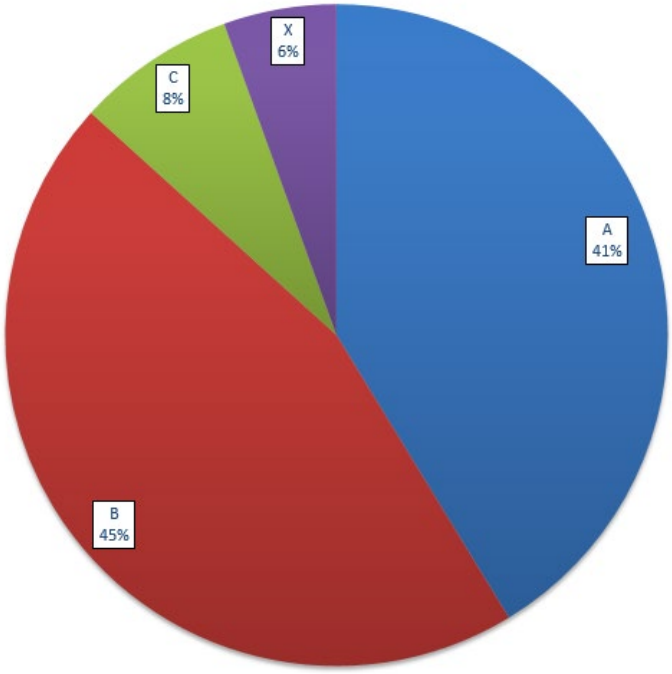

Figure 5: Criticality / Category

Size and material type can have a profound impact on the manner in which outfalls deteriorate. While in the collection system, flow type also has a profound effect; flow type effects are much less pronounced in outfall pipes. For example, conventional deterioration mechanisms that commonly occur in the WWS and CS inventory such as H_2S attack in concrete pipe are not common in outfalls due to the location of flow diversion structures, which isolate

them from raw wastewater flow streams. However, in colder climates, all flow types can be exposed to elevated chloride levels due to the widespread use of de-icing salts for road safety. Elevated de-icing salts can create a very corrosive environment in CSP/CMP and concrete pipes. Loss of invert as seen in Figure 6 is far more common in outfalls than it is in the collection system and as such has presented unique challenges for conventional inspection techniques.

The prevalence of larger diameter CSP/CMP in the inventory also requires scrutiny of its primary structural failure modes as it differs markedly from more conventional rigid materials in the collection system such as concrete or clay tile pipe.

Figure 6: CSP Internal Corrosion

Characterization of its defects with WRc codes requires that the reviewer must pay very close attention to the subtle buckling mechanisms that can govern failure in larger diameter CSP/CMP as standard coding of deflection alone can seriously overstate the severity of its condition state.

While WRc coding quantifies deflection correctly the standard scoring can elevate the initial assessment of the condition state of CSP severely at 5% to 10% deflection. The true risk of buckling failure at these deflection levels is often much less if the deflection is truly elliptical and no localized buckling features are present (e.g. reverse curvature does not usually occur until 20% deflection or more).

Structural failure in larger diameter CSP is more commonly caused by localized buckling modes rather than reversal of curvature due to over-deflection (see Figure 7). The practical ramifications of this are that the reviewer needs to carefully scrutinize both visual and dimensional features from the inspection and the CCTV/multi-sensor inspector can often benefit from additional CSP defect assessment training as it is rarely encountered in the collection system inventory.

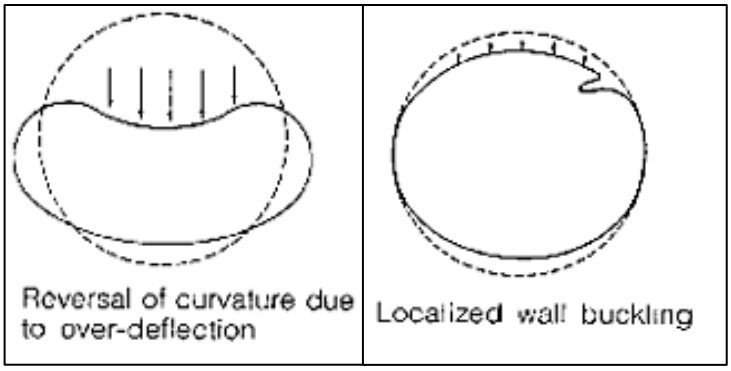

Figure 7: Flexible Pipe Failure Modes

The age distribution for material types is presented in Figure 2 and is unique, while much of the collection system in Winnipeg is approaching or in excess of 100 years old, the outfall inventory has a much younger age profile. This is due to the fact that many of the oldest outfalls have already been replaced on one or two occasions. It would appear that the average effective design life is much shorter than the collection system piping.

3. Unique Aspects of Outfall Systems

The primary objective of the program was to inspect the outfall pipe and its associated end treatment works to enable risk-based capital investment rehabilitation decisions for the outfall asset class and ultimately determine the sustainable funding level required to ensure maintenance of various levels of service.

Aside from their normal function, the outfall system in Winnipeg are also inherently part of the primary line of defense for flood protection and can become complex structures especially in CSO and emergency overflow configurations. A typical outfall system configuration is depicted in Figure 8 for a standard CSO or emergency overflow.

While the condition of the sewer network and control structures are assessed in other programs, the outfall condition assessment program includes the assessment of:

- All outfall piping from the control structure feature to the discharge point,
- All geotechnical slope conditions that could logically engage the pipe, the control structure and/or adjacent assets of significance (e.g. buildings, roads, etc.), and
- The outlet end section and toe erosion and/or discharge channel erosion control features.

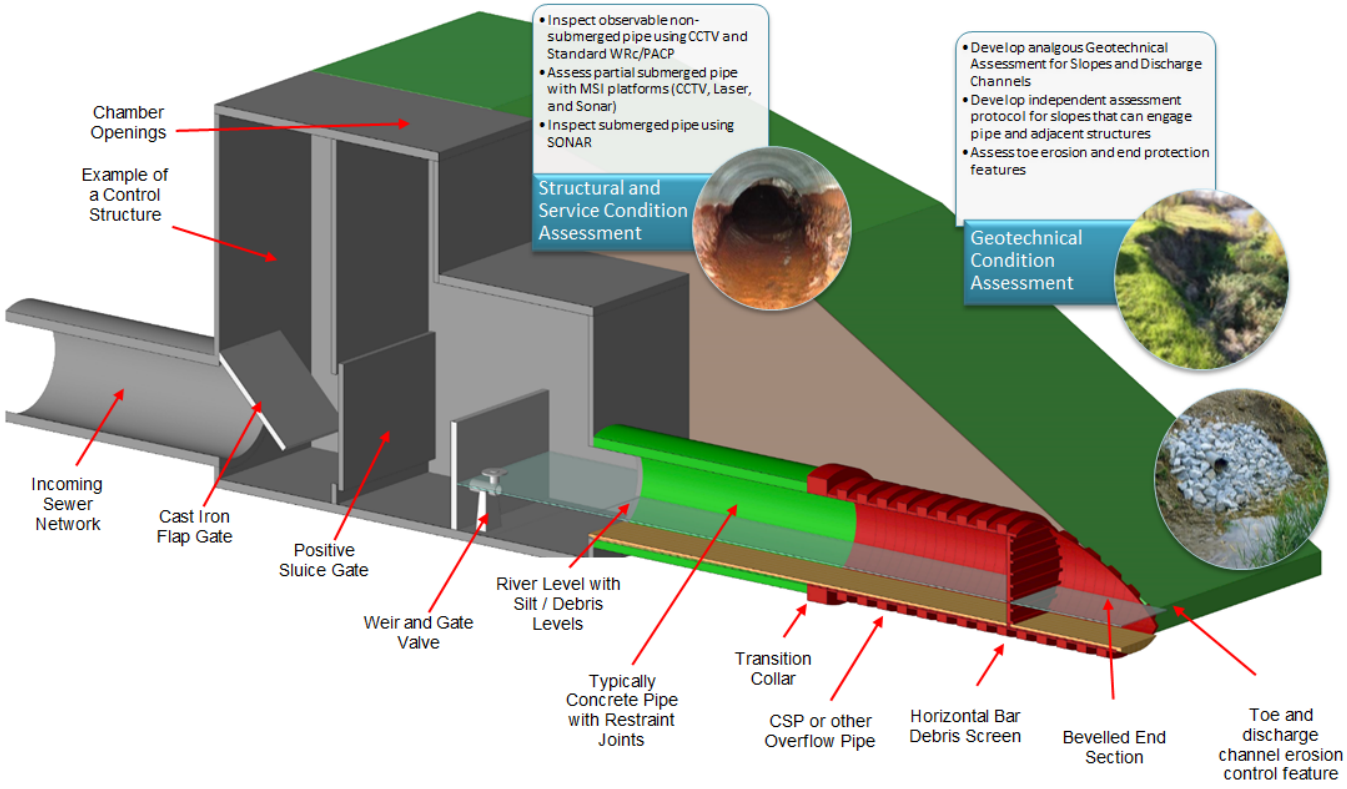

Figure 8: Typical Outfall System Configuration

As shown in Figure 8, outfall pipes can pose unique assessment challenges as the pipe condition is not necessarily governed by traditional pipe deterioration processes alone, such as internal pipe fabric breakdown or structural failures due to conventional pipe/soil interaction. Their condition can also be heavily influenced by more complex geotechnical processes such slope instabilities and end erosion that can engage the pipe in very irregular manners and initiate quite severe structural failure modes.

The river level can vary considerably which contributes to the challenge of rationalizing inspection type and timing. During winter conditions the river lowered to about 2.0 m lower than the long-term normal summer water level. As a frame of reference, the James Pumping Station Datum (JPSD) is approximately the winter low level value. As a datum, this is elevation 0.00, which corresponds to a geodetic elevation of 221.56 m. River level change is commonly referenced to the JPSD value. More recently, the summer water level has been increasingly affected by wet weather events and its 5 year average is about 3.5 m above JPSD. The spring freshet can be even more extreme with a moderate flood at elevations of 5.5 m and extreme events of 7.5 m or more above the JPSD. To match the correct pipe inspection technique to each outfall, therefore, needs to consider the elevation of the outfall, the range of river levels it sees and the appropriate timing and inspection platform for assessment.

4. Aligning River Level and Pipe Inspection Method

The seasonal variation in the river level played an important role in determining when and how the inspection of outfall piping would be carried out. The work program started with determining the relationship between outlet invert elevation and typical river levels which revealed that a significant variation from outfall to outfall existed as well as the seasonal variation that would be encountered. Some outfalls were only accessible during winter periods when the river level would be at its lowest, while other sites were still readily accessible during unusually high summer water levels.

The entire outfall network was analysed under various seasonal river constraints as noted in Figure 9, for the fall/winter river levels after fall drawdown.

From an inspection perspective, three primary inspection platforms were considered to match to the prevailing pipe outlet condition; conventional CCTV; Multi Sensor Instrumentation (MSI - Platforms with CCTV, Laser, and SONAR); and pure SONAR. From a logistical perspective, CCTV would be targeted at areas where visual access was readily achievable in an unsubmerged mode or at very low flow levels; MSI would be targeted where higher flow levels precluded good visual capture for the lower quadrants of the pipe and SONAR alone was used for fully submerged assets.

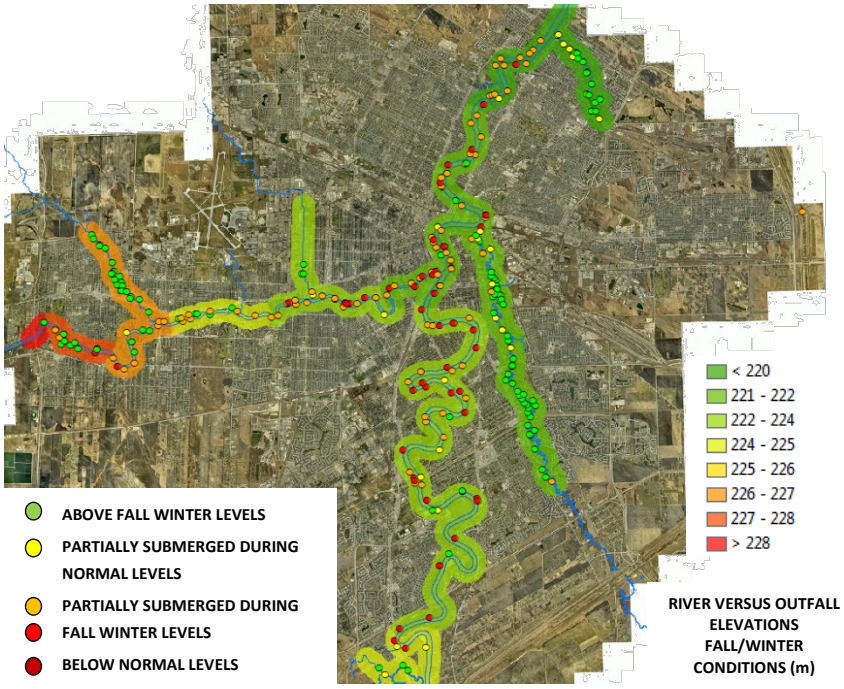

Figure 9: Outfall Accessibility During Fall/Winter River Levels

Planning started by utilizing a balance of known river levels based on seasonal variation and statistical norms for summer conditions. A spatial interpolation method (the Inverse Distance Weighted method) was subsequently used to relate these elevations to each specific outfall location. Three river level conditions were established for the system:

- The regulated fall/winter level (for post drawdown fall/winter operations);
- The long term Normal Summer Water Level (NSWL) (for long term normal summer conditions); and
- The June, 5-year frequency level (representing more extreme summer conditions experienced in recent years).

In addition to representing more extreme summer conditions from extended periods of wet weather, the June 5-year level was indicative of the higher river level trend that the City of Winnipeg has been experiencing over the last 20 years. The trend is variable but needed to be considered to maximize the number of sites that may still be accessible under higher river level summer conditions.

Each outfall was categorized in terms of the river levels that would logically be present at various times of the year. Many of these classifications were verified during the geotechnical survey which was conducted prior to the outfall pipe inspections.

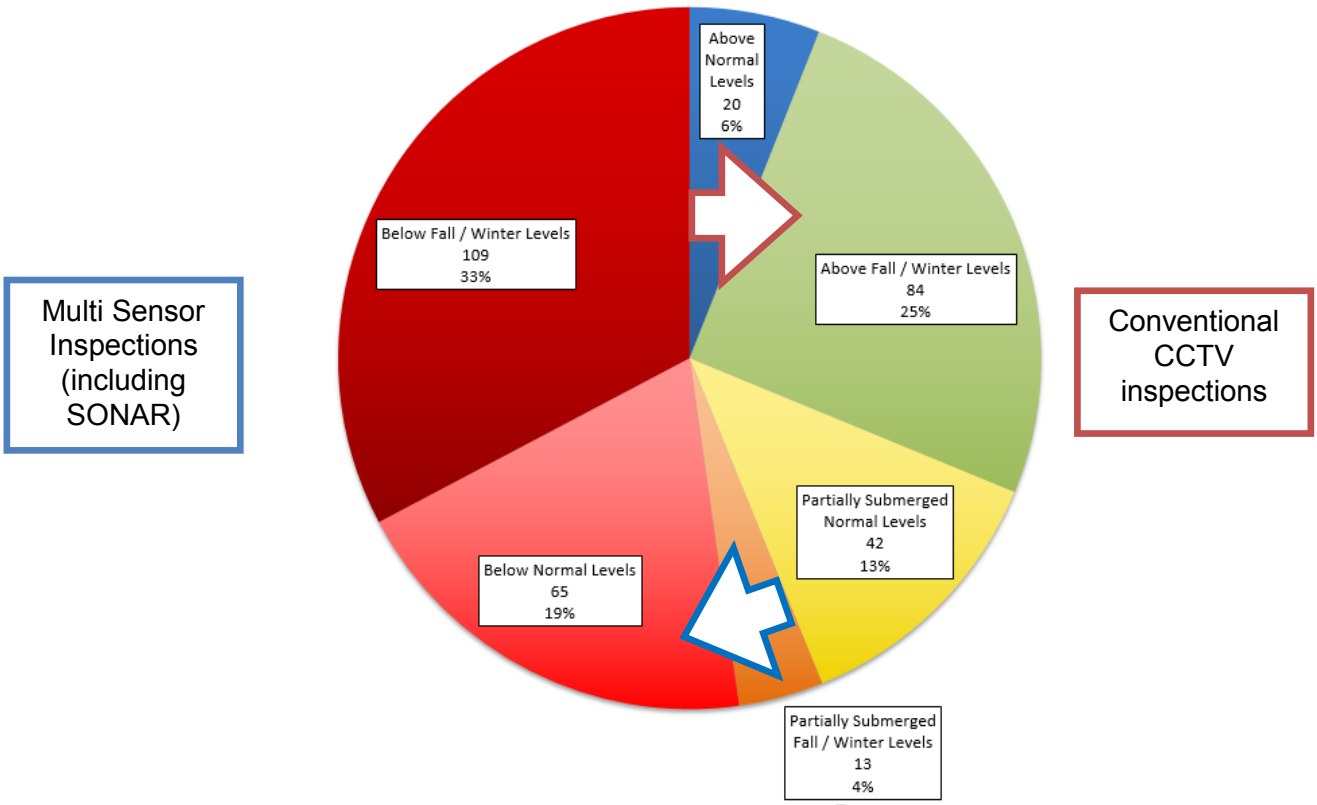

Figure 10: Pipe Inspection Approach Versus Outfall River Level Classification

5. Work Program Summary

The City awarded the Outfall Condition Assessment Program to AECOM on May 29, 2015 under Request for Proposal (RFP) No. 931-2014 to provide professional consulting services and contract administration for the inspection of approximately 362 outfall pipe segments. This would constitute 601 pipe segments that range in diameter from 200 mm to 3700 mm in height of varying material types totalling 22,319m of pipe that forms part of the City's sewer and storm relief system. Work would also include the analytical services from the resulting inspections in addition to geotechnical assessments for each outfall location.

Initially, the outfall inspection program was tendered as one program under Bid Opportunity 692-2015. Almost half of the outfalls were at risk of no visual CCTV inspections and were consequently re-allocated for Sonar Inspection work. The quantities were also broken out by diameter ranges and would be priced based on a greater than / less than 120m inspection distance trigger for pricing to recognise extra effort to complete full outfall inspections. The project schedule was subdivided into seasonal inspections based on Section 4's understanding of river levels. This program also introduced a cleaning component to provide a debris free channel within the pipe and help facilitate inspection. This created additional requirements; the use of non-chlorinated water for cleaning with a contaminated response plan to inhibit the introduction of siltation and contaminants into the river or watercourse to meet DFO-MPO requirements. Feedback from Contractors noted the risks associated with potential contamination and the costs to mitigate penalties by capturing sediments was a fundamental reason for not bidding on the work. The risk was considered too great and as such, the cleaning component was removed as part of an addendum. Furthermore, Contractors were challenged with the per meter rate and, irrespective of the <>120m trigger, found the risks associated to outfall inspections too great, wanting a per location payment unit rate instead. Consequently, the above noted Bid Opportunity received no bidders.

Further consultation with the City concluded the outfall inventory would be packaged into two Contracts based on matching inspection technologies to the prevailing river level condition (summarized in Figure 10: Pipe Inspection Approach Versus Outfall River Level Classification):

- 160 would be packaged into a relatively conventional CCTV contract, and
- 164 outfalls and 7 sewer segments would be packaged into a specialty contract that is largely MSI work with an anticipated limited number of SONAR only inspections.
- 29 had been removed from the internal inspection program, largely based on the results of the geotechnical inspections, which are discussed in Section 6.

The 160 conventional CCTV outfall inspections were added to the City's annual Sewer Inspection Contract, under Bid Opportunity 232-2016 that was in addition to the 154 km of sewer inspections. This bid opportunity is similar to previous cleaning and televising contracts of late, was summarised in the 2016 Sewer Condition Assessment Bid Opportunity 232-2016 report, and will not be discussed in further detail. The portion of outfall inspections was awarded to Uni-Jet Industrial Pipe Ltd (Uni-Jet) on May 19, 2016 (Letter of Award) with work commencing on May 30, 2016.

For the MSI package, a separate Contractors Bid, Bid Opportunity 420-2016 was tendered but was reissued as a service Bid Opportunity, 558-2016 to remove the bond requirements that imposed substantial insurance conditions that would potentially exclude small businesses from bidding. This portion of outfall inspections was awarded to AquaCoustic Remote Technologies (AquaCoustic) on August 12, 2016 (Letter of Award) however, work commenced on October 12, 2016.

Both Contracts are represented in Figure 11 and Figure 12.

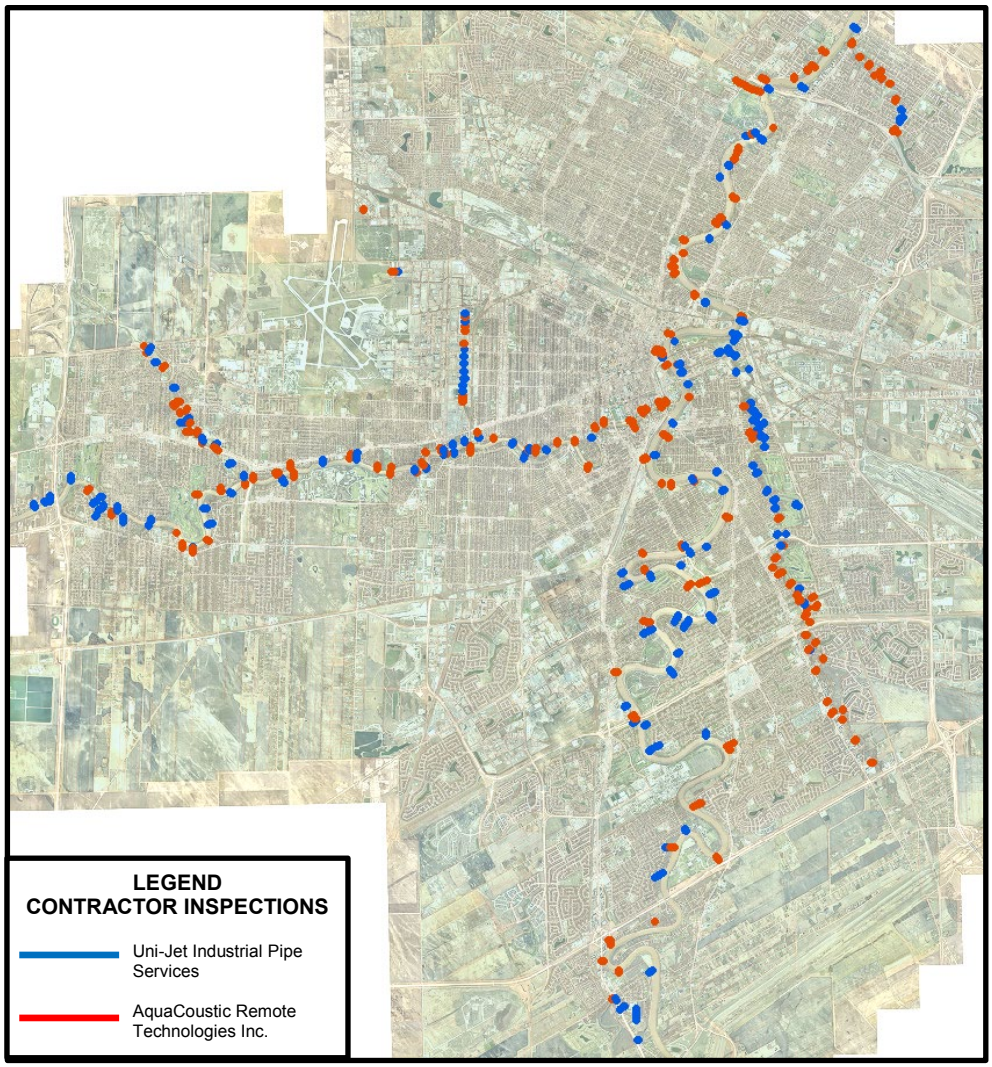

Figure 11: Assignment of Outfall Inspections by Contractor

As water and debris levels are highly variable in the outfalls, the MSI platforms needed to contemplate a wide variety of equipment setups to optimize data capture and inspection effectiveness. Based on the detailed understanding of prevailing river level conditions, much of the equipment selection process and proposed set up could be done in desktop exercises prior to mobilization to specific sites. Equipment setups included floatation, submersible and tracked platforms (see Figure 12) were equipped with high resolution CCTV, Time of Flight laser, SONAR, and inertial guidance systems in their setup.

Figure 12: Tracked, Submersible and Float Propelled MSI Platforms

The use of MSI platforms in areas where pure visual classification methods were compromised, allowed for the assessment to incorporate some innovative post-processing of laser and SONAR point cloud data. This enabled the detection of very subtle defects in CSP in sections where CCTV imagery alone rendered some assessments inconclusive. Reverse image point clouds, for example (see Figure 13) provided unique perspectives in both circumferential and axial directions.

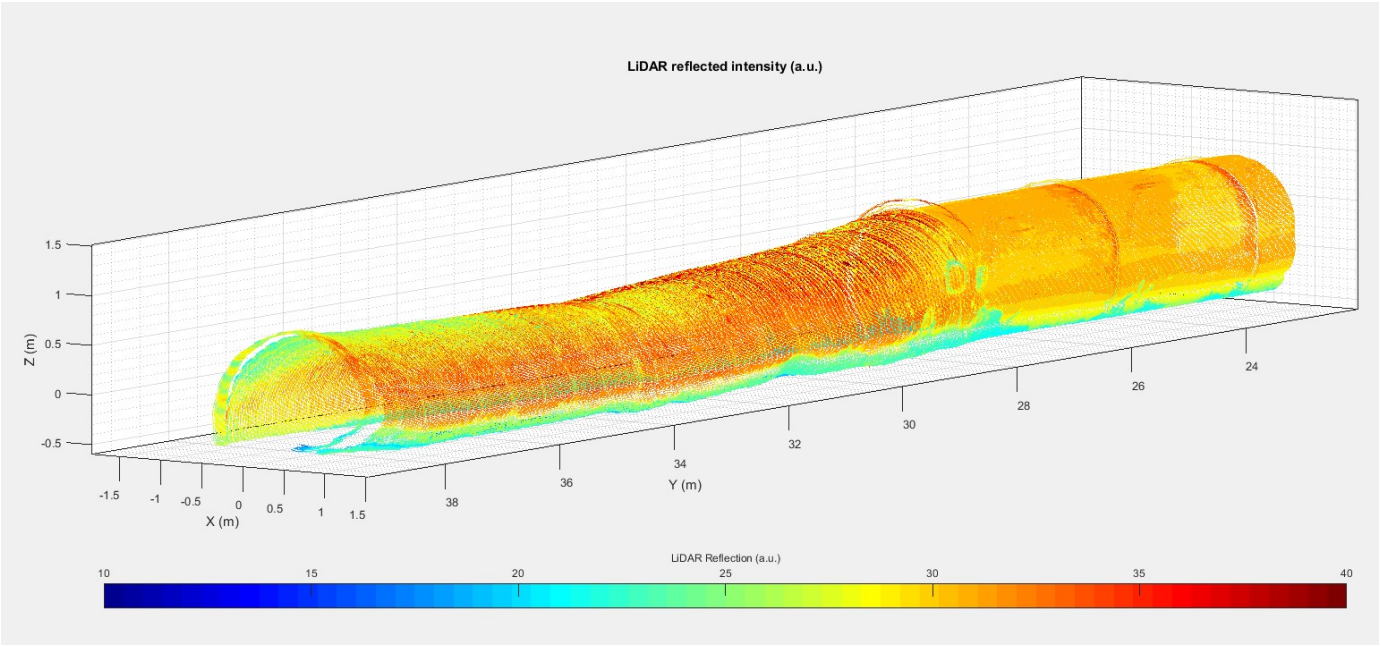

Figure 13: Inverse Point Cloud Imagery at a Concrete to CSP Transition

For the conventional CCTV inspection program, further emphasis on access to restricted outfall pipes introduced specifications for man entry using hand held waterproof “Go Pro” © or alternative cameras that would be waterproof using intrinsically safe lighting to facilitate similar inspections but with tape measurements or paint sprayed chainage distances for defect positioning. This method of inspection was not employed by Uni-Jet as inspections were achieved using conventional CCTV equipment and where survey abandonment was experienced, man-entry was not possible.

5.1 Summary of Inspections

5.1.1 Uni-Jet

The Contractor, Uni-Jet, attempted to inspect a total 207 entities having a total tender inspection distance of 8,833m during the course of the outfall inspection program where additional entities were discovered or merged as GIS corrections or an introduced sewer segment entity to the program as a means of access to the outfall pipe. Of the 207 entities, 7 were finally merged with other adjoining outfall assets while 12 other outfall entities were removed by the City leaving 188 entities for inspection and assessment.

The 188 segments were inspected between the months of October 2016 and March 2017 totalling 6,592m of inspection where 94 outfalls achieved full inspection. 28 entities were survey abandoned though the Contract was arranged such that an incomplete inspection with CCTV footage would correctly document the survey abandonment having a pay item to discern reasoning and allow limited but credible condition assessment.

Table 2: Inspections Attempt Period

Inspected Date	Inspection Type			
	ADDITIONAL	OUTFALL	UPSTREAM	Grand Total
October 2016		3		3
November 2016	15	62		77
January 2017	8	24	4	36
February 2017	4	52	7	63
March 2017	2	7		9
Grand Total	**29**	**148**	**11**	**188**

Table 3: Inspection Percentage Completion by Distance in Meters and (Segment Count)

Inspection Type	0%		1 to 19%		20 to 39%		40 to 59%		60 to 79%		80 to 99%		100%		Grand Total	
ADDITIONAL	0.0	(5)									43.5	(1)	783.4	(23)	826.9	29
OUTFALL CCTV	0.0	(23)	23.3	(2)	214.0	(6)	333.7	(10)	624.5	(15)	1,568.8	(31)	2,372.6	(61)	5,136.9	148
UPSTREAM CCTV											73.0	(1)	555.2	(10)	628.2	11
Grand Total	**0.0**	**(28)**	**23.3**	**(2)**	**214.0**	**(6)**	**333.7**	**(10)**	**624.5**	**(15)**	**1,685.3**	**(33)**	**3,711.2**	**(94)**	**6,592.0**	**188**

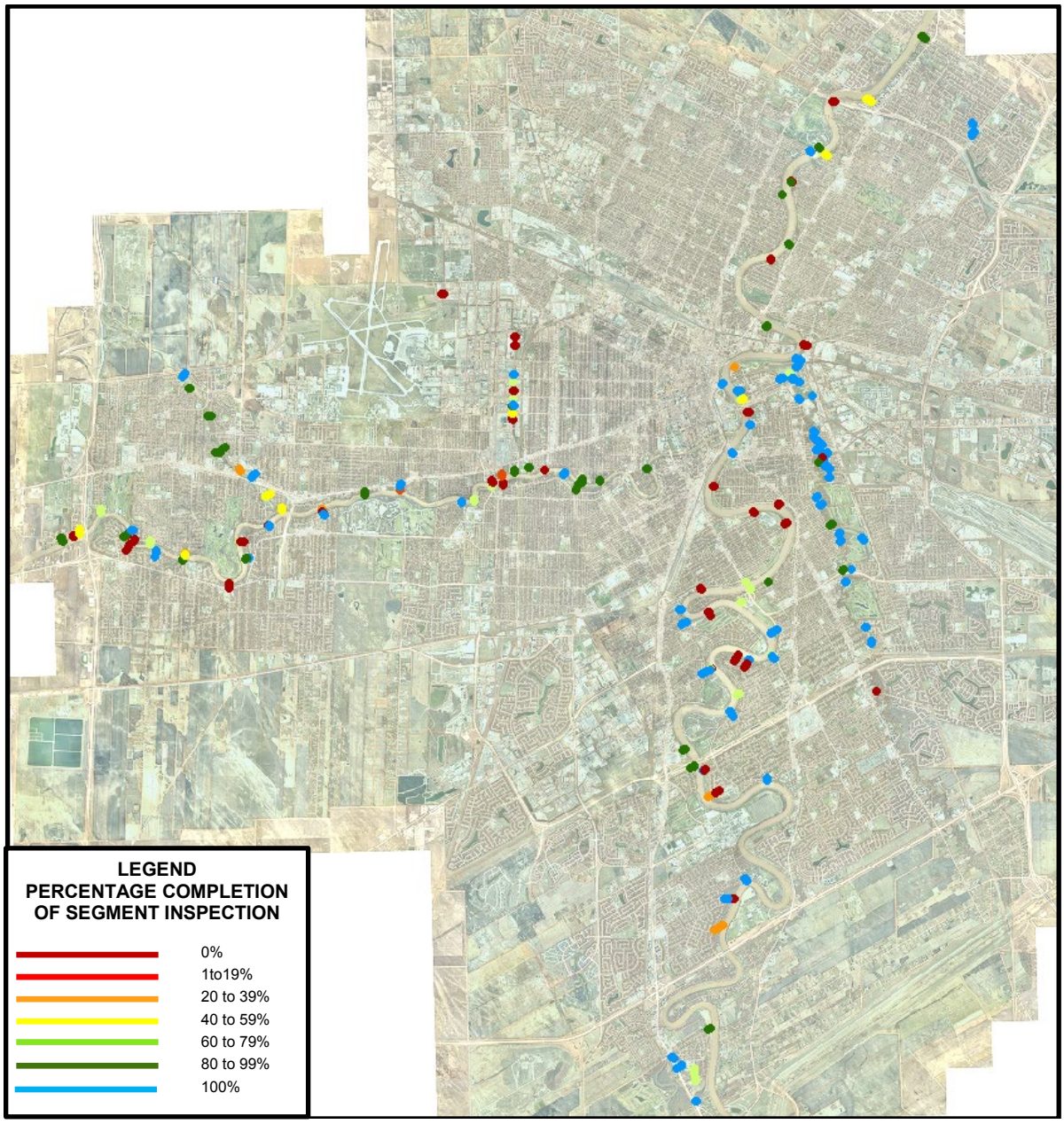

Figure 14: Uni-Jet Percentage Completion of Outfall Segments

5.1.2 AquaCoustic

The Contractor, AquaCoustic, attempted to inspect 173 pipe segments however, through GIS correction due to segment separation, this increased to 177 entities. A total inspection distance of 9,698m would be attempted however, 8 outfalls were removed by the City due to abandonment or safety concerns relating to working at height as access points at pump stations were elevated. A further 6 entities were added bringing the total number of pipe segments to 175. The additional entities totalled 432m of pipe.

The 175 segments were inspected between the months of October 2016 and March 2017 having a distance of 5,387m of inspection where 94 outfalls achieved full inspection. For the remaining inspections, AquaCoustic suffered survey abandonment due high levels of siltation and saw significant site-specific quantity variations, disproportionate to the level of effort required to be expended on a site-by-site basis. Schedule slipped and liquidated damages were incurred. A Change Order was requested and implemented. CO#1 changed the work arrangement to reflect logistic access and meterage uncertainties but did not change the overall Contract Price. A change in the method of measurement for inspection on a site-specific basis was made, from unit price and estimated quantity, to a unit rate

basis per site with the unit rates determined by the original Bid total amount for each site (i.e. the original unit rates multiplied by the original estimated quantity values). AquaCoustic's returned in the summer to complete the inspections prior to the adjusted Substantial date having stringent contract administration allowing for the review and acceptance of survey abandonment with subsequent per site payment or inspection re-attempts using other types of inspection technologies and equipment.

Table 4: Inspections Attempt Period

Inspected Date	Inspection Type		
	ADDITIONAL	MSI	Grand Total
October 2016	1	26	27
November 2016	2	27	29
December 2016		3	3
August 2017	1	69	70
September 2017	2	44	46
Grand Total	**6**	**169**	**175**

Table 5: Inspection Percentage Completion by Distance in Meters and (Segment Count)

Inspection Type	0%		1 to 19%		20 to 39%		40 to 59%		60 to 79%		80 to 99%		100%		Grand Total	
ADDITIONAL											441.23	(5)	20.74	(1)	461.97	(6)
MSI	5.36	(5)	116.38	(43)	135.00	(8)	733.37	(22)	762.38	(18)	2,075.69	(47)	1096.62	(26)	4,924.80	(169)
Grand Total	**5.36**	**(5)**	**116.38**	**(43)**	**135.00**	**(8)**	**733.37**	**(22)**	**762.38**	**(18)**	**2,516.92**	**(52)**	**1,117.36**	**(27)**	**5,386.77**	**(175)**

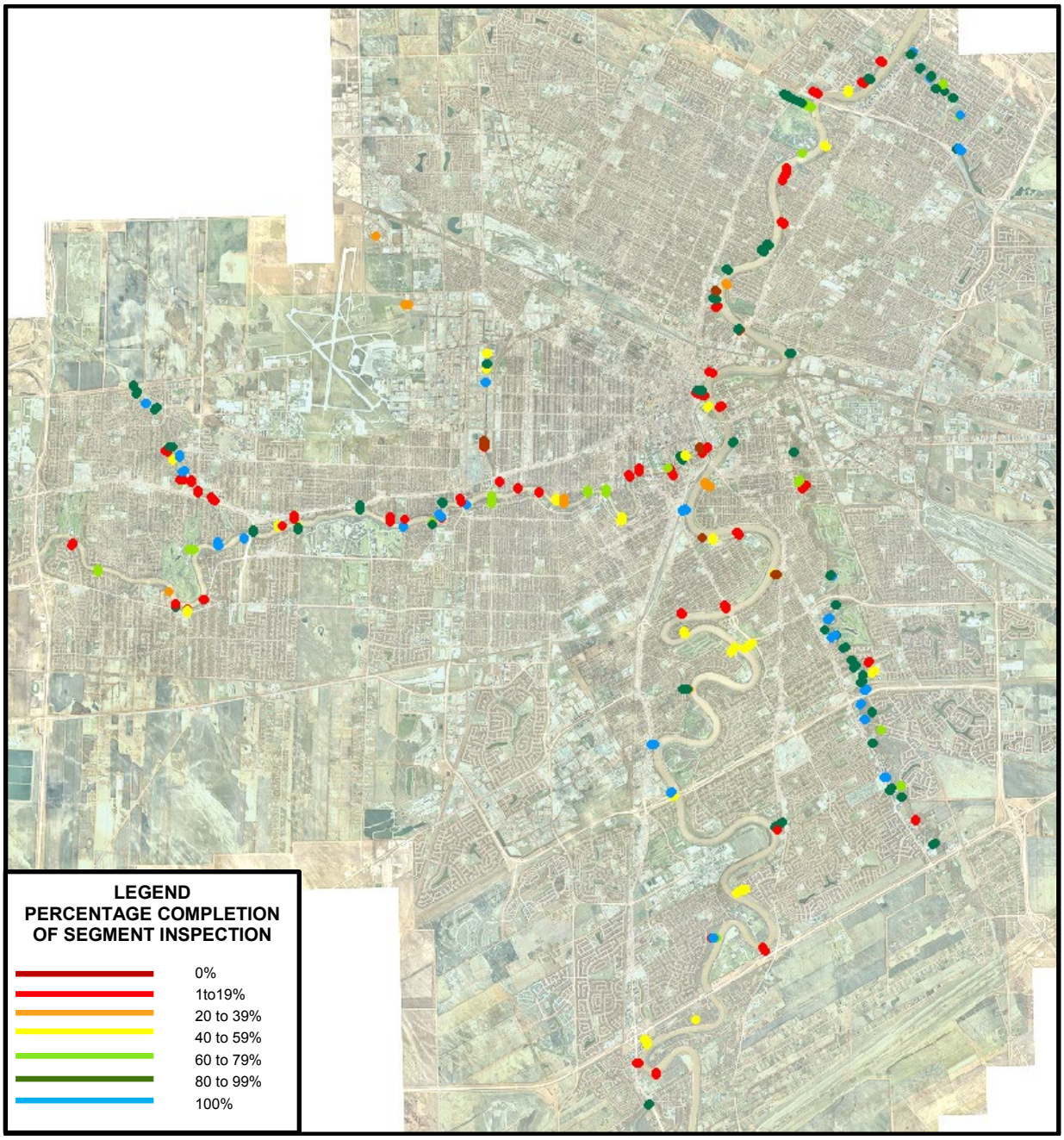

Figure 15: AquaCoustic Percentage Completion of Outfall Segments

5.2 Causes for Incomplete Inspections

For all 363 outfall and associated sewer inspections, 99 outfalls were survey abandoned of varying distances where debris levels impeded travel for the multitude of inspection equipment. Table 6 identifies the number of outfalls that experienced debris levels for both Contractors where the debris percentage level were recorded at point of survey abandonment but not necessarily the maximum debris level likely to exist within the uninspected portion of the pipe segment. Table 7 correlates the level of debris encountered and the percentage of pipe segment inspection. Inspection success was based on a number of factors such as environmental (frozen water / debris), distance of debris first encountered, equipment choice to Contractors level of effort. Figure 18 provides spatial reference to the debris where assets MA60003875 (DWG194), MA70023285 (DWG 265) saw immediate 90% siltation levels. Assets MA60021687,MA70022370 (both on DWG 172) and MA00017914 (DWG 328) recorded 100% debris levels. Debris was the predominant cause for survey abandonment though not the only reason; timber wall plate and column structural supports placed within multiple corrugated metal pipes in efforts to mitigate pipe failure inhibited full

inspections. Furthermore, access to many of the control structures that are connected to the flood defense pump stations were restricted in access size and elevated 2 to 3m above finish floor level which presented health and safety concerns and were survey abandoned if deemed too dangerous to attempt inspection. Hiab lifting arms were used by the City and Contractors to lift the heavy camera rigs into position but for a number of locations, no fall and arrest hooks or railings existed at the elevated access point that meant survey abandonment due to further health and safety implications. These restricted locations have been spatially referenced within Figure 19 in addition to assets removed from the Contracts by the City.

Table 6: Survey Abandonment Due to Debris

Debris Levels (%) at SA	Contractor		Grand Total
	AQC	Uni-Jet	
5	5	5	10
10	19	2	21
15	3	1	4
20	11	8	19
25	5	1	6
30	7	4	11
40	5	2	7
50	4	4	8
60	1		1
65	1		1
70	6		6
75	1		1
90	1	1	2
100	2		2
Grand Total	**71**	**28**	**99**

Table 7: Inspection Percentage Completion Attained Based on Debris Levels Encountered

Debris Levels (%)	Outfall Pipe Segment Percentage Completion												
/	100%	90 - 99%	80 - 89%	70 - 79%	60 - 69%	50 - 59%	40 - 49%	30 - 39%	20 - 29%	10 - 19%	1 - 9%	0%	Total
5				4	1	1		1		1	2		10
10	1	2	2	1	3	3	3		1	1	2	2	21
15			1			1	1				1		4
20	1			2	3	2	3	2	1	1	3	1	19
25		1		1	2						2		6
30		1	1	2	1	1	1				2	2	11
40					1	2	1				2	1	7
50			2			1		2			1	2	8
60			1										1
65											1		1
70			1		1		1				3		6
75									1				1
90							1					1	2
100											2		2
Grand Total	**2**	**4**	**8**	**10**	**12**	**11**	**11**	**5**	**3**	**3**	**21**	**9**	**99**

Figure 16: Atypical Outfall Pipes Having Sufficient Debris to Cause Survey Abandonment

Figure 17: Working at Height and Access Issues

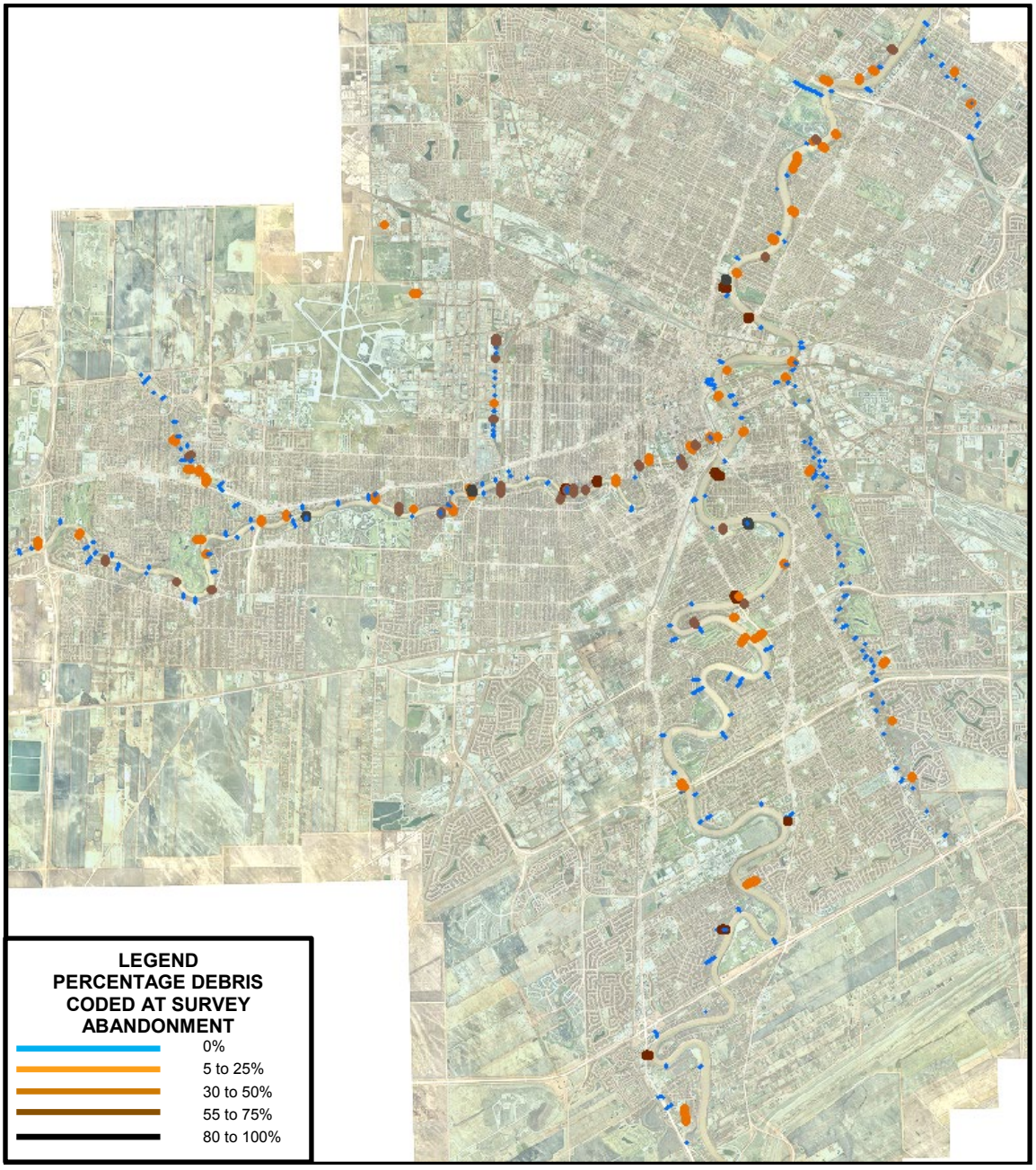

Figure 18: Debris Levels Experienced Within Outfall and Associated Sewer Segments

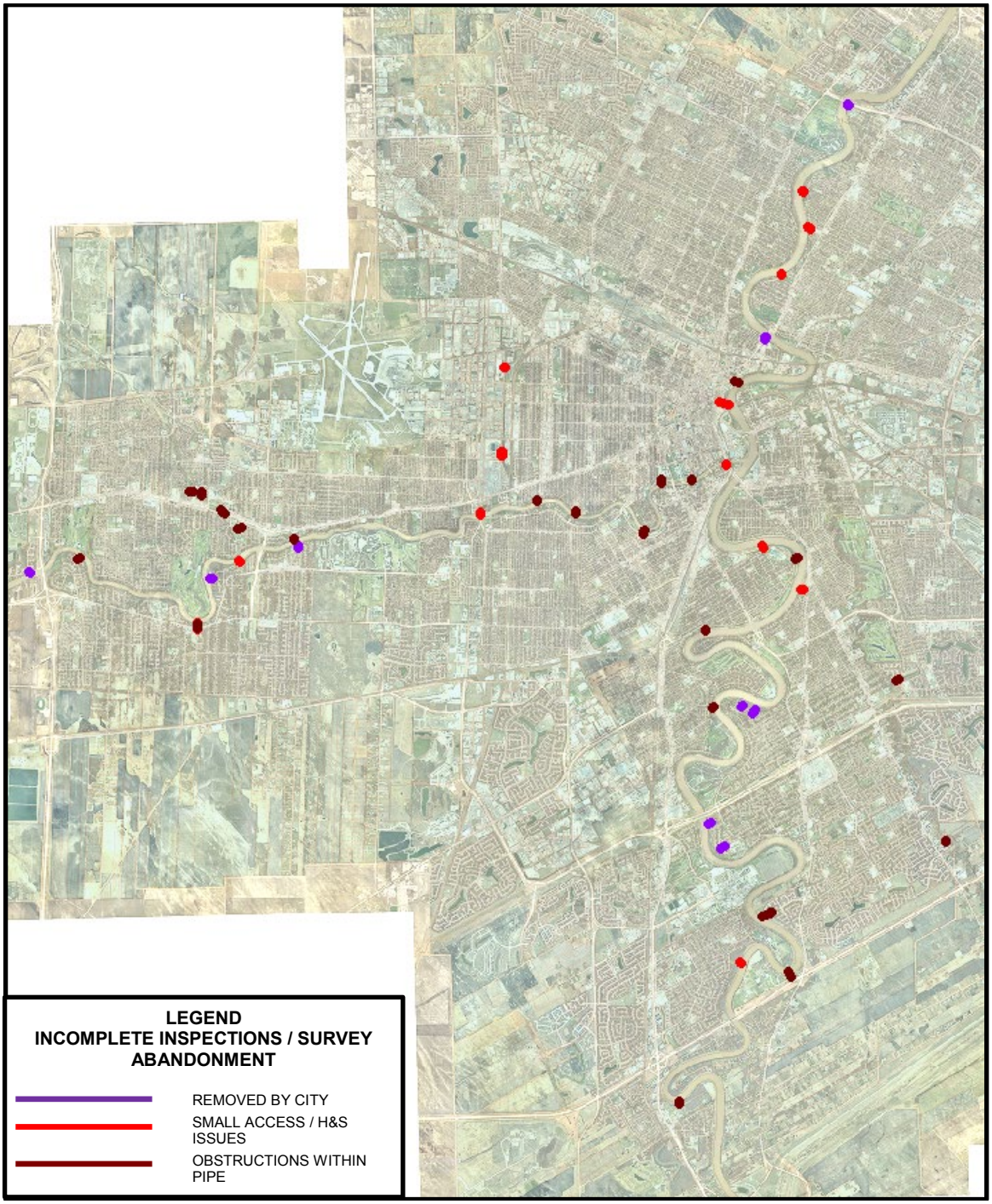

Figure 19: Incomplete Inspections, Survey Abandonments or Removed from Contract by the City

Other reasons for survey abandonment saw 2 outfalls having closed valves to protect the sewer network from river levels, a further 22 outfall entities saw survey abandonment due to additional obstructions such as concrete blocks or dislodged slivers of concrete from previous invert repairs, ice levels and finally pipe structural defects, where pipe separation from ground movement caused open joints. A number of outfalls saw excessive deterioration of the invert further compounded by raccoon nesting within the holes.

Figure 20: Open Joint / Pipe Separation

Figure 21: Concreted at 0.0m at MA70016043

Figure 22: Raccoon Nesting Within Degraded CMP Outfalls

Furthermore, a number of outfalls had been survey abandoned as the asset was deemed abandoned such as MA70016043 where the chamber to pipe interface had been concreted over.

Figure 23: Missing invert within CMP

6. Geotechnical Assessment – Data Capture and Assessment Methodology

The geotechnical assessment was carried out in a staged manner that included a robust desktop assessment followed by detailed site specific inspection visits to assess slope stability and end treatment condition.

With the availability of detailed digital elevation data along the river bank embankments (LiDAR data) that was provided by the City, the desktop assessment included a review of the topography at each site to quantify the steepness of banks and the potential for bank instability.

ESRI GIS software was applied to create a thematic map of bank steepness both on the river and dike slopes at the outfalls. This allowed areas with steep banks to be highlighted for review in greater detail in the field. A sample ground slope map illustrates and helps quantify the embankment steepness thus locations with more severe embankment erosion enabled the creation of unique site specific inspection plans for each and every outfall.

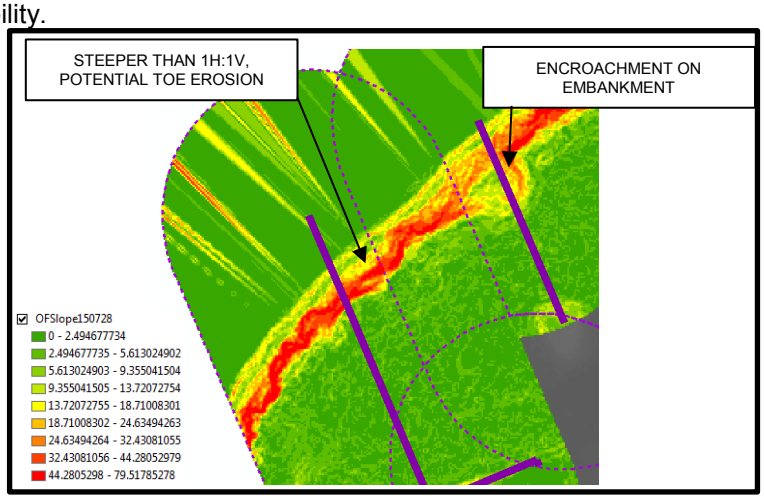

Figure 24: Ground Slope Map

Field inspection data was collected using an iPad fitted with custom designed digital forms in an 'on-the-fly" GIS format that allowed for direct input of attributes along with mapped, spatially accurate inspection features (Figure 25). This facilitated a standardized data capture that would allow for future comparison over time to review instances of progressive bank movement.

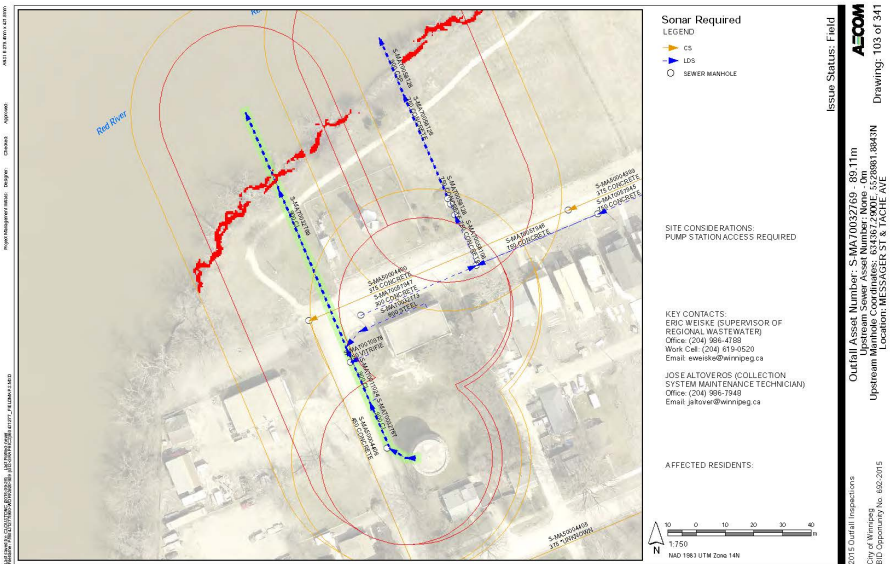

Figure 25: Geotechnical Investigation Drawings

Pulldown fields populated on the iPad were pre-loaded, to as great a degree as possible, with information such as riverbank height and inclination (based on LiDAR data) and most probable soil types in terms of alluvial versus lacustrine soils. Features that were unique at each location were mapped with points in the iPad data collection PDF map and populated with relevant attribute data at that point. Attributes pertaining to riverbank condition were recorded noting signs of instability, scarps, toe bulging, tension cracks, settlement, seepage, etc. Typical erosion observations included global erosion, gulley or toe erosion local to the outfall pipe. Other attributes included slope inclination, visible infrastructure and its condition, vegetation etc.

This information was used to rate the condition of the riverbank in terms of its potential to damage the outfall pipe or outfall structure. A 1 to 5 condition assessment grade was assigned to each site in a manner directly analogous to WRc condition grading protocol. WRc protocol includes both structural (defects that impact structural stability in a sewer) and service (defects that impair a sewer's function) condition grades. Defect ratings in WRc protocol are used to generate capital upgrading requirements (largely based on structural grades) and O&M related work (largely based on service grades).

Similarly, the geotechnical rating system included an assessment of general slope failure potential, known as the Slope Condition Grade (SCG); and a rating for erosion known as the Erosion Condition Grade (ECG). The SCG is directly analogous to structural grades in the pipe assessment protocol as they relate to slope conditions that could engage the pipe and cause structural failures. The ECG ratings are analogous to the pipe's service ratings as their impact on the pipe drives treatments that are more operation and maintenance related as opposed to larger capital program works. While the ECG and SCG rating systems are closely aligned, an illustrative example of the rationale for SCG ratings included consideration of:

- A bank actively failing was considered to have a factor of safety against bank failure of unity by definition and given an SCG of 5.
- A bank that exhibited small bank displacements consistent with creep movement or from smaller slip movements was assigned an SCG of 4.
- SCG's of 1 to 3 where illustrative of stable banks at time of inspection. An SCG of 3 indicated that there was potential for river bank displacement if toe erosion of the bank was not addressed. While the bank was stable, its condition was directly analogous to the implication of a WRc SPG 3 for the pipe, which means *"Collapse unlikely in the near future but further deterioration likely".*

The SCG rating system is summarized in Table 8 below in terms of the risk of failure and implications of each rating value.

Table 8: Illustrative Geotechnical Riverbank Slope Condition Assessment Rating System

SCG Value	SHORT DESCRIPTION RISK OF FAILURE	IMPLICATIONS
1	Minimal	No past or present evidence of bank instability. Slope inclination is a small angle or relatively flat. Shoreline is protected against erosion either with well-established vegetation or rip rap.
2	Low	No past or present evidence of bank instability. Slope inclination is between a small angle to moderately steep. Shoreline is not protected against erosion.
3	Moderate	Erosion at river bank toe may lead to progressive lower bank failure in the future. If left unchecked may lead to upper slope failure in the distant future or with extreme changes in groundwater / river conditions. Slope is moderately steep.
4	High	Evidence of small displacements from the recent past. Past failure evident with major global features. Progressive creep displacements. Severe erosion leading to potential failure in the near future. Slope is steep with greater potential for instability.
5	Presently Failing or At Risk of Imminent Failure	Evidence of active displacement. Exposed fresh soil at scarp face. Fine detail of attenuating tension cracks evident. Vegetation freshly cut or displaced with roots exposed or severed.

Three treatments were created and agreed with the City to be incorporated within SMS to align with the geotechnical rating system including Erosion Control, Slope Regrading and Slope Stabilization.

6.1.1 Erosion Control

Erosion control stems the loss of riverbank soil particularly at the toe of a riverbank. Prolonged erosion of the riverbank toe can result in loss of overall riverbank support and slope instability. Erosion control more frequently consists of armoring with rip rap (large diameter rock called boulders). Boulder size is dependent on the strength of wave action to dislodge material. Rip rap is underlain with non-woven geotextile as a filter medium to prevent loss of the finer riverbank soil from beneath the rip. Rip rap should typically extend to a height of about ±1m above and below the normal summer water level but the height may be dependent on other parameters. The rip rap should extend along the river length for a distance approximately equal to a 45-degree projection from the location of the outfall piping at the crest of the riverbank to the riverbank toe. Erosion protection guards against wave action due to river flow and outfall flow at the outlet.

6.1.2 Slope Regrading

Slope regrading improves overall riverbank stability by offloading the upper bank through soil removal and, as required, placing soil along the toe of the riverbank. Soil along the upper bank imparts a destabilizing force while soil along the toe imparts a stabilizing force. A balance point lies at a boundary between these two conditions somewhere near the mid slope of a riverbank profile. Slope regrading is generally one of the more cost effective stabilization options. Erosion control also forms part of the final work for slope regrading.

6.1.3 Slope Stabilization

Slope stabilization refers to more invasive types of erosion protection such as installation of rock columns or shear keys. These methods are based on the premise of removing a proportion of the weaker (failing) clay and replacing it with stronger compacted limestone rock fill that intersects the failure plane in the riverbank. Rock columns involve drilling large diameter shafts (typically about 2.4m diameter) backfilling with limestone rock fill and compacting with vibratory equipment. Shear keys involve excavation of soil at the riverbank toe, placing limestone rock fill, and compacting. Rock columns generally involve less risk of overall riverbank stabilization during construction owing to the relatively smaller amount of soil removal at any one time compared to shear key construction. Both methods can be very expensive. Erosion control also forms part of the final work for slope stabilization.

A summary of ECG and SCG condition grades are shown n Figure 26 below.

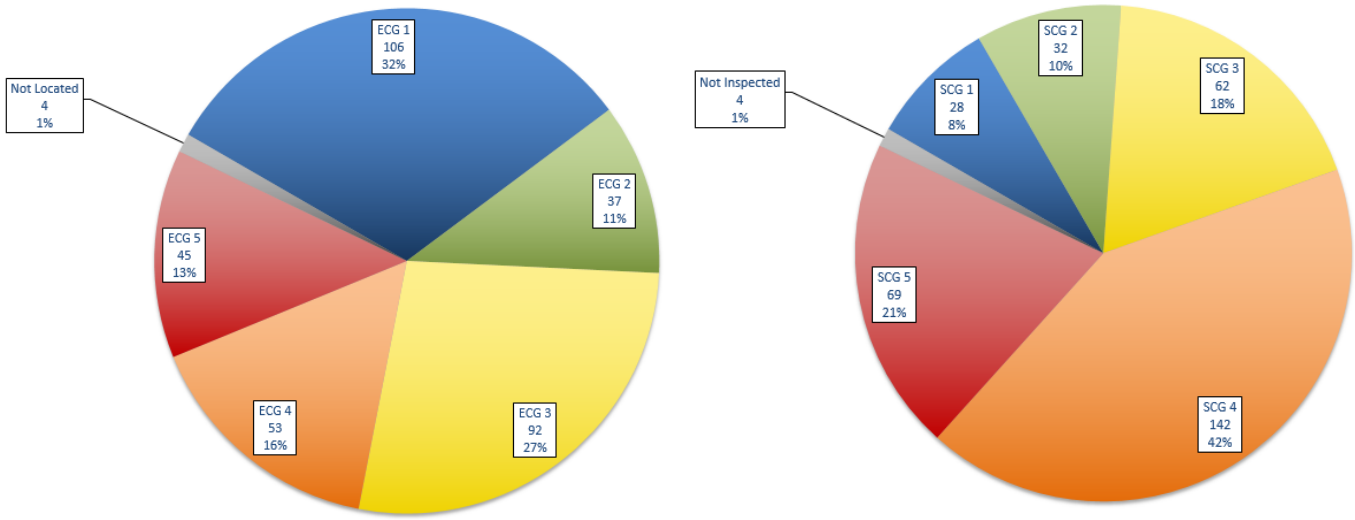

Figure 26: Summary of ECG and SCG Ratings

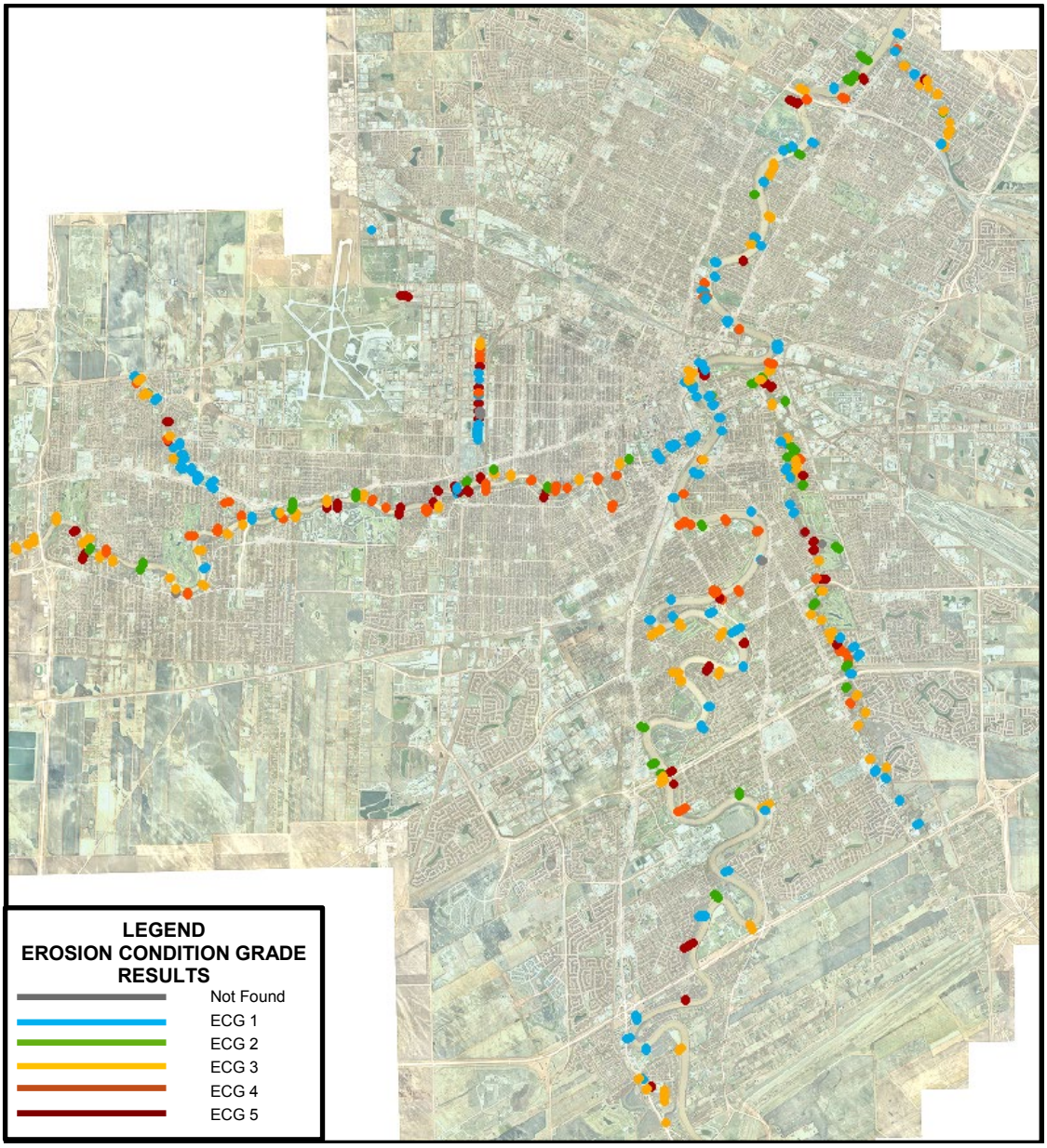

Figure 27: Spatial Representation of All Outfall Erosion Condition Grades

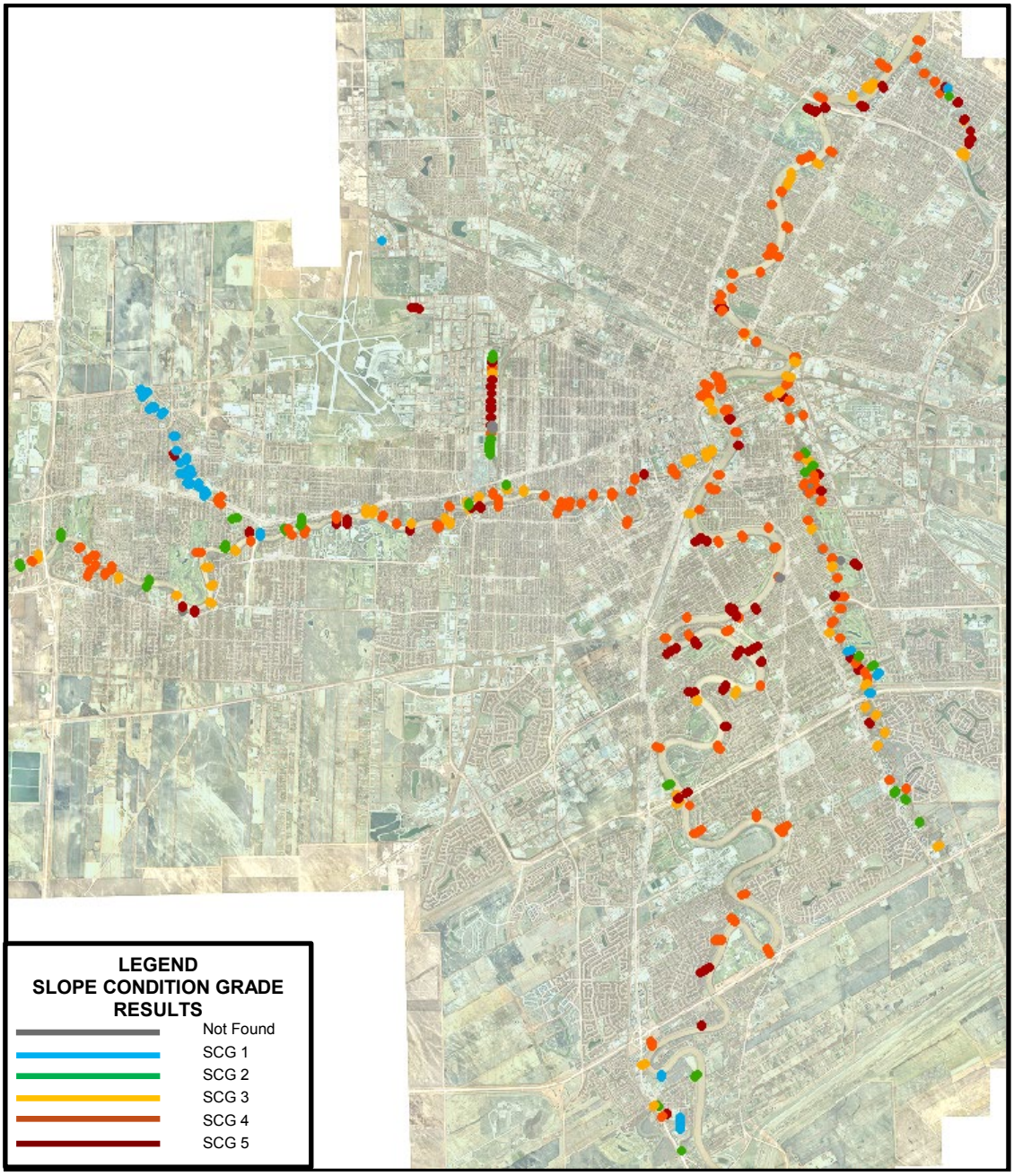

Figure 28: Spatial Representation of All Outfall Slope Condition Grades

The geotechnical survey was completed over an 8-week period in the fall of 2015. The fall window for the geotechnical inspections was chosen to maximize the visual data capture at lower river levels but prior to snow cover being present that would obscure proper visual classification of conditions.

The inventory results are summarized in Figure 26 where 42% of the inventory exhibits a slope condition grade of 4 while 21% exhibits a slope experiencing incipient failure having a SCG of 5. The geotechnical inspections occurred prior to any internal pipe inspections. While this was more inadvertent than by plan (due to the complexity of preparing and resubmitting pipe inspection contracts), there were a number of direct benefits associated with the work being carried out in this manner:

- It improved the planning of the pipe inspection works (inspection platform selection, site access logistics, etc.).
- Some sites were identified with serious instabilities that warranted immediate attention. This enabled risk-based capital rehabilitation programming without further detailed pipe assessment which reduced the number of pipe

inspections required (i.e. the visual evidence of damage to the pipes was evident to a sufficient degree to conclude no internal pipe inspection was required). This reduced the size of the pipe inspection program by 29 sites.

- Knowledge of sites with slope instabilities provided valuable insight to improve the focus of data capture priorities for internal pipe inspections.

Site investigations and findings were summarised onto “Asset Cards” that provided all geotechnical conditions within a 30m influence of each outfall and were provided to the City for reference purposes and will be provided as an electronic submittal to accompany this report.

7. Integration of Geotechnical and Pipe Condition Assessment Output

The assessment process requires an integration of both the pipe and the geotechnical assessment processes. The approach for collection system assessment in Winnipeg was developed based on the 3rd Edition of the WRc's Sewerage Rehabilitation Manual (SRM), which since 2007 has been renamed the Sewerage Risk Manual, to better reflect the Risk Based Process that is embodied in the approach.

Given that a primary overall objective for the Program was *"to enable risk-based capital investment rehabilitation decisions for the outfall asset class…"*; integration of the two assessment aspects of the program needed to consider a number of factors:

- Both assessment methods needed to be risk-based with a common value output for computed risk.
- The consequence side of the equation was easily aligned as the consequence of failure was for the same asset and was, by definition, equal.
- The probability of failure for each condition grade was aligned by focusing on the implications of each grade and ensuring agreement in principle. This was accomplished by aligning the implications of each grade using the raw implications stated in WRc grading methodology, where:
  - Grade 1 – No defects – no short term deterioration likely.
  - Grade 2 – Defects present, further deterioration likely but over the longer term.
  - Grade 3 – Defects present with minimal likelihood for short term failure but further deterioration is highly likely in short term.
  - Grade 4 – Failure likely in the short term.
  - Grade 5 – Failed or in a state of incipient failure.
- The raw WRc methodology offer two distinct benefits in this regard:
  - Its implications are easily replicable for pipe structural and service grades as well as the geotechnical slope and erosion grades.
  - By simply adding consideration of deterioration potential to earlier grades as well as failure probability, a time scale can be inferred, which can better be tied into the longer term picture of rationalizing investment levels into the asset class.

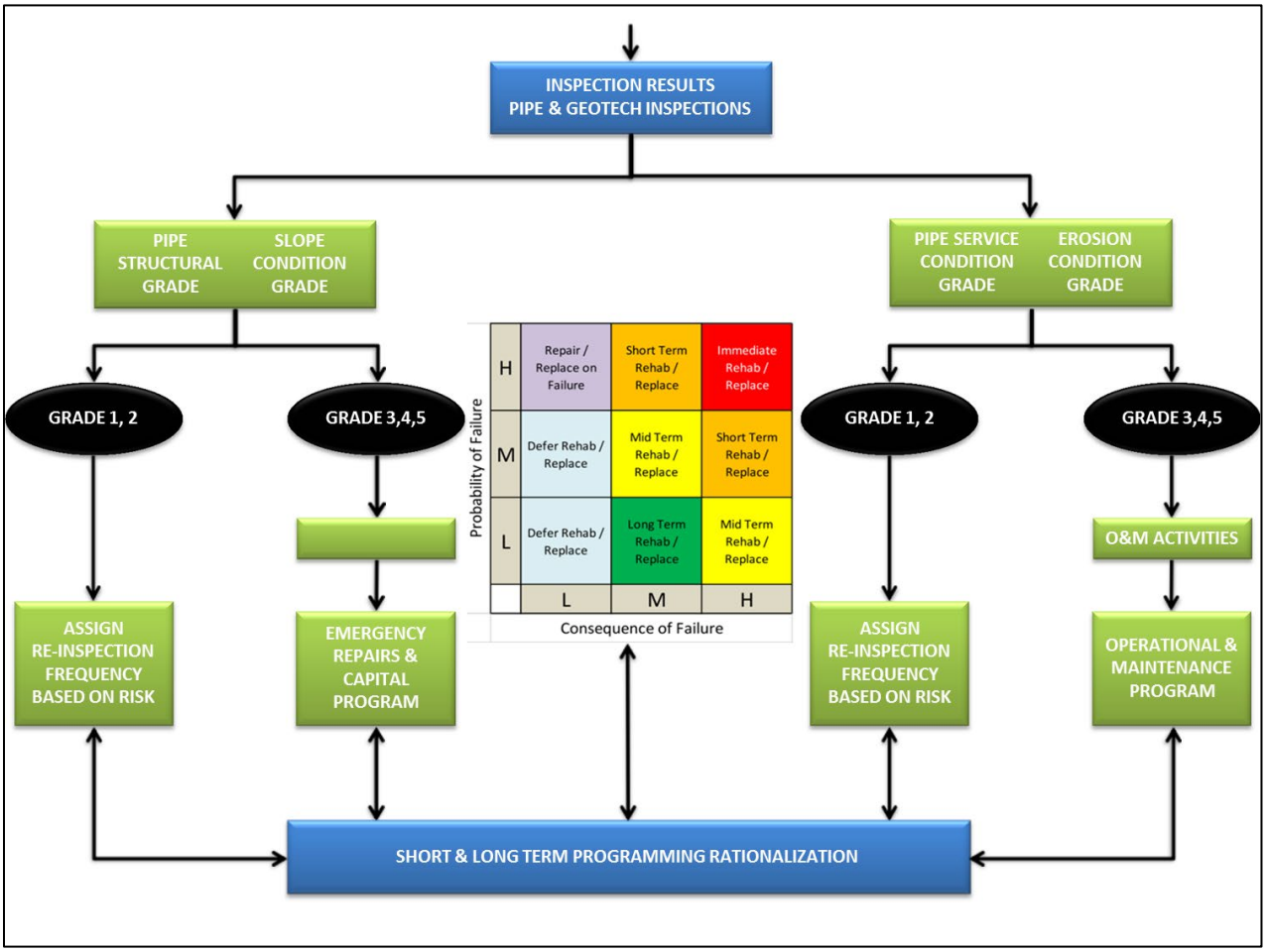

Figure 29: Integrated Outfall Condition Assessment Process

A standard Risk Matrix as noted in Figure 29 is used to establish priorities for work activities that are identified from the inspection process. Specific work activities (treatment or O&M work) are developed for all Grades of 3 or higher and a re-inspection frequency is rationalized for Grades 1 or 2. Both re-inspection frequency and prioritization of short and longer term programing are driven by the Risk Matrix, with shorter re-inspection and intervention timelines associated with higher consequence assets.

While the governing condition for calculating overall site specific risk is the worst of the pipe's structural and service condition grades and geotechnical SCG and ECG; all individual ratings are retained within the City's Sewer Management System (SMS) to preserve a complete picture of each asset. These conditions help rationalize logical packaging of work at each site for overall program development, and, over time, to ascertain the likely time frame associated with transition from one condition state to another. Within SMS, the ECG and SCG has been retained within the Inspection comments field to provide an understanding to the decision driver for the resultant SPG value.

Integration of all condition grades with failure consequence is used to develop short and long term programing requirements as well as forming the fundamental basis for business case development for the asset class. Business case development will ultimately establish the intervention timeline associated with each consequence class of outfall. This will include both benefit cost and service level reliability considerations.

While intervention will be based on consequence considerations the following guidelines provide some insight into how condition grades will be used to assist in the rationalization of short and long term programing:

- Grade 5 Condition – Immediate work requirements
  - Over time higher consequence assets would not be permitted to advance to this condition state
  - Will logically make up the 1-3 year upgrading and O&M program
- Grade 4 Condition – Short term upgrading requirements
  - Consciously deferred work in lower consequence assets
  - Logical intervention for highest consequence assets
  - Will initially represent the 3-5 year upgrading activities
- Grade 3 Condition – Longer term identifiable upgrading program
  - Consciously deferred work in lower consequence assets
  - Will logically represent the majority of the 5-15 year upgrading requirements

All Grade 1 and 2 outfalls will be assigned re-inspection frequencies in accordance with the City's current re-inspection versus risk matrix and any upgrading not undertaken within these timelines would also be re-inspected based on risk to preclude unanticipated failures. Re-inspection, over time, is necessary to establish more precisely the timeframe associated with condition state transition, which in turn will establish the sustainable funding requirements for the outfall asset class.

A summary of the computed Internal Condition Grade (ICG), Slope Condition Grade and Erosion Condition Grade for all pipe inspections broken out by conventional CCTV, multi-sensor and GIS corrected Outfalls are provided in Table 9, Table 10 and Table 11. For upstream sewer entities, the conventional sewer assessment took place and their corresponding SPG value is summarised in Table 12.

Table 9: Computed Internal Condition Grade by Outfall

	Not Inspected	New ICG					
Inspection Type		**1**	**2**	**3**	**4**	**5**	**Grand Total**
GIS Corrected Outfalls		19	6	6	3	1	35
Multi Sensor Inspection	2	102	23	31	8	3	169
CCTV Inspections	1	44	40	38	6	19	148
Grand Total	**3**	**165**	**69**	**75**	**17**	**23**	**352**

Table 10: Slope Condition Grade by Outfall

	Not Found	New SCG					
Inspection Type		**1**	**2**	**3**	**4**	**5**	**Grand Total**
GIS Corrected Outfalls	2	2	5	6	13	7	35
Multi Sensor Inspection	1	22	13	33	77	23	169
CCTV Inspections	1	7	18	24	63	35	148
Grand Total	**4**	**31**	**36**	**63**	**153**	**65**	**352**

Table 11: Erosion Condition Grade by Outfall

	Not Found	New ECG					
Inspection Type		**1**	**2**	**3**	**4**	**5**	**Grand Total**
GIS Corrected Outfalls	2	6	7	13	2	5	35
Multi Sensor Inspection	1	65	16	49	25	13	169
CCTV Inspections	1	37	20	40	27	23	148
Grand Total	**4**	**108**	**43**	**102**	**54**	**41**	**352**

8. Summary of Outfall Inspection Results

8.1 Overall Condition Summary

Both pipe inspection programs were compiled immediately after completion and integrated with the geotechnical assessments to provide insight as to the state of the overall system and establish financial ramifications of the inventory. The SPG values (the worst of all assessed grades) are tabulated in Table 12 below.

Table 12: Governing Structural Performance Grade for All Outfall and Upstream Sewer Entities

	Not Assessed	New SPG					
Inspection Type		**1**	**2**	**3**	**4**	**5**	**Grand Total**
GIS Corrected Outfalls		1	8	8	10	8	35
Multi Sensor Inspection	1	6	26	34	71	31	169
CCTV Inspections	2	5	25	24	41	51	148
Upstream Sewer Entities			9	2			11
Grand Total	**3**	**12**	**68**	**68**	**122**	**90**	**363**

The individual pipe structural grades and slope condition grades were combined as noted in Figure 29 and used to assess emergency repair and overall capital upgrading requirements. Similarly, the pipe service grades were combined with the erosion condition grades and used to define operational and maintenance program requirements. The commonality of grade implication allows for direct comparison across the grading systems and uses the “worst” grade present method to drive the need for assessment of a rehabilitation treatment or an O&M activity.

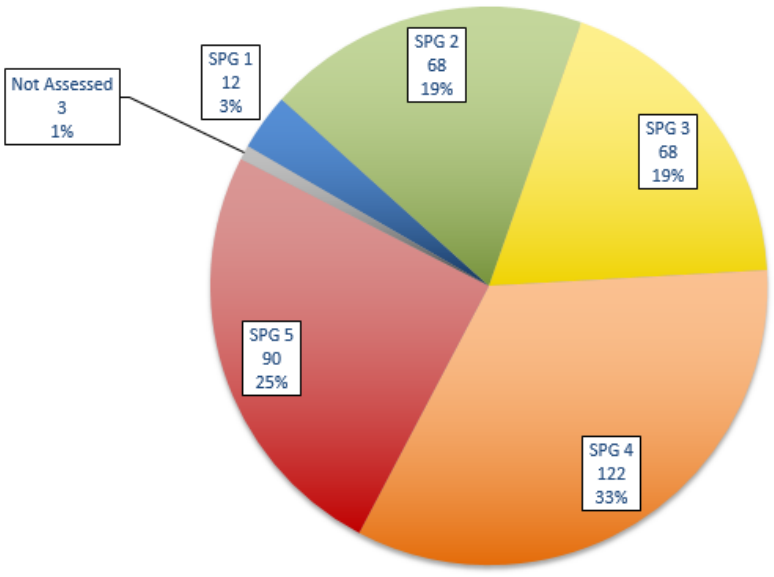

Figure 30: Final SPG Value for All Inspected Entities

The prominent driver for governing SPG value was overwhelmingly the geotechnical condition state as opposed to the pipe condition state. While only 11% of the outfall pipe inventory (40 of 352 locations as noted in Table 9) is in

need of short term remediation (ICG values of 4 to 5), the prevailing geotechnical condition grades elevated the SPG for the site to SCG 4 and 5's for 58% of the inventory (as depicted in Figure 30).

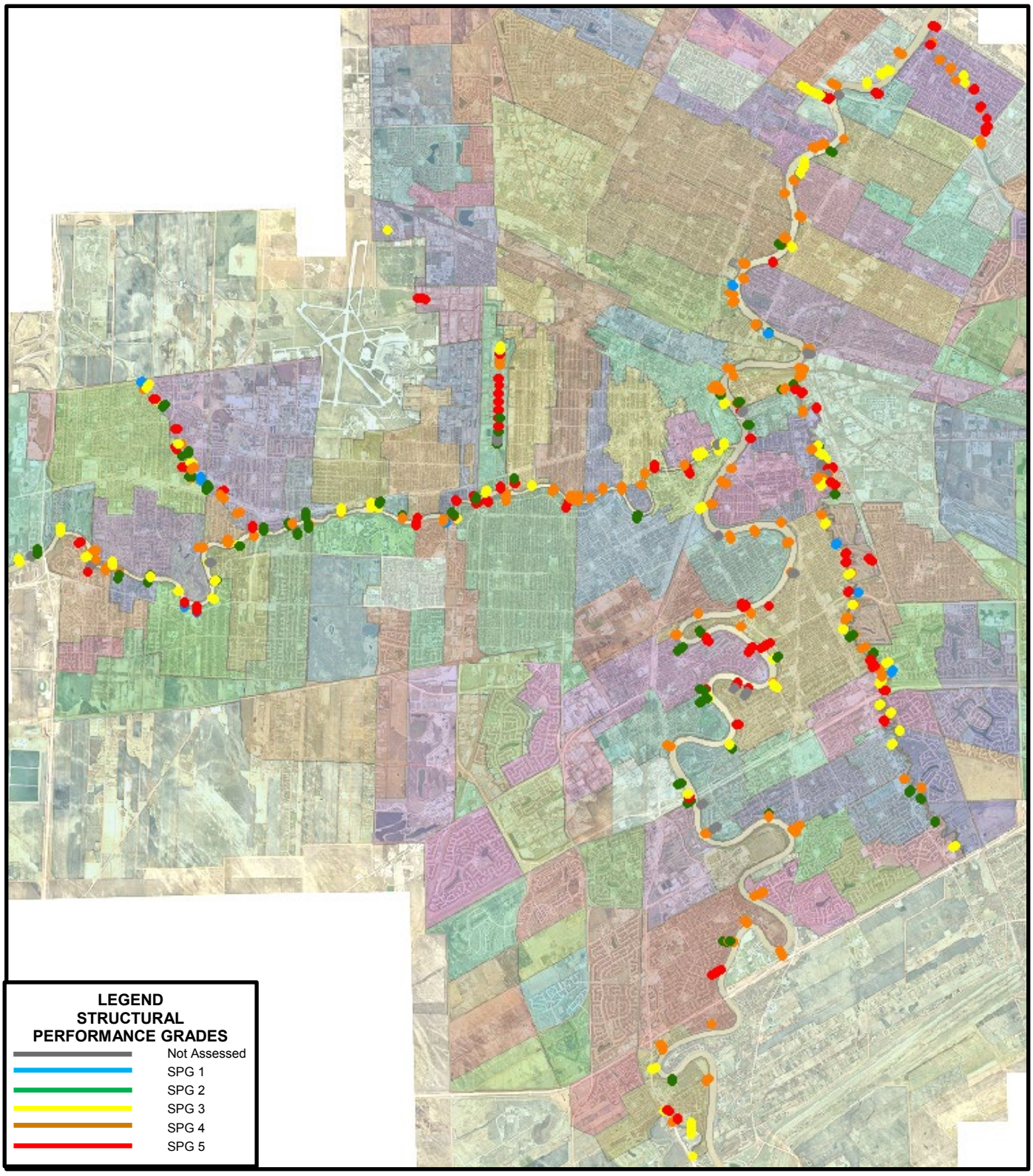

Figure 31: Overall Structural Performance Grade for the Inspection Program

Figure 31 depicts the spatial distribution of all Overall SPG values while Appendix B details the total inspected number of outfall inspections by their SPG value within their respective sewer service district.

In addition to the raw condition scores, the MSI imagery, in higher consequence assets, provided considerable insight into the condition state of the CMP/CSP inventory. While it requires more robust review than conventional CCTV, it provided unique clarity in cases of severe deformation of the outfall as to whether the deformation was logically the result of conventional pipe-soil interaction or whether the deformation was being driven by slope instabilities. Figure 32 below is an example of an outfall with extreme deformation that could be attributed to conventional pipe-soil interaction and would be deemed to be stable as opposed to being driven by slope instabilities which would render the pipe unstable and in a state of incipient failure.

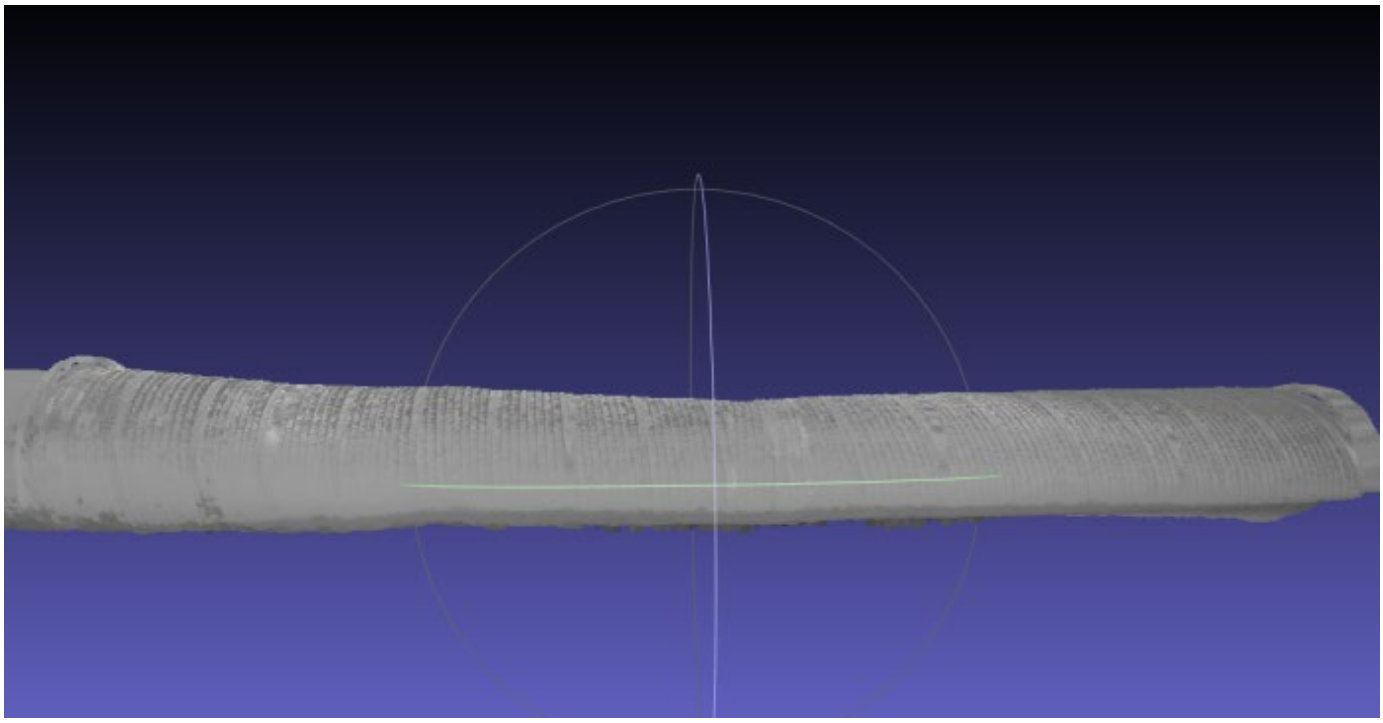

Figure 32: Point Cloud Resolution Used to Assess Detailed Deformation in CSP Outfall

9. Treatment Assignment

9.1 Overview of Treatment Assignments

Having completed the development of Structural Performance Grades using the criteria set out in Section 4.0 of Volume I of the Sewer Management Study and the supplemental treatment assignment categories developed for actionable slope related deficiencies developed for this study; treatment strategies were assigned to each outfall asset, where warranted (i.e. SPG 3 or greater). This involved matching the appropriate treatments required for each asset based on the severity and spatial distribution of defects as well as the nature of the defects themselves. Once a treatment strategy was rationalized, an estimated cost was developed for the treatment by utilizing a master cost-estimating database developed for this study, which was driven by the nature of the treatment assigned, and the physical characteristics of the outfall (e.g. pipe depth, size, and location factors, etc.).

Treatment Assignment also included a QA/QC process where raw inspection data was reviewed to confirm the accuracy and consistency of the assigned Condition Grades and treatment selections in accordance with the established procedures for assigning rehabilitation to specific defect patterns. The sewers requiring rehabilitation were assigned a 'backlogged' Work Order within the SMS indicating the nature and extent of the work. Based on an assessment of the observed defect pattern, sewer rehabilitation was slotted into the following work streams reflecting the required level of coordination with surface works; in the following categories:

- stabilization (man-entry repairs)
- full segment renovation (lining)
- trenchless point repairs

Pure Trenchless Categories

- augmented renovation (lining with supplementary external repairs or fully deteriorated design)
- full segment replacement (renewal)
- external point repairs

Minimum Excavation / Replacement Categories

- Erosion Control
- Slope Regrading
- Slope Stabilization

From Rip Rap Armouring to Invasive Rock Column and Shear Key Geotechnical Categories

Table 13 through Table 18 provide raw summaries of the spatial extent of outfalls requiring some form of treatment and an initial estimate of capital cost from the following perspectives:

- Table 13 provides a summary of pipe treatments alone based on the primary inspection method of the pipes. In addition to the CCTV and MSI inspection contracts, some treatments were assigned in GIS corrected outfall elements and one outfall's remedial requirements was identified/rationalized based on upstream inspections. Based on this categorization approach, some 2.8 km of outfall pipe requires remedial work (SPG of 3 or higher) totalling approximately $4.8 million. Approximately 68% of the pipeline remediation work could be accomplished by trenchless means, without consideration of the geotechnical work scope. There are two provisos to this:
  - In instances where there are major slope stability works, a business case would need to be developed for the overall site remediation as discussed in Section 9.2.
  - The budget values may be somewhat understated as the requirements for trenchless work in close proximity to water with fish habitat will increase the capital cost of relining technologies due to a requirement for using alternative curing and on-site treatment technologies or styrene free resins with CIPP. Past practice of relining outfalls with HDPE needs to be reviewed due to the flammability of HDPE and the potential resulting hydraulic restrictions.

- Table 14 provides a summary of geotechnical upgrading treatment associated with the same inspection types as noted in Table 13 above. The $35.15 million in potential treatment costs are dominated by major slope stabilization works totalling $23.43 million.
- Table 15 provides a summary of pipe treatment works based on severity of existing condition, which illustrates that about 58% of the $4.77 million of pipe upgrading, $2.79 million, are failed outfall pipes or pipes in a state of incipient failure.
- Table 16 presents the slope treatment costs by severity and illustrates that $17.55 million of the $35.15 million of slope treatment works (50%) are at locations where the slopes are presently failing or at risk of imminent failure.
- Table 17 summarizes pipe treatment costs by criticality of the outfall pipe and indicates that $2.94 million of the $4.77 million (62%) outfall pipe upgrading costs are at Category A outfalls or the most critical outfall pipes. Only $256,000 worth of pipe works are at locations of unknown criticality.
- Table 18 summarizes the geotechnical upgrading costs by criticality of location and illustrates that $17.73 million of the $35.15 million of geotechnical upgrading costs (50%) are at Category A outfall locations or the most critical outfall pipes. A further $2.78 million worth of geotechnical works are at locations of unknown criticality.

The Category attributes in SMS have 20 assets that could not be prioritized through the prioritization process as noted in Appendix D. A cumulative summary for structural and service related defects was, therefore, compiled to illustrate prioritization where no assignment of Category could be derived. These unique prioritization summaries are presented in Appendix E and Appendix F for structural and service related rehabilitation treatments, respectively, and their associated cost.

Table 13: Pipe Treatment Assignment Allocation by Inspection Type

	GIS CORRECTED OUTFALLS		CCTV INSPECTION CONTRACT		MSI INSPECTION CONTRACT		UPSTREAM SEWER INSPECTIONS		Total Quantity	Total Estimated Cost
Work Type	**m**	**$K**	**m**	**$K**	**m**	**$K**	**m**	**$K**	**m**	**$K**
1-STABILIZATION (MAN ENTRY)			201.34	$402.58	34.10	$16.20			**235.44**	**$418.78**
2-FULL SEGMENT RENOVATION (RELINING)	441.33	$921.15	790.90	$1,078.44	354.94	$431.95	173.93	$248.06	**1,761.10**	**$2,679.60**
2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)			200.00	$152.20	145.28	$138.21			**345.28**	**$290.41**
3-TRENCHLESS POINT REPAIR			56.82	$150.38	10.00	$34.90			**66.82**	**$185.28**
5-FULL SEGMENT REPLACEMENT (RENEWAL)			82.76	$262.53	55.17	$219.97			**137.93**	**$482.50**
6-EXTERNAL POINT REPAIRS	15.30	$61.29	32.44	145.75	195.86	$508.56			**243.60**	**$715.60**
Total	**456.63**	**$982.44**	**1,364.26**	**$2,191.88**	**795.35**	**$1,349.79**	**173.93**	**$248.06**	**2,790.17**	**$4,772.17**

Table 14: Geotechnical Treatment Assignment Allocation by Inspection Type

	GIS CORRECTED OUTFALLS		CCTV INSPECTION CONTRACT		MSI INSPECTION CONTRACT		Total Quantity	Total Estimated Cost
Work Type	**m**	**$K**	**m**	**$K**	**m**	**$K**	**m**	**$K**
68-EROSION CONTROL	36.10	$300.00	442.52	$4,200.00	248.82	$1,300.00	**727.44**	**$5,800.00**
69-SLOPE REGRADING	112.80	$400.00	536.77	$3,125.00	686.81	$2,400.00	**1,336.38**	**$5,925.00**
70-SLOPE STABILIZATION	44.22	$375.00	1,030.54	$9,625.00	2,281.14	$13,425.00	**3,355.90**	**$23,425.00**
Total	**193.12**	**$1,075.00**	**2,009.83**	**$16,950.00**	**3,216.77**	**$17,125.00**	**5,419.72**	**$35,150.00**

Table 15: Pipe Treatment Assignment Allocation by SPG Value

Sum of QUANTITY	SPG 3		SPG 4		SPG 5		Total Quantity	Total Estimated Cost
Work Type	m	$K	m	$K	m	$K	m	$K
1-STABILIZATION (MAN ENTRY)			109.74	$218.38	100.20	$200.40	**209.94**	$418.78
2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)					345.28	$290.41	**345.28**	$290.41
2-FULL SEGMENT RENOVATION (RELINING)	874.97	$1,676.17	474.30	$528.04	411.83	$475.39	**1,761.10**	$2,679.60
3-TRENCHLESS POINT REPAIR	42.72	$98.88	14.20	$48.20	9.90	$39.20	**66.82**	$185.28
5-FULL SEGMENT REPLACEMENT (RENEWAL)			32.21	$120.90	105.72	$361.59	**137.93**	$482.50
6-EXTERNAL POINT REPAIRS			172.59	$469.00	71.01	$246.60	**243.60**	$715.60
Grand Total	**917.69**	**$1,775.05**	**803.04**	**$1,384.52**	**1,043.94**	**$1,612.59**	**2,764.67**	**$4,772.17**

Table 16: Geotechnical Treatment Assignment by SPG

	SPG 3		SPG 4		SPG 5		Total Quantity	Total Estimated Cost
Work Type	m	$K	m	$K	m	$K	m	$K
68-EROSION CONTROL	230.00	$1,700.00	172.56	$1,500.00	324.88	$2,600.00	**727.44**	**$5,800.00**
69-SLOPE REGRADING	771.27	$2,800.00	424.98	$2,100.00	140.13	$1,025.00	**1,336.38**	**$5,925.00**
70-SLOPE STABILIZATION	39.90	$250.00	2,019.74	$9,250.00	1,296.26	$13,925.00	**3,355.90**	**$23,425.00**
Total	**1,041.17**	**$4,750.00**	**2,617.28**	**$12,850.00**	**1,761.27**	**$17,550.00**	**5,419.72**	**$35,150.00**

Table 17: Pipe Treatment Assignment Allocation by Category

Sum of QUANTITY	A		B		C		X		Total Quantity	Total Estimated Cost
Work Type	m	$K	m	$K	m	$K	m	$K	m	T$K
1-STABILIZATION (MAN ENTRY)	113.04	$226.08	4.40	$7.10			92.50	$185.00	**209.94**	**$418.78**
2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)			248.68	$219.11	96.60	$71.30			**345.28**	**$290.41**
2-FULL SEGMENT RENOVATION (RELINING)	1,088.77	$2,129.61	509.85	$479.79	162.48	$70.21			**1,761.10**	**$2,679.60**
3-TRENCHLESS POINT REPAIR	13.40	$50.00			53.42	$135.28			**66.82**	**$185.28**
5-FULL SEGMENT REPLACEMENT (RENEWAL)	86.22	$330.96	34.51	$102.12	17.20	$49.41			**137.93**	**$482.50**
6-EXTERNAL POINT REPAIRS	71.55	$199.64	116.15	$314.45	33.10	$130.15	22.80	$71.36	**243.60**	**$715.60**
Grand Total	**1,372.98**	**$2,936.29**	**913.59**	**$1,123.17**	**362.80**	**$456.35**	**115.30**	**$256.36**	**2,764.67**	**$4,772.17**

Table 18: Geotechnical Treatment Assignment by SPG

	A		B		C		X		Total Quantity	Total Estimated Cost
Work Type	m	$K	m	$K	m	$K	m	$K	m	$K
68-EROSION CONTROL	278.51	$2,450.00	282.51	$1,900.00	92.32	$950.00	74.10	$500.00	**727.44**	**$5,800.00**
69-SLOPE REGRADING	560.88	$3,100.00	589.14	$1,900.00	114.66	$525.00	71.70	$400.00	**1,336.38**	**$5,925.00**
70-SLOPE STABILIZATION	1,941.78	$12,175.00	933.93	$6,875.00	305.39	$3,000.00	174.80	$1,375.00	**3,355.90**	**$23,425.00**
Total	**2,781.17**	**$17,725.00**	**1,805.58**	**$10,675.00**	**512.37**	**$4,475.00**	**320.60**	**$2,275.00**	**5,419.72**	**$35,150.00**

9.2 Practical Programming Considerations for Outfall Upgrading

The complex nature of outfalls and the often, very high, cost associated with major slope stabilization works have been a programming conundrum as long as outfalls have been in service. The mere imbalance of $35.15 million of slope stability related works and $4.77 million of pipe rehabilitation works highlight this issue.

The value of erosion control measures to reduce exposure to larger general slope stability problems is both self-evident and very easy to rationalize in terms of the business case for carrying out toe erosion control when the opportunity presents itself. Toe erosion control measures are typically in the 10 to 100's of thousands of dollars while major slope stability works go from 100's of thousands to millions and often require the extension of work into adjacent private lands due to the three dimensional nature of stability requirements. While some general slope stability works are not solely related to retrogressive toe erosion, toe erosion exacerbates general stability of slope in almost all cases.

The outfall pipes are obviously critical as they usually represent the sole outlet for the sewer systems they serve; however, they often have unique failure modes if the failure is driven by major slope stability events. When failure is driven by major instabilities the function of the outfall can usually be readily re-established due to the proximity of the pipe to the river as long as reasonable emergency response measures are in place. The conundrum of how much to invest in slope stability to protect an outfall pipe has been studied in numerous projects in Winnipeg going back to major slope stabilization programs at Lyndale Drive and Mager Drive in the 1980's. In these cases, the amount of investment into slope stabilization was analysed and justified as a business case based on the total assets affected by the slope instability (e.g.: road or lift station) as opposed to the outfall asset alone. Without this level of assessment, that examines the three dimensional requirements of the stability measures in conjunction with all affected City owned and private assets, no true cost-benefit assessment can be made.

To address this unique assessment requirement and to develop a coherent Outfall Remediation Program all rationalized treatments noted in Section 9.1 were broken into Assignment Classification Types as follows:

- **Assignment Type I – Conventional Pipe Rehabilitation**

  These are sites where conventional pipe rehabilitation and maintenance or erosion control measures may be required, however, slope stabilization works are either not required or of such a small value that no additional business case rationalization is required.

- **Assignment Type II – Geotechnical Study with Cost-Benefit Assessment**

  These represent potentially large capital investments and need unique benefit-cost assessments. The studies need to reasonably establish the extent of slope stabilization required, the total assets affected by the instability, and assess whether and to what degree slope stabilization is warranted for the site based on the City owned assets affected and a reasonable assessment of private assets that may warrant consideration. The capital cost currently identified should represent a conservative estimate of potential financial exposure but needs to be vetted on a site by site basis to establish a true business case for the funding. The actual funding expended would be a Preliminary Engineering Assessment.

- **Assignment Type III - Preventative Maintenance - Geotechnical**

  These are sites where toe erosion control is warranted but no other works are currently required. Given the high value of toe erosion works the classification type of work should be considered as having large benefits relative to the expenditure.

- **Assignment Type IV - Preventative Maintenance – Pipe**

  These are sites where only pipe service related defects are present. There is currently no cost estimating basis for these defects, although they should be somewhat elevated in priority as the most common service related defect is excessive debris, which impairs capacity of the outfall.

- ***Assignment Type V - Preventative Maintenance – Pipe and Geotechnical***

  These are sites where both geotechnical (toe erosion) and pipe related service defects are present. As the Classification has both integrated activities and are highly beneficial relative to the cost, they should be deemed to be a very high priority as an actionable item.

Based on the above, all actionable treatment items were assigned Assessment Type Classifications for all Pipe and Slope Condition Driven Work (Table 19) and for all Maintenance Driven Work (Table 20). As no budget values were derived for Pipe Service Related Defects, the number of sites are noted in lieu of a budget value.

By examining the severity of the defect driver for each site and using the Defect Implication guidelines, a logical program structure can be developed. The defect implication guidelines suggest the following response timing to preclude unanticipated failure:

- SPG = 5; Complete immediately for failures to within 3 years for incipient failures. Execute Category A immediately and defer Category B and C expenditures.
- SPG = 4; Complete in 3-5 years. Prioritize based on Criticality Category (A, B and C).
- SPG = 3; Complete in 5-10 years. Prioritize based on Criticality Category (A, B and C).
- Preventative Maintenance Opportunities where no structural pipe defects or slope stability issues are present. These works would be classified as very high value to restore full outfall function and to prevent future increased exposure to major slope instabilities. Program for completion in the next 5 years, prioritized by Criticality Category (A, B and C).

The financial ramifications of this approach is summarized in Table 21. Assessment Types I, III, IV and V can readily be justified as required capital expenditures based on the current business cases presented in the Sewer Management Study and herein for toe erosion preventative maintenance value. The amounts noted for Assessment Type II should be construed more as a potential financial exposure based on currently identified threats and a conservative view of the costs associated to remediate the sites. The true short term financial exposure would be the preliminary engineering costs associated with carrying out the benefit-cost analysis. While the assessments will generate additional capital funding requirements, it is not possible to estimate the required magnitude with any reasonable degree of certainty without extensive site specific investigation. The business case to support the expenditure would be generated by the preliminary engineering assessment itself. The preliminary engineering cost exposure can reasonably be estimate as a percentage of the financial exposure.
Based on these considerations the 5 year capital expenditure level for outfalls would be as follows:

1. Assignment Type I - $270,000 annually for 5 years
2. Assignment Type II - $285,000 annually for 5 years for preliminary engineering, instrumentation and studies to reduce the Financial Exposure to over $34 million in slope remediation to as great an extent as possible. An additional allowance would have to be made for actual capital programs justified based on the site-specific business cases.
3. Assignment Type III, IV and V - $1,285,000 annually over 5 years for preventative maintenance for toe erosion plus an allowance for outfall debris removal to reinstate full outlet capacity.

This translates to $1.841 million in annual funding over the next 5 years and two, as of yet, undefined allowances.

Table 19: Assignment Types for Outfall Pipe and Slope Condition Driven Sites

Outfall Pipe and Slope Driven Condition Works											
Criticality	**SPG**	**SCG**	**Pipe Works**			**Slope Work**				**Totals**	***Assignment Type***
			Rehab		**Maintenance**	**Stabilization**		**Erosion**			
Criticality	SPG	SCG	**Pipe Rehab**	**Pipe Rehab $**	**Main #**	**Slope Stab #**	**Slope Stab $ (k)**	**Erosion #**	**Erosion $ (k)**	**totals**	
A	***5***	***5***	3	$400	8	24	$6,900	4	$800	$8,100	***II***
	5	***4***	5	$113	1	4	$500	1	$100	$713	***II***
	5	***3***	1	$47	1	0	$0	1	$100	$147	***I***
	5	***<3***	1	$114	0	0	$0	0	$0	$114	***I***
B	***5***	***5***	3	$137	2	12	$3,250	0	$0	$3,387	***II***
	5	***4***	1	$34	0	4	$475	4	$400	$909	***II***
	5	***3***	3	$162	1	0	$0	2	$200	$362	***I***
	5	***<3***	2	$77	0	0	$0	0	$0	$77	***I***
C	***5***	***5***	3	$38	0	9	$1,625	2	$250	$1,913	***II***
	5	***4***	6	$153	0	5	$600	2	$200	$953	***II***
	5	***3***	1	$21	0	0	$0	0	$0	$21	***I***
	5	***<3***	2	$96	0	0	$0	0	$0	$96	***I***
X	***5***	***5***	0	$0	1	3	$600	1	$100	$700	***II***
	5	***4***	1	$23	1	1	$125	1	$100	$248	***II***
A	***4***	***4***	7	$344	14	48	$5,700	5	$500	$6,544	***II***
	4	***3***	3	$193	1	1	$100	1	$100	$393	***II***
	4	***<3***	2	$112	0	0	$0	0	$0	$112	***I***
B	***4***	***4***	12	$344	5	28	$3,425	1	$100	$3,869	***II***
	4	***3***	1	$20	0	0	$0	1	$100	$120	***I***
	4	***<3***	5	$192	0	0	$0	0	$0	$192	***I***
C	***4***	***4***	0	$0	0	0	$0	0	$0	$0	***None***
	4	***3***	0	$0	0	0	$0	0	$0	$0	***None***
	4	***<3***	1	$13	1	0	$0	1	$100	$113	***I***
X	***4***	***4***	2	$49	0	5	$625	0	$0	$674	***II***
	4	***3***	0	$0	1	1	$100	0	$0	$100	***II***
	4	***<3***	0	$0	0	0	$0	0	$0	$0	***None***
A	***3***	***3***	0	$0	2	0	$0	0	$0	$0	***IV***
	3	***<3***	4	$968	0	0	$0	2	$200	$1,168	***I***
B	***3***	***3***	2	$157	6	15	$1,525	5	$500	$2,182	***II***
	3	***<3***	0	$0	3	0	$0	3	$300	$300	***V***
C	***3***	***3***	0	$0	0	0	$0	0	$0	$0	***None***
	3	***<3***	1	$99	1	0	$0	0	$0	$99	***I***
X	***3***	***3***	0	$0	0	0	$0	0	$0	$0	***None***
	3	***<3***	0	$0	1	0	$0	0	$0	$0	***IV***
A	***4***	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	3	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	<3	***5***	0	$0	0	1	$250	1	$250	$500	***II***
B	***4***	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	3	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	<3	***5***	0	$0	0	0	$0	0	$0	$0	***None***
C	***4***	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	3	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	<3	***5***	0	$0	0	1	$500	1	$500	$1,000	***II***
X	***4***	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	3	***5***	0	$0	0	0	$0	0	$0	$0	***None***
	<3	***5***	0	$0	0	0	$0	0	$0	$0	***None***
A	***3***	***4***	3	$519	0	1	$100	0	$0	$619	***I***
	<3	***4***	0	$0	0	7	$800	2	$200	$1,000	***II***
B	***3***	***4***	2	$111	0	2	$200	0	$0	$311	***II***
	<3	***4***	0	$0	3	1	$100	0	$0	$100	***II***
C	***3***	***4***	0	$0	0	0	$0	0	$0	$0	***None***
	<3	***4***	0	$0	0	2	$225	0	$0	$225	***II***
X	***3***	***4***	0	$0	0	0	$0	0	$0	$0	***None***
	<3	***4***	0	$0	2	1	$125	0	$0	$125	***II***
A	***<3***	***3***	0	$0	2	0	$0	1	$326	$326	***V***
B	***<3***	***3***	0	$0	1	0	$0	0	$0	$0	***IV***
C	***<3***	***3***	0	$0	0	1	$125	0	$0	$125	***II***
X	***<3***	***3***	0	$0	0	0	$0	0	$0	$0	***None***

Table 20: Assignment Types for Maintenance Driven Sites

Maintenance Driven Program Works (Pipe SPG and SCG <3)							
	ServiceC	*ECG*	Service	Erosion		Total Number	*Assignment Type*
Criticality	*ServiceC*	*ECG*	Service #	Erosion #	Erosion $ (k)	Total #	
A	**5**	**5**	0	0	$0	0	***None***
	4	**5**	0	0	$0	0	***None***
	3	**5**	3	0	$0	3	***IV***
	<3	**5**	4	5	$1,050	9	***V***
B	**5**	**5**	4	1	$100	5	***V***
	4	**5**	0	0	$0	0	***None***
	3	**5**	2	1	$100	3	***V***
	<3	**5**	4	4	$400	8	***V***
C	**5**	**5**	0	0	$0	0	***None***
	4	**5**	0	0	$0	0	***None***
	3	**5**	2	1	$125	3	***V***
	<3	**5**	1	3	$325	4	***V***
X	**5**	**5**	4	1	$100	5	***V***
	4	**5**	0	0	$0	0	***None***
	3	**5**	0	0	$0	0	***None***
	<3	**5**	2	1	$100	3	***V***
A	**4**	**4**	0	0	$0	0	***None***
	3	**4**	2	1	$100	3	***V***
	<3	**4**	11	7	$700	18	***V***
B	**4**	**4**	0	0	$0	0	***None***
	3	**4**	8	1	$100	9	***V***
	<3	**4**	5	1	$100	6	***V***
C	**4**	**4**	0	0	$0	0	***None***
	3	**4**	5	1	$100	6	***V***
	<3	**4**	2	1	$100	3	***V***
X	**4**	**4**	0	0	$0	0	***None***
	3	**4**	3	0	$0	3	***IV***
	<3	**4**	2	0	$0	2	***IV***
A	**3**	**3**	7	2	$200	9	***V***
	<3	**3**	7	4	$400	11	***V***
B	**3**	**3**	8	4	$400	12	***V***
	<3	**3**	6	7	$700	13	***V***
C	**3**	**3**	2	1	$100	3	***V***
	<3	**3**	2	2	$200	4	***V***
X	**3**	**3**	0	0	$0	0	***None***
	<3	**3**	0	3	$300	3	***V***

Table 21: Summary of Assignment Classification Types and Associated Timing

Note: Assignment Type II should be viewed as a Potential Financial exposure as a opposed to a known Capital Upgrading Value.

				Timing			
				0-3 Years	3-5 Years	5-10 Years	0-5 Years
Assignment Classification	Assignment Type	Number of Pipe Maintenance Sites	Total Cost in k$	SPG 5	SPG4	SPG3	No Pipe Work Identified
I	Conventional pipe rehabilitation	27	$3,240	$817	$537	$1,886	$0
II	Geotechnical study with cost benefit analysis to determine balance of stabilization works and pipe works	50	$34,070	$16,923	$11,579	$2,493	$3,075
III	Preventative Maintenance - Geotechnical	0	$0	$0	$0	$0	$0
IV	Preventative Maintenance - Pipe	8	$0	$0	$0	$0	$0
V	Preventative Maintenance - Geotechnical and pipe	88	$6,426	$200	$0	$1,525	$4,701

Initial exposure is for Preliminary Engineering Services only to facilitate detailed cost-benefit assessment and Business Case Development

10. Conclusions and Recommendations

10.1 Condition Summary

10.1.1 The overall condition of the inspected outfall pipes varies considerably across the inventory. Outfall pipes that were above river levels have a condition more conducive to corrosion, likely due to de-icing salts, and are in markedly poorer condition than fully submerged pipes. Many partially or fully submerged outfalls, however, exhibit high levels of debris that are restricting full condition assessment of the pipe segment. The most pronounced deterioration mechanisms on the inventory are geotechnical in nature where widespread slope stability and toe erosion issues have engaged or will potentially engage, the outfall pipes and induce catastrophic failures over time. A summary of results note the following:

- Calculated internal condition grades determined 40 outfall pipes are failing or at a point of incipient failure having values of ICG 4 and 5 based on their observed pipe condition alone.
- The outfall slope condition assessment identified 218 sites that have a high risk of failure or are presently failing embankments with elements of progressive creep, and severe toe erosion. There is evidence of fresh soil at identified scarps and tension cracks at 153 sites with SCG 4 values and 65 locations with SCG 5 values.
- When pipe structural condition and geotechnical condition assessments are integrated as noted within Section 7, the resultant Structural Performance Grade results identified 122 outfall locations at SPG 4 and 90 locations at SPG 5 where in many cases, geotechnical failures have engaged the pipe with pipe separation evident. This represents 62% of the overall inventory.

10.1.2 33 outfall locations exhibited high debris levels within the sewer network upstream of the sewer to outfall manhole interface, control structure or lift station. Visual inspection and zoom technologies in addition to pipe end visuals from the Geotechnical assessment enabled the analytical assessor to have a sufficient understanding of condition to rationalize a logical treatment assignment.

10.1.3 A total of 99 outfall pipes exhibited excessive debris; 71 of these assets were in a partial to fully submerged condition which appears to have had considerable influence on excessive debris accumulation due to river sediment deposition. The City should consider remedial action to inhibit sediment build up within assets at risk of blockages such as Duckbill or Tideflex Check valves.

10.2 Targeted Re-inspection Outfall Locations

As noted, all Grade 1 and 2 outfalls should be assigned re-inspection frequencies in accordance with the City's current re-inspection versus risk matrix and any upgrades not undertaken within these timelines would also be re-inspected based on risk to preclude unanticipated failures.

Given the current SPG values, outfall location quantities for re-inspection should be undertaken given the recommended frequency:

Table 22: Sewer Management Study - WRc Recommended Re-inspection Frequency

New SPG	Flow Type and Category				
/	CS & WWS		LDS & SRS		Total
	A	B	A	B	
5	8 Rehabilitate n/a	3 Rehabilitate n/a	19 Rehabilitate n/a	35 Rehabilitate n/a	65
4	29 1 Year	10 5 Years	26 1 Year	43 5 Years	108
3	9 3 Years	4 15 Years	8 5 Years	30 20 Years	51
2	4 5 Years	7 20 Years	16 10 Years	22 25 Years	49
1	2 10 Years	3 25 Years	0 20 Years	5 30 Years	10
Grand Total	52	27	69	135	283

The City should revisit the 25 outfall locations that have not been categorised with emphasis on the geotechnical results to determine the good ground/bad ground field within SMS to help with their categorisation. A further 20 outfall pipes exhibit SPG 5 and are classified as Category C that are advised to be included on an annual inspection frequency in addition to the aforementioned. The remaining 24 outfall assets are classified as SPG 1 to 4 and have a Category C Criticality designation.

Table 23: Sewer Management Study - Further Recommended Re-inspection Frequency

New SPG	Flow Type and Category				
/	CS & WWS		LDS & SRS		Total
	C	X	C	X	
5	4 1 Year	1 1 Year	16 1 Year	4 1 Year	25
4	2	1	6	6	15
3	5	1	4	5	15
2	4	1	1	3	9
1	1	1	1	2	5
Grand Total	16	5	28	20	69

A total of 69 assets have been assigned operational related service work orders from full length sewer cleaning (≥15% of the cross sectional area loss of the pipe) to the removal of obstructions within the line. During re-inspection, consideration must be given to the inclusion of additional costs for the cleaning work orders applied to existing outfall assets to maximise pipe exposure and ascertain more confident delineation of all structural condition related defects.

10.3 Treatment Summary Characteristics

The overall 2016 Outfall Condition Assessment Program identified almost $40 million of potential rehabilitation upgrading. This includes $4.7 million of backlog from outfall pipe deficiencies and $35.2 million of potential geotechnical upgrading erosion control and slope regrading or stabilization. While many of the treatments are substantiated based on commonly accepted rehabilitation/replacement, the large value of slope stabilization works needs to be assessed as noted in Section 9.2 of this report to establish site-by-site validity and scope. Based on the inspections and rationalized treatment selections, the defects present suggest the following treatment strategies:

10.3.1 About 78% of the outfall pipe works should be able to be completed by technologies with minimal construction footprint and little to no excavation based on current observed condition. Trenchless CIPP

work in outfalls needs to employ elevated environmental controls related to styrene management and the use of HDPE as a lining material needs to be carefully vetted due to its combustibility and potential reduction in capacity with sliplining technologies.

10.3.2 190 Geotechnical work orders were assigned within SMS with 68 slope stabilization work orders at Category A outfall pipe locations with 59 of those work orders on SPG 5 outfall pipes (with most SPG's generated by slope as opposed to present pipe condition).

10.3.4 121 service related work orders were generated within SMS that range from full length Sewer Cleaning, Erosion Control to Roots and Obstruction Removal. 55 of these work orders are at Category A outfall pipe locations with 18 locations with an SPG value of 5. No cost summary was possible for pipe related service work orders (Appendix F) due to SMS not including a service cost model. However, the high-level geotechnical service related Erosion Control work orders have been estimated to be approximately $5.8 million.

10.4 Programming of Outfall Treatments

The high cost of slope stabilization relative to the cost of the outfall pipe asset alone makes it difficult to resolve the business case for upgrading at many sites. A practical approach to programming outfall related upgrading is proposed as outlined in Section 9.2 in this report. Highlights of that approach include:

10.4.1 The delineation of all assigned treatment into 5 distinct Assignment Type Classifications as follows:

- Assignment Type I – Conventional Pipe Rehabilitation
- Assignment Type II – Geotechnical Study with Cost-Benefit Assessment
- Assignment Type III - Preventative Maintenance - Geotechnical
- Assignment Type IV - Preventative Maintenance – Pipe
- Assignment Type V - Preventative Maintenance – Pipe and Geotechnical

Assignment Types I, III, IV and V are conventional type of engineering assignments that would carry capital cost estimates for execution and the nature of the work would include a nominal amount of conventional preliminary engineering, design and contract administration services. As no current cost model has been developed within SMS for service related deficiencies, a capital allowance would need to be provided for this work type.

Assignment Type II would be a pure preliminary engineering assignment largely driven by geotechnical and cost benefit financial assessments. The scope would include delineating the true extent of the major slope instability present, and the optimum balance of stabilization improvements and pipe upgrading/rehabilitation. Run to fail options would need to be considered as well as whole asset financial risk exposure within the area affected by the instability.

10.4.2 Based on this approach and conventional worst first prioritization by Criticality Category, the following program was developed for the 5 year capital program and beyond (from Table 21):

				Timing			
				0-3 Years	3-5 Years	5-10 Years	0-5 Years
Assignment Classification	Assignment Type	Number of Pipe Maintenance Sites	Total Cost in k$	SPG 5	SPG4	SPG3	No Pipe Work Identified
I	Conventional pipe rehabilitation	27	$3,240	$817	$537	$1,886	$0
II	Geotechnical study with cost benefit analysis to determine balance of stabilization works and pipe works	50	$34,070	$16,923	$11,579	$2,493	$3,075
III	Preventative Maintenance - Geotechnical	0	$0	$0	$0	$0	$0
IV	Preventative Maintenance - Pipe	8	$0	$0	$0	$0	$0
V	Preventative Maintenance - Geotechnical and pipe	88	$6,426	$200	$0	$1,525	$4,701

Note: Assignment Type II should be viewed as a Potential Financial exposure as a opposed to a known Capital Upgrading Value. Initial exposure is for Preliminary Engineering Services only to facilitate detailed cost-benefit assessment and Business Case Development

10.4.3 Based on the proposed programming approach, the 5 year capital expenditure level for outfalls would be as follows:

1. Assignment Type I (Conventional Pipe Rehabilitation) - $270,000 annually for 5 years.
2. Assignment Type II (Preliminary Engineering for Major Slope Stabilization Driven upgrading) - $285,000 annually for 5 years for preliminary engineering, instrumentation and studies to reduce the Financial Exposure of over $34 million in slope remediation to its optimum value. An additional allowance would have to be made for actual capital programs justified based on the site-specific rehabilitation business cases that are developed.
3. Assignment Types III, IV and V (preventative pipe maintenance and erosion control) - $1,285,000 annually over 5 years for preventative maintenance for to erosion plus an allowance for outfall debris removal to reinstate full outlet capacity.

This translates to $1.841 million in annual funding over the next 5 years, plus the additional cost allowances noted above.

10.5 Closing Synopsis

The City of Winnipeg has a diverse inventory of outfalls that service the sewer collection and land drainage systems. Outfalls range in service area size from localized outfall sites serviced by very small diameter outfalls to very large service areas, very critical in nature and logically serviced by very large outfall pipes with extensive end treatment systems.

While outfall assets can be very challenging to assess, the integration of standard WRc pipe assessment protocol combined with a geotechnical assessment framework that is well aligned to the core WRc condition implications creates an assessment framework that is readily adapted into the same risk-based framework used in the City for collection system assessment.

Careful interpretation of the ramifications of each condition state in conjunction with failure consequence provide a sound basis for risk based planning and business case development for outfalls that is necessary to clarify short and long term upgrading requirements. While longer term upgrading requirements will eventually require re-inspection of

key sites to verify initial assumptions of deterioration timelines, the overall framework provided identifies a prioritized picture of immediate (1-3 year), short term (3-5 year) and longer term (5-10 year) upgrading requirements.

The high cost of major slope stabilization relative to the cost of an outfall pipe alone requires the development of three distinct Assignment Classification Types to rehabilitate and preserve long-term outfall integrity. These include:

- Conventional outfall pipe and appurtenance upgrading assignments coupled with associated preventative maintenance work tasks (driven by a Civil Engineering discipline),
- More advanced geotechnical studies with cost-benefit analysis to optimize approaches for sites where major slope instabilities are present and are driving the rehabilitation process, and
- Preventative maintenance work streams, targeted at locations where no major structural pipe deficiencies or slope instabilities are present, for pipe debris removal to maintain hydraulic capacity and toe erosion control to offset future exposure to larger slope instabilities and localized failure at outfall end sections.

Appendix A

Technical Memorandum - Outfall Condition Assessment Methodology

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204 284 2040 fax

Technical Memorandum

To	Jennifer Coey, Cynthia Wiebe	Page	1
CC	Chris Mitchell, Darren Yarechewski		
Subject	Technical Memorandum Outfall Condition Assessment Methodology		
From	C.C. Macey		
Date	August 21, 2015	Project Number	60431277 (502)

The flowchart attached at the end of this memorandum represents the sequences of tasks that will be performed and the documents that will be produced under the proposed methodology for outfall inspection and assessment. The background color scheme in the flowchart divides the overall procedure into six main blocks which are numbered in accordance with the relevant sections of this document. The initial procedures involve two parallel inspection streams:

- Section 1, outfall pipe inspection (represented in light orange) and
- Section 2, geotechnical site inspection (represented in light green).

The outfall pipe inspections are performed and assessed in conformance with Section 4.3 of Volume I of the Sewer Management Study[1] while the Geotechnical Rating System is presented in Appendix A of this Memorandum.

The two streams come together in Section 3 (represented in light purple) in which the outfall structures are assessed on the basis of both pipe condition and geotechnical criteria and assigned an overall SPG rating. The greater of the two SPG ratings shall govern in terms of treatment approach and risk rating, while the overall data capture of both assessment streams will be captured and preserved within the City's SMS software platform.

In Section 4 (represented as light blue) recommended treatments and associated costs are assigned to the observed defects and deficiencies. In Section 5 (pink) outfall structures are assessed on the basis or urgency and risk. Those in need of immediate repair are identified and the remaining outfalls are classified on the basis of risk to produce a capital plan for repair, monitoring or re-inspection. The final section, Section 6 (white), is the production of the final report which is driven by the overall assessment process.

Appendix A describes the proposed geotechnical assessment criteria and Appendix B is a brief description of the emergency repair process.

[1] *UMA Engineering, "Technical Memoranda for Sewer Condition Assessment, Sewer Rehabilitation Design, and Sewer Maintenance Management for the City of Winnipeg", July 2001*

1. Outfall Pipe Inspection

1.1 Prioritization for Inspection Seasonal Timing (River Level Variation Considerations)

In an effort to minimize the risk that a selected outfall is submerged at the time of inspection hydraulic analysis will be performed using typical river levels for selected times of the year to determine which outfall sites are at risk. The hydraulic analysis will be used to produce an optimal schedule to minimize the risk that pipes will be submerged at the scheduled time of inspection. The primary objective of the inspections is to maximize the visual data capture and carry out other sensing techniques, only where necessary.

1.1.1 CCTV or SONAR

Preliminary analysis has revealed that some outfall structures will likely have a submerged portion for the entire period and will require SONAR inspection technology, or a mix of CCTV and SONAR. All sites will be reviewed and the appropriate inspection methodology(ies) will be assigned.

1.2 Inspection Contracts

This phase of the work requires AECOM to provide the following deliverables:

- Drawings and Bid Opportunity Documents
- Pre-Tender Estimates
- Table of Assets to be inspected in MS Excel format

During the tender period work will include liaising with Materials Management on tender issues, addressing contractor inquiries prior to tender closing, assessing the bid submissions, conducting a pre-award meeting as required, and preparing the recommendation of awards.

1.3 Data Entry and Initial Condition Assessment

Data files submitted by the inspection contractor will be entered into the SMS system which automatically assigns an Internal Condition Grade (ICG) to the structure. Documentation at this point will consist of the inspection histogram produced by SMS, the contractors CCTV video file, and the raw coding used to generate the histogram.

2. Geotechnical Site Inspection

2.1 Preparation for Geotechnical Site Inspections

Tasks that must be performed in preparation for geotechnical inspection fall into two categories, (1) data gathering and (2) rationalizing standardized evaluation procedures. The data gathering tasks include compiling all the relevant GIS data into base maps. The data set includes sewer and outfall pipe attributes, geometry and surrounding buffers as well as air photo, LIDAR and cadastral data.

The geotechnical inspections will use the rating system in Appendix A to capture the state of slope failures and erosion using standardized rating scales. The rating for slope failure will be known as the Slope Condition Grade (SCG) and the rating for erosion known as the Erosion Condition Grade (ECG). The SCG would be analogous to structural grades in the pipe assessment as they relate to slope conditions that could engage pipe structural failures. The ECG ratings are analogous to the pipe's service ratings as their impact on the pipe is more service related and the resulting treatments that it would highlight are analogous to maintenance activities.

In addition, a clear set of rules must be devised for consequence levels that trigger the use of the "Strategic Location" flag in SMS. In very general terms if any SCG or ECG could result in a failure that could engage a major structure (a pumping station, a control structure, etc.), the "Strategic Location" flag within SMS will be turned on and the risk of the outfall will be properly flagged for overall prioritization.

2.2 Geotechnical Site Inspection

Geotechnical site inspection will be accomplished with the aid of an iPad. Software on the iPad will enable on-site data entry and photography. The software enables photographs, attributes and comments to be linked together with the spatial location provided by the embedded GPS. All collected data is machine readable and can be imported directly to AECOM's GIS.

2.3 Processing of Geotechnical Inspection Data

Once geotechnical inspection data has been downloaded from the iPad into the GIS, the inspection data will be overlaid on the base map data described in Section 2.1. Documentation created from this process will consist of geotechnical observation maps hyperlinked to geotechnical inspection photographs. The data produced at this stage will be further processed and exported to Portable Document Format (PDF) in the form of reports, maps and photographs for import into SMS

2.4 Entry of Geotechnical Data into SMS

The Slope Condition Grade (SCG) and the Erosion Condition Grade (ECG) are reviewed prior to entry in SMS. The two ratings will be linked to the asset number of the outfall. In cases where required the "Strategic Location" flag will be set in accordance with the criteria created in Section 2.1. SMS will have to be updated to enable utilize file linking functionality. Once the capability is enabled, PDF documents created in Section 2.3 will be entered into SMS and linked to the outfall assets.

3. Assigning an Overall Structural Performance Grade

The Structural Performance Grade (SPG) will be assigned manually. The SPG can only be assigned once inspection data from both streams, the outfall pipe inspection and the geotechnical inspection, has been entered into SMS. The greater of the two SPG ratings shall govern in terms of treatment approach and risk rating, while the overall data capture of both assessment streams will be captured and preserved within the City's SMS software platform.

4. Treatment Recommendation Procedures

4.1 O & M and Structural Treatments

4.1.1 Outfall Specific Treatments

The recommended treatments will not be limited to structural defects alone. It is anticipated that there will be important service (operation and maintenance) defects that will require attention. In addition there may be treatments required for structural and service defects specific to outfall structures which are not defined in the SMS cost estimating table. These new treatments will be formally defined and assigned unit costs. The new treatments and unit costs would then be entered into SMS master cost estimating table.

4.1.2 Entry of Structural and O&M Treatments in SMS

Once the new structural and service treatments and unit costs have been entered into the SMS database in accordance with Section 3.1.1 treatments can be directly assigned to defects for each inspected outfall.

4.2 Geotechnical Treatments

4.2.1 Rationalizing Geotechnical Treatments and Costs

A complete set of treatment options for remediation of geotechnical deficiencies will be compiled in a format suitable for entry in the SMS database. The treatment list must be imported into the SMS database before assignment of geotechnical treatments can begin. The geotechnical treatments represent a new feature for SMS and the necessary documentation for their use will be provided.

4.2.2 Entry of Geotechnical Treatments in SMS

Once the complete set of treatment options has been entered into SMS, assignment of treatments to geotechnical defects or deficiencies can begin.

5. Assessment of Condition

5.1 Emergency Repairs

Criteria for determining the combinations of conditions and consequences that constitute emergency repairs must be established and documented. These criteria will represent an expanded version of the criteria in present use for sewer infrastructure, adding geotechnical concerns and those structural and service concerns that are unique to sewer outfall structures.

An Emergency Repair Plan will be prepared. The plan will document all the required outfall work that constitutes emergency repairs under the new criteria. The plan will be assembled from data exported from SMS for all assets requiring emergency repairs.

5.2 Prioritize Repair and Re-inspection for Capital Planning

Criteria for scheduling re-inspection of outfall structures will be established and documented. The criteria will be applied to the inspected assets to determine a re-inspection schedule. These will be provided in terms of a Memorandum to update the overall inspection frequency of sewers as currently outlined in Section 5.3 of Volume I of the Sewer Management Study[2].

A capital plan will be prepared for all assets evaluated with a SPG of 3 or higher. The plan will separate the assets into risk categories on the basis of condition and consequence of failure. Each asset will be positioned within a 3 by 3 matrix of nine risk categories based on the three condition grades (3, 4 and 5) and three criticality groups (A, B and C). The existing criteria for assigning the criticality ratings to sewer infrastructure will form the basis of an enhanced criticality rating scheme which will take into consideration consequences of failure specific to outfall structures.

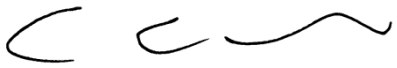
6. Final Report

The document will provide charts and tables that detail the results of the inspections. The information will be presented in form consistent with the capital planning objectives in Section 5.2. In addition to

[2] *UMA Engineering, "Technical Memoranda for Sewer Condition Assessment, Sewer Rehabilitation Design, and Sewer Maintenance Management for the City of Winnipeg", July 2001*

detailed information, charts and tables will be provided to convey the best overview of the general condition of the outfall structures. Repair costs will be prioritized in accordance with assessed risk.

The final report will also summarize all documentation produced to this point including reports of GIS errors.



C.C. Macey, P. Eng.
North America Technical Practice Leader
Condition Assessment and Rehabilitation
/gms

Outfall Condition Assessment

1. OUTFALL INSPECTIONS

Determine Outfall Inspection Prioritization

Prioritization

Submerged Outfalls

Conduct Hydraulic Analysis to Determine Outfall Accessibility

WRc Rating System

Outfall Pipe Inspection Contract (Conventional CCTV or SONAR for Submerged Outfalls)

GIS Correction Reports to WWD

Outfall Pipe Inspection Data

Import Inspection Data to SMS, Calculate Internal Condition Grade (ICG)

Inspection Videos and SMS Histogram

Other Pipe Condition Related Factors (Hydraulics, etc.)

Outfall Pipe

Geotechnical

2. GEOTECHNICAL INSPECTIONS

Rationalize Consequences of Slope Failure For SMS "Strategic Location" Flag

Geotechnical Rating System

Rationalize Geotechnical Rating System (Slope Failure and Erosion Rating Scales)

Outfall Geotechnical Site Inspections

Base Maps

Compile Base Maps

Geotechnical Inspection Data (CSV)

Cadastral, Air Photo, Sewer / Outfall Pipes and Chambers, Slope (LIDAR), Outfall Buffer Zones

Create Geotechnical Observation Maps (Overlay Inspection Observation Points on Base Map)

Review for Overall Slope Condition Grade (SCG) and Erosion Condition Grade (ECG). Results in Database (Link by Outfall Asset Number)

Geotechnical Observation Maps

Geotechnical Inspection Photos

Set SMS "Strategic Location" Flag (May Engage Other Structures If Slope Fails).

3. SPG

Rationalize Final SPG in SMS (Consider both Pipe and Geotechnical Related Factors)

Link Geotechnical Reports to SMS Assets

Create PDF Reports of Geotechnical Observations and Key Photos

Update SMS to Utilize File Linking Functionality

4. TREATMENTS

SMS Treatments and Unit Costs

Rationalize Both O&M and Structural Pipe Treatments, Apply in SMS

Rationalize Both Erosion and Slope Failure Geotechnical Treatments, Apply in SMS

Geotechnical Treatments and Costs

Outfall Pipe Specific Treatments and Costs

Import Outfall Treatments and Unit Costs into SMS

Rationalize Treatments and Unit Costs for Outfall Remediation not in SMS

Import Geotechnical Treatments and Unit Costs into SMS

Rationalize Treatments and Unit Costs for Geotechnical Remediation

5. ASSESSMENT

Establish Re-Inspection Criteria

Re-Inspection Criteria

Rationalize Re-Inspection Requirments

Emergency Repairs Required?

No

Yes

Emergency Repair Criteria

Establish Emergency Repair Criteria

Identify Capital Plan Export Outfall Work From SMS by Asset Number and Prioritize by SPG, Category A,B,C and Strategic Location

Identify Emergency Repair Plan Export Outfall Work From SMS by Asset Number Meeting Emergency Repair Criteria

Probability of Failure	C	B	A
5	Repair / Replace on Failure	Short Term Rehab / Replace	Immediate Rehab / Replace
4	Defer Rehab / Replace	Mid Term Rehab / Replace	Short Term Rehab / Replace
3	Defer Rehab / Replace	Long Term Rehab / Replace	Mid Term Rehab / Replace

Consequence of Failure

6. FINAL REPORT

Compile Final Report

Appendix A

Geotechnical Assessment

Appendix A: Geotechnical Assessment

Data will be collected using an iPad complete with digital forms in GIS (geographic information system) format that allows for direct input of attributes along with a mapped location of the feature. This results in a standardized dataset that allows for comparison over time and replication of results by different inspectors.

The following are attribute fields that will be populated in the iPad. Some of these will be pulldown fields where there are a discrete number of selections for a single attribute. Others may be values for measurements, while still others are Boolean with a “Yes” versus “No” style of entry to indicate whether or not that particular attribute is present. Some information will be pre-populated such as river bank height and inclination (based on LiDAR data) and possible soil type in terms of alluvial versus lacustrine soils. This information will be used to gauge the impact of other attributes in the field during inspection.

Features that are unique at a particular location on the bank will be mapped by setting a point in the iPad data collection PDF map and populating attribute data at that point. Slopes may have several points denoting the location of features depending on the number and uniqueness of features encountered.

The attributes and form of data to be collected is listed as follows.

- **Photos**
- **River Bank Condition**
    - Instability Type (Where Present)
        - Slump
        - Rotation
        - Retrogressive
        - Creep
        - Planar
    - Hummocky Terrain
    - Toe Bulge at Water Edge
    - Scarps
        - Recent (Active)
        - Past
        - Measure the height
        - Map the extent
    - Tension Crack
        - Width
        - Depth
    - Surficial Soil Type (Where Exposed)
        - Clay
        - Silt
        - Sand
        - Gravel
    - Soil Type from Air Photo Interpretation
        - Alluvial
        - Lacustrine
    - Settlement
    - Seepage Evident from the Bank

  - Rip rap present
    - Loose rip rap
    - Grouted rip rap
    - Map rip rap extent
  - Tree Verticality (May also Apply to Other Infrastructure that
    - Tree Lean – Whole tree
    - Tree Bent – Tree was leaning at some point in the past but is now growing vertical since the event that caused the tree to lean has ceased.
- **Slope Inclination**
  - Ratio of horizontal (H) to vertical (V) slope inclination (for example 4H:1V).
  - Obtained from LiDAR terrain model prior to inspection.
  - Measurement of slope inclination will be made with a handheld laser measuring device where recent displacement has occurred and the terrain may not be accurately represented from the LiDAR data.
- **Bank Height**
  - Obtained from LiDAR terrain model prior to inspection.
- **Erosion**
  - Surficial
  - Gulley
    - Depth
    - Width
  - Toe Erosion
  - Global Erosion
    - Outside Bend – Typically prone to erosion
    - Inside Bend – Typically prone to deposition
    - Straight Section – Typically a neutral condition tending neither toward erosion or deposition
  - Global Erosion along River Edge
    - Minor Erosion – 20m to 30m from the Outfall
    - Moderate Erosion – 10m to 20m from the Outfall
    - Significant Erosion – Less than 10m from the Outfall
    - Severe Erosion – Erosion at the Outfall
    - Critical Erosion – Outfall Structure being Undermined
- **Vegetation**
  - None to Limited Grass
  - Grass
  - Small Trees
  - Large Trees
- **Instrumentation**
  - Presence of instrumentation implies that some party in the past had a concern with regard to bank stability and gone a step further by installing and monitoring this instrumentation. The presence of instrumentation does not necessarily mean that displacements are occurring. This can only be borne out by the results of the instrumentation data itself but the mere presence of instrumentation may be an indicator that bank observations in the past have led to a need for a quantifiable examination through instrumentation.
  - Presence of slope inclinometer casings implying monitoring for evidence of slope displacements
  - Presence of piezometer casings implying monitoring of groundwater elevation.

- **Infrastructure**
    - Fences
    - Posts
    - Buildings
    - Equipment
- **Infrastructure Condition**
    - Concrete Crack
    - Brick/Mortar Crack
    - Door / Window Frames Out of Alignment

This information will be used to rank the condition of the river bank in terms of the potential to damage the outfall pipe or outfall structure(s) (for example, pumping station, gate chamber). The assignment of a river bank rank is dependent on the collective attributes as a whole. For example, a tension crack located at a slope toe can be an indicator of localized slumping at the river edge but a similar tension crack at the overall slope crest may be an indicator of global deep-seated movement. The tension crack at the crest has far greater implication for river bank stability than the tension crack at the toe demonstrating that relationship to other attributes and location is important, not easily programmable, and therefore requires sound judgement in assessing the collective attributes.

The factor of safety against bank instability is not used in the qualification of rank with the exception of a bank that is presently failing. The factor of safety is calculable either through computer software or simplified charts but otherwise open to ranging interpretation in the absence of calculation. A bank actively failing is considered to have a factor of safety against bank failure of unity by definition and given Rank 5. A bank that exhibits attributes associated with bank displacement that are small can be related to creep displacements or may have resulted from a slip that occurred in the past that has now ceased moving, potentially by regaining some equilibrium after the displacement, and these may be given a Rank 4. Rank 1 to 3 point to a bank that is generally stable at the present time of inspection. Rank 3 points to the potential for river bank displacement if the erosion potential at the bank toe is left unverified. The progress of the erosion may be years or decades and loss of this toe support could lead to failure farther upslope in the future. The timeframe for this progression is unpredictable at this inspection time owing to a single observation point, and therefore a single point of reference, but comparison with previous terrain models could aid in assessing the rate of toe erosion with time and a simple stability model can be used to assess the critical bank geometry to produce failure. This is outside the scope of this work but establishes the importance of replicable data collection. The following table presents the ranking system.

Geotechnical River Bank Condition Assessment Ranking System

RANK	SHORT DESCRIPTION RISK OF FAILURE	QUALIFICATIONS
1	Minimal	No past or present evidence of bank instability. Slope inclination is a small angle or relatively flat. Shoreline is protected against erosion either with well-established vegetation or rip rap.
2	Low	No past or present evidence of bank instability. Slope inclination is between a small angle to moderately steep. Shoreline is not protected against erosion.
3	Moderate	Erosion at river bank toe may lead to progressive lower bank failure in the future. If left unchecked may lead to upper slope failure in the distant future or with extreme changes in groundwater / river conditions. Slope is moderately steep.
4	High	Evidence of small displacements from the recent past. Past failure evident with major global features. Progressive creep displacements. Severe erosion leading to potential failure in the near future. Slope is steep with greater potential for instability.
5	Presently Failing or At Risk of Imminent Failure	Evidence of active displacement. Exposed fresh soil at scarp face. Fine detail of attenuating tension cracks evident. Vegetation freshly cut or displaced with roots exposed or severed.

The potential requirement for bank improvements does not find a place within this ranking system. Remedial measures will be examined within the context of the consequences associated with failure of the system of outfall piping and associated structures. Consequence of failure will not be discussed here but in brief relates to the impact on socio-economic factors and will range from the cost of infrastructure through to the social impact to the community. Similarly, the need for additional instrumentation and monitoring also hinges on the consequence of failure and the rank of present river bank condition.

This ranking system will be used to categorize the present condition of the river banks at the outfall locations and within the region that the outfall occupies. The attributes collected will also include information from adjacent banks should there be evidence of bank instability that may approach the outfall location from upstream or downstream directions. With this information, the potential impact of the river bank on the infrastructure can be assessed along with the need for additional action.

Appendix B

Urgent Repair Protocol

Appendix B: Urgent Repair Protocol

A Sharepoint site will be created and maintained by AECOM to coordinate all aspects of the urgent repair procedure. Once the Emergency Repair Plan described in Section 5.1 has been assembled the list of required works and affected assets will be posted on the Sharepoint site and WWD will be notified. The City will undertake the necessary repairs and update the Sharepoint site with the date of completion. Re-inspection will be undertaken as required

Appendix B

Structural Performance Grades by District

District	Survey Abandoned	SPG 1	SPG 2	SPG 3	SPG 4	SPG 5	Grand Total
AINSLIE			4		3	2	9
ALEXANDER					1		1
AREA 21					1		1
AREA 21.1					1		1
AREA 22			1				1
AREA 5A				1			1
AREA 8					1	1	2
AREA 9.1				2	1	1	4
AREA 1(NE)				3	7	9	19
AREA 11			2	1		1	4
AREA 16			1	1	1	1	4
AREA 18				2	2	2	6
AREA 19			1		1		2
AREA 2(NE)						1	1
AREA 20				1			1
AREA 21					1		1
AREA 22			2		1		3
AREA 22.2			1	1	1		3
AREA 22.3				1	1		2
AREA 27				1			1
AREA 4.1			2		3		5
AREA 5.1			2	2			4
AREA 6		2	1	2		4	9
AREA 7			2		1		3
AREA 8				1	1	2	4
AREA 9.1				2	1		3
ASH			1	1	3	4	9
ASSINIBOINE				3	1		4
AUBREY					4		4
BALTIMORE		1			4	2	7
BANNATYNE			1	3	2		6
BROOKLANDS				1			1
CLIFTON			1	1		1	3
COCKBURN					1		1
COLONY					1		1
COLONY 40						1	1
CORNISH					4		4
CRANE			2	2	1		5
DESPINS			1		1	2	4

District	Survey Abandoned	SPG 1	SPG 2	SPG 3	SPG 4	SPG 5	Grand Total
DOUGLAS PARK			1		1		2
DUMOULIN	1				1	1	3
FERMOR						1	1
FERRY ROAD						1	1
GOLF COURSE						1	1
HART	1				1		2
HAWTHORNE			1		1		2
HERITAGE	1	2	2	3	2	1	11
JEFFERSON E					1		1
JESSIE			1	1		1	3
KILKENNY			2		5	1	8
LA VERENDRYE			2		5		7
LINDEN	1	1			2		4
MAGER		1	4	6	9	11	31
MARION					3		3
METCALFE					2		2
MISSION	1	1	7	5	4	7	25
MISSION SEPARATE				1			1
MISSION SEPARATE			2		4	2	8
MOORGATE			2	3	1		6
MUNROE				1		1	2
NEWTON					3		3
PARKDALE			2	1	3	4	10
POLSON			1		2		3
RIVER				1		1	2
RIVERBEND			2			3	5
RIVERBEND S						2	2
SELKIRK					2		2
SEWPCC					1		1
SOUTHDALE		1	1	1		1	4
ST CHARLES				2			2
ST NORBERT					1		1
ST JOHNS PARK					1		1
ST NORBERT			1	4	2	2	9
STRATHMILLAN			1				1
SYNDICATE		1	1		1		3
TUXEDO		1			2	1	4
TYLEHURST		1	4	3	2	9	19
WEST PERIMETER				1			1

District	Survey Abandoned	SPG 1	SPG 2	SPG 3	SPG 4	SPG 5	Grand Total
WEST PERIMETER			1				1
WESTWOOD			1	2	3		6
WILLOW			4		1	4	9
WINDSOR PARK		1			1	1	3
WOODHAVEN					2		2
Grand Total	**5**	**13**	**68**	**67**	**120**	**90**	**363**

Appendix C

All Assets with Condition Grades and Rehabilitation Assigned Treatments in order of Asset Number

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA00000073	1	2	3	3	SLOPE REGRADING	0.00	80.80	80.80	-	100.00
S-MA00000120	1	2	4	4	SEWER CLEANING	0.00	77.50	77.50	-	-
					SLOPE STABILIZATION	25.00	77.50	52.50	-	125.00
S-MA00000385	1	3	4	4	SLOPE STABILIZATION	95.00	128.00	33.00	-	125.00
S-MA00017098	3	0	0	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	350.60	350.60	824.90	-
S-MA00017100	3	5	5	5	SLOPE STABILIZATION	180.00	200.23	20.23	-	500.00
S-MA00017633	1	2	4	4	SLOPE STABILIZATION	0.00	17.33	17.33	-	125.00
S-MA00017645	3	1	4	4	SLOPE STABILIZATION	0.00	36.50	36.50	-	125.00
S-MA00017914	1	4	4	1	SEWER CLEANING	0.00	37.41	37.41	-	-
S-MA00017926	1	1	4	4	SEWER CLEANING	3.90	67.40	63.50	-	-
					SLOPE STABILIZATION	0.00	68.70	68.70	-	125.00
S-MA00017939	1	1	4	4	SLOPE STABILIZATION	0.00	45.30	45.30	-	125.00
S-MA00017967	1	3	4	4	SEWER CLEANING	0.00	13.10	13.10	-	-
					SLOPE STABILIZATION	0.00	13.10	13.10	-	125.00
S-MA00017988	1	4	4	4	EROSION CONTROL	15.00	22.50	7.50	-	100.00
					SLOPE REGRADING	10.00	22.58	12.58	-	100.00
S-MA20000064	1	5	5	5	SLOPE STABILIZATION	35.00	53.68	18.68	-	250.00
S-MA20000065	1	4	5	5	OBSTRUCTION REMOVAL	0.00	22.90	22.90	-	-
					SLOPE STABILIZATION	0.00	22.90	22.90	-	250.00
S-MA20000072	1	3	1	3	EROSION CONTROL	0.00	11.40	11.40	-	100.00
					SEWER CLEANING	0.00	11.40	11.40	-	-
S-MA20000077	4	3	1	4	6-EXTERNAL POINT REPAIRS	51.90	53.60	1.70	15.89	-
						63.50	66.00	2.50	17.25	-
					EROSION CONTROL	51.80	65.70	13.90	-	100.00
S-MA20000078	5	5	1	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	57.21	57.21	25.10	-
					SLOPE STABILIZATION	47.90	57.21	9.31	-	125.00
S-MA20000088	5	3	1	5	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	96.60	96.60	71.30	-
S-MA20000107	3	1	1	4	6-EXTERNAL POINT REPAIRS	54.10	61.60	7.50	25.75	-
S-MA20000157	3	1	1	3	3-TRENCHLESS POINT REPAIR	0.00	42.72	42.72	98.88	-
S-MA20002277	3	4	1	4	EROSION CONTROL	10.00	21.30	11.30	-	100.00
S-MA20002394	5	1	1	5	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	32.05	32.05	114.22	-
S-MA20002395	2	3	1	3	SEWER CLEANING	0.00	32.30	32.30	-	-
S-MA20002806	3	4	4	4	SEWER CLEANING	75.00	96.32	21.32	-	-
					SLOPE STABILIZATION	75.00	96.32	21.32	-	125.00
S-MA20003569	2	3	2	3	EROSION CONTROL	85.00	91.05	6.05	-	100.00
S-MA20003870	1	1	1	1	SEWER CLEANING	0.00	3.50	3.50	-	-
S-MA20003873	1	1	1	2	SEWER CLEANING	0.00	62.31	62.31	-	-
S-MA20003886	5	1	4	5	1-STABILIZATION (MAN ENTRY)	0.00	92.50	92.50	185.00	-
					2-FULL SEGMENT RENOVATION (RELINING)	92.50	119.30	26.80	67.21	-

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA20005604	2	4	2	4	3-TRENCHLESS POINT REPAIR	48.40	52.60	4.20	13.30	-
					EROSION CONTROL	101.60	105.61	4.01	-	100.00
					SEWER CLEANING	0.00	52.60	52.60	-	-
S-MA20006898	1	1	1	3	SEWER CLEANING	0.00	3.20	3.20	-	-
S-MA20007097	1	5	5	5	SLOPE STABILIZATION	0.00	54.62	54.62	-	125.00
S-MA20007260	1	5	5	5	SEWER CLEANING	0.00	28.80	28.80	-	-
					SLOPE STABILIZATION	60.00	84.66	24.66	-	250.00
S-MA20008519	1	4	4	4	SEWER CLEANING	0.00	24.83	24.83	-	-
					SLOPE STABILIZATION	0.00	24.83	24.83	-	125.00
S-MA20008520	2	4	4	2	SEWER CLEANING	0.00	68.53	68.53	-	-
S-MA20008800	3	5	3	5	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	20.28	20.28	45.21	-
S-MA20008967	4	5	4	5	1-STABILIZATION (MAN ENTRY)	16.00	21.30	5.30	10.60	-
					6-EXTERNAL POINT REPAIRS	32.00	34.51	2.51	17.27	-
					SLOPE STABILIZATION	0.00	33.10	33.10	-	125.00
S-MA20009774	1	5	4	5	EROSION CONTROL	10.00	15.10	5.10	-	100.00
					SLOPE STABILIZATION	0.00	26.80	26.80	-	125.00
S-MA20009804	3	5	5	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	23.47	23.47	10.13	125.00
					EROSION CONTROL	0.00	23.47	23.47	-	125.00
					SLOPE REGRADING	10.00	23.47	13.47	-	125.00
S-MA20009806	1	5	5	5	EROSION CONTROL	20.00	22.54	2.54	-	125.00
					SLOPE STABILIZATION	0.00	22.54	22.54	-	125.00
S-MA20009860	1	1	5	5	SLOPE STABILIZATION	0.00	23.01	23.01	-	250.00
S-MA20009935	5	5	5	5	6-EXTERNAL POINT REPAIRS	5.00	6.00	1.00	13.00	125.00
					SLOPE STABILIZATION	0.00	10.00	10.00	-	125.00
S-MA20009953	1	1	5	5	SLOPE STABILIZATION	0.00	15.37	15.37	-	250.00
S-MA20010431	1	4	4	4	SLOPE STABILIZATION	0.00	20.82	20.82	-	125.00
S-MA20010432	1	4	3	4	SEWER CLEANING	0.00	10.10	10.10	-	-
					SLOPE REGRADING	0.00	10.10	10.10	-	100.00
S-MA20010505	1	4	5	5	SLOPE STABILIZATION	0.00	19.82	19.82	-	125.00
S-MA20010513	1	3	2	3	SEWER CLEANING	0.00	11.90	11.90	-	-
					SLOPE REGRADING	0.00	11.90	11.90	-	100.00
S-MA20010515	1	3	2	3	SEWER CLEANING	0.00	22.47	22.47	-	-
					SLOPE REGRADING	12.47	22.47	10.00	-	100.00
S-MA20011467	2	5	4	5	EROSION CONTROL	50.00	60.80	10.80	-	100.00
S-MA20011468	5	3	3	5	6-EXTERNAL POINT REPAIRS	27.00	33.00	6.00	20.50	-
S-MA20011477	1	2	2	2	SEWER CLEANING	0.00	36.78	36.78	-	-
S-MA20013203	1	1	3	3	SEWER CLEANING	0.00	39.78	39.78	-	-
					SLOPE REGRADING	0.00	39.78	39.78	-	100.00
S-MA20013332	1	1	4	4	SLOPE STABILIZATION	170.00	191.34	21.34	-	125.00

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA20013630	3			4	6-EXTERNAL POINT REPAIRS	20.80	59.36	38.56	78.55	-
					SLOPE STABILIZATION	20.20	43.60	23.40	-	125.00
S-MA20014087	2	1	3	3	SLOPE REGRADING	60.00	71.60	11.60	-	100.00
S-MA20014095	1	1	3	3	SEWER CLEANING	0.00	58.10	58.10	-	-
					SLOPE REGRADING	40.00	58.10	18.10	-	100.00
S-MA20014505	1	2	5	5	SLOPE STABILIZATION	25.00	61.86	36.86	-	500.00
S-MA20020018	3	2	3	3	SLOPE REGRADING	40.00	53.87	13.87	-	100.00
S-MA232-0034	4	5	4	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	28.91	28.91	11.44	-
					SLOPE STABILIZATION	0.00	28.91	28.91	-	125.00
S-MA232-0035	5	2	4	5	6-EXTERNAL POINT REPAIRS	11.70	22.80	11.10	28.15	-
					SLOPE STABILIZATION	11.00	22.80	11.80	-	125.00
S-MA232-0038	1	3	4	4	EROSION CONTROL	10.00	12.20	2.20	-	100.00
S-MA232-0056	1	1	3	3	SEWER CLEANING	0.00	67.70	67.70	-	-
					SLOPE REGRADING	50.00	67.70	17.70	-	100.00
S-MA232-0063	3	4	5	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	143.90	143.90	257.04	-
					EROSION CONTROL	135.00	149.40	14.40	-	100.00
					SLOPE STABILIZATION	130.00	149.40	19.40	-	250.00
S-MA232-0064	3	5	5	5	EROSION CONTROL	0.00	20.00	20.00	-	100.00
					SLOPE REGRADING	0.00	20.00	20.00	-	100.00
S-MA40000014	5	1	4	5	3-TRENCHLESS POINT REPAIR	0.00	6.50	6.50	23.10	-
					5-FULL SEGMENT REPLACEMENT (RENEWAL)	77.00	94.20	17.20	49.41	-
S-MA40000143	1	3	4	4	SLOPE STABILIZATION	0.00	15.50	15.50	-	125.00
S-MA40000202	3	1	4	4	1-STABILIZATION (MAN ENTRY)	20.20	21.20	1.00	1.00	-
					2-FULL SEGMENT RENOVATION (RELINING)	0.00	25.30	25.30	18.42	-
					SLOPE STABILIZATION	0.00	25.30	25.30	-	125.00
S-MA40000244	1	3	4	4	SLOPE STABILIZATION	0.00	20.00	20.00	-	125.00
S-MA40000250	2	1	4	4	SLOPE STABILIZATION	20.00	27.20	7.20	-	125.00
S-MA40000284	3	4	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	28.40	28.40	54.34	-
					SLOPE STABILIZATION	0.00	28.40	28.40	-	125.00
S-MA40000289	5	1	4	5	6-EXTERNAL POINT REPAIRS	13.50	26.00	12.50	34.25	-
					SLOPE STABILIZATION	13.50	26.00	12.50	-	125.00
S-MA40000355	1	3	1	3	EROSION CONTROL	0.00	3.60	3.60	-	100.00
S-MA40000750	1	4	5	5	SLOPE STABILIZATION	85.00	114.07	29.07	-	250.00
S-MA40001338	3	3	5	5	1-STABILIZATION (MAN ENTRY)	8.60	9.60	1.00	2.00	-
					SLOPE STABILIZATION	0.00	14.03	14.03	-	250.00
S-MA40001339	1	3	5	5	EROSION CONTROL	50.00	65.00	15.00	-	100.00
					SLOPE STABILIZATION	40.00	65.00	25.00	-	250.00
S-MA40001340	2	3	5	5	SLOPE STABILIZATION	40.00	65.15	25.15	-	500.00
S-MA40001341	3	3	5	5	SLOPE STABILIZATION	0.00	18.40	18.40	-	250.00

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA40001409	3	3	5	5	6-EXTERNAL POINT REPAIRS	12.00	14.00	2.00	14.50	250.00
					SLOPE STABILIZATION	0.00	14.00	14.00	-	250.00
S-MA40001432	3	3	5	5	6-EXTERNAL POINT REPAIRS	0.00	17.10	17.10	42.07	250.00
S-MA40002011	2	2	3	2	ROOTS REMOVAL	0.00	37.10	37.10	-	-
S-MA40003056	4	3	3	4	6-EXTERNAL POINT REPAIRS	53.00	65.00	12.00	33.40	-
					SLOPE REGRADING	53.00	65.00	12.00	-	100.00
S-MA40005212	3	5	4	5	EROSION CONTROL	10.00	21.90	11.90	-	100.00
					SLOPE REGRADING	10.00	21.90	11.90	-	100.00
S-MA40006872	1	3	4	4	6-EXTERNAL POINT REPAIRS	65.00	79.28	14.28	37.28	-
					SLOPE STABILIZATION	60.00	79.28	19.28	-	125.00
S-MA40011011	2	1	4	4	SLOPE REGRADING	30.00	41.50	11.50	-	100.00
S-MA50002498	2	1	3	2	SLOPE STABILIZATION	0.00	6.00	6.00	-	125.00
S-MA50002566	5	3	4	5	6-EXTERNAL POINT REPAIRS	12.00	17.60	5.60	19.90	-
					SLOPE REGRADING	0.00	16.09	16.09	-	100.00
S-MA50002903	2	4	5	5	SLOPE STABILIZATION	0.00	22.50	22.50	-	250.00
S-MA50008353	3	4	4	4	1-STABILIZATION (MAN ENTRY)	37.70	40.00	2.30	4.60	-
					SLOPE STABILIZATION	20.00	43.80	23.80	-	125.00
S-MA50008393	1	4	5	5	SLOPE STABILIZATION	60.00	78.66	18.66	-	250.00
S-MA50008789	2	4	4	4	EROSION CONTROL	60.70	67.30	6.60	-	100.00
					SEWER CLEANING	0.00	67.30	67.30	-	-
					SLOPE REGRADING	60.70	67.30	6.60	-	100.00
S-MA50008850	2	3	4	4	SLOPE STABILIZATION	20.00	30.50	10.50	-	125.00
S-MA50010420	1	3	4	4	SLOPE STABILIZATION	150.00	190.70	40.70	-	125.00
S-MA50010691	1	5	4	5	EROSION CONTROL	25.00	32.80	7.80	-	100.00
S-MA50011163	1	5	5	5	SLOPE STABILIZATION	0.00	20.48	20.48	-	250.00
S-MA50011491	3	1	4	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	96.52	96.52	173.89	-
S-MA50011492	4	1	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	35.01	35.01	65.94	-
					SLOPE REGRADING	20.00	35.00	15.00	-	100.00
S-MA50012073	2	3	4	4	SLOPE STABILIZATION	0.00	31.20	31.20	-	125.00
S-MA50013076	1	5	4	5	EROSION CONTROL	19.00	21.20	2.20	-	100.00
S-MA50013561	3	2	3	2	OBSTRUCTION REMOVAL	0.00	10.00	10.00	-	-
S-MA50014432	3	3	1	4	6-EXTERNAL POINT REPAIRS	73.60	77.60	4.00	19.80	-
					EROSION CONTROL	73.60	77.60	4.00	-	100.00
S-MA50014591	2	4	4	4	5-FULL SEGMENT REPLACEMENT (RENEWAL)	27.60	45.31	17.71	51.88	-
					SEWER CLEANING	22.20	44.30	22.10	-	-
S-MA50014761	3	1	5	5	SLOPE STABILIZATION	35.00	56.34	21.34	-	250.00
S-MA50015373	3	3	4	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	43.30	43.30	36.98	-
S-MA50015374	3	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	29.60	29.60	26.70	-
					SLOPE STABILIZATION	0.00	29.60	29.60	-	125.00

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA50015411	2	5	4	5	EROSION CONTROL	26.00	30.91	4.91	-	100.00
					SLOPE STABILIZATION	0.00	30.91	30.91	-	125.00
S-MA50015464	2	5	4	5	EROSION CONTROL	0.00	9.40	9.40	-	100.00
S-MA50017305	3	2	3	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	31.20	31.20	32.58	-
S-MA50017691	1	4	5	5	SLOPE STABILIZATION	0.00	8.40	8.40	-	250.00
S-MA50017699	2	4	5	5	SLOPE STABILIZATION	0.00	5.80	5.80	-	500.00
S-MA50018093	3	2	3	3	SLOPE REGRADING	0.00	25.90	25.90	-	100.00
S-MA50018567	5	5	4	5	6-EXTERNAL POINT REPAIRS	23.50	29.30	5.80	22.86	-
					EROSION CONTROL	20.00	29.30	9.30	-	100.00
S-MA60001546	1	5	4	5	SLOPE STABILIZATION	10.00	24.38	14.38	-	125.00
S-MA60001604	3	3	4	4	6-EXTERNAL POINT REPAIRS	45.00	67.67	22.67	51.54	-
					SLOPE STABILIZATION	45.00	67.67	22.67	-	125.00
S-MA60001609	4	3	3	4	6-EXTERNAL POINT REPAIRS	58.00	62.11	4.11	19.98	-
					EROSION CONTROL	55.00	62.11	7.11	-	100.00
S-MA60003296	3	3	3	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	17.98	17.98	14.39	-
					SEWER CLEANING	0.00	17.98	17.98	-	-
					SLOPE REGRADING	0.00	17.98	17.98	-	100.00
S-MA60003371	1	3	3	3	SLOPE REGRADING	30.00	42.60	12.60	-	100.00
S-MA60003741	3	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	33.10	33.10	39.26	-
					SLOPE STABILIZATION	0.00	33.10	33.10	-	125.00
S-MA60003875	1	3	4	4	SEWER CLEANING	10.00	25.21	15.21	-	-
					SLOPE STABILIZATION	0.00	25.00	25.00	-	125.00
S-MA60004165	3	5	5	5	SEWER CLEANING	0.00	37.92	37.92	-	-
					SLOPE STABILIZATION	0.00	37.92	37.92	-	250.00
S-MA60006745	5	1	3	5	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	15.80	15.80	47.02	-
S-MA60006747	3	5	5	5	SLOPE STABILIZATION	0.00	8.88	8.88	-	250.00
S-MA60007249	5	5	4	5	1-STABILIZATION (MAN ENTRY)	98.20	99.60	1.40	2.80	125.00
					3-TRENCHLESS POINT REPAIR	97.20	100.60	3.40	15.10	125.00
					SLOPE STABILIZATION	98.20	126.25	28.05	-	125.00
S-MA60012037	1	1	4	4	SLOPE STABILIZATION	20.00	39.49	19.49	-	125.00
S-MA60012432	1	4	5	5	CB REPAIR	14.90	27.80	12.90	-	-
					SEWER CLEANING	0.00	27.80	27.80	-	-
					SLOPE STABILIZATION	14.90	27.80	12.90	-	250.00
S-MA60013422	1	3	5	5	SEWER CLEANING	50.00	65.60	15.60	-	-
					SLOPE STABILIZATION	0.00	65.60	65.60	-	250.00
S-MA60013599	1	4	4	4	SLOPE STABILIZATION	0.00	55.37	55.37	-	125.00
S-MA60016840	3	2	3	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	35.80	35.80	31.35	-
					SLOPE REGRADING	0.00	35.80	35.80	-	100.00

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA60020193	1	1	4	5	SEWER CLEANING	0.00	153.72	153.72	-	-
					SLOPE STABILIZATION	100.00	153.72	53.72	-	125.00
S-MA60021014	1	5	5	5	EROSION CONTROL	60.00	80.00	20.00	-	500.00
					SLOPE STABILIZATION	60.00	80.00	20.00	-	500.00
S-MA60021034	1	1	4	4	SLOPE REGRADING	95.00	118.41	23.41	-	100.00
S-MA60021687	1	4	4	4	SEWER CLEANING	0.00	46.19	46.19	-	-
S-MA60022470	2	1	3	3	SEWER CLEANING	2.00	69.90	67.90	-	-
					SLOPE REGRADING	10.00	50.00	40.00	-	100.00
S-MA60022526	4	3	2	4	6-EXTERNAL POINT REPAIRS	57.30	63.63	6.33	23.76	-
S-MA60022654	2	3	1	3	EROSION CONTROL	157.00	167.00	10.00	-	100.00
S-MA60023323	5	5	5	5	6-EXTERNAL POINT REPAIRS	17.00	18.20	1.20	13.30	500.00
					SLOPE STABILIZATION	0.00	25.73	25.73	-	500.00
S-MA60023328	2	1	1	2	OBSTRUCTION REMOVAL	0.00	8.89	8.89	-	-
S-MA70000304	1	1	4	2	SEWER CLEANING	0.00	27.30	27.30	-	-
S-MA70000751	1	1	5	5	SLOPE STABILIZATION	160.00	195.00	35.00	-	250.00
S-MA70000991	1	3	4	4	SLOPE STABILIZATION	40.00	71.40	31.40	-	125.00
S-MA70001233	1	3	3	3	EROSION CONTROL	0.00	18.40	18.40	-	100.00
S-MA70003216	4	3	4	4	1-STABILIZATION (MAN ENTRY)	19.10	19.20	0.10	0.10	-
S-MA70004387	1	1	3	3	SLOPE REGRADING	20.00	26.33	6.33	-	100.00
S-MA70005806	1	2	4	4	SEWER CLEANING	0.00	53.59	53.59	-	-
					SLOPE STABILIZATION	26.00	53.59	27.59	-	125.00
S-MA70006168	2	1	3	3	SLOPE REGRADING	0.00	46.49	46.49	-	100.00
S-MA70006325	1	4	5	5	SEWER CLEANING	0.00	95.43	95.43	-	-
					SLOPE STABILIZATION	50.00	95.43	45.43	-	250.00
S-MA70006655	1	4	4	4	SLOPE STABILIZATION	0.00	47.31	47.31	-	125.00
S-MA70006845	2	4	5	5	SLOPE STABILIZATION	50.00	60.00	10.00	-	250.00
S-MA70006919	2	1	1	2	SEWER CLEANING	53.50	61.00	7.50	-	-
S-MA70007351	1	5	5	5	EROSION CONTROL	50.00	61.00	11.00	-	250.00
					SLOPE STABILIZATION	45.00	61.00	16.00	-	250.00
S-MA70007427	1	1	4	4	SLOPE STABILIZATION	50.00	116.66	66.66	-	125.00
S-MA70007444	5	3	3	5	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	103.40	103.40	80.90	-
S-MA70007461	1	3	5	5	SLOPE STABILIZATION	0.00	15.60	15.60	-	250.00
S-MA70007473	3	2	4	4	SLOPE STABILIZATION	0.00	39.20	39.20	-	125.00
S-MA70007510	3	1	4	4	3-TRENCHLESS POINT REPAIR	0.00	10.00	10.00	34.90	-
					SLOPE STABILIZATION	0.00	27.20	27.20	-	125.00
S-MA70007540	2	1	4	2	SEWER CLEANING	0.00	115.20	115.20	-	-
S-MA70007543	1	3	3	3	EROSION CONTROL	0.00	26.90	26.90	-	100.00
S-MA70007547	1	1	4	4	SEWER CLEANING	0.00	72.62	72.62	-	-
					SLOPE STABILIZATION	60.00	72.62	12.62	-	125.00
S-MA70007551	1	1	4	4	SLOPE STABILIZATION	30.00	58.70	28.70	-	125.00

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S-MA70007561	3	1	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	48.40	48.40	16.12	-
					SLOPE STABILIZATION	35.00	48.40	13.40	-	125.00
S-MA70007642	1	3	5	5	SLOPE STABILIZATION	60.00	89.13	29.13	-	250.00
S-MA70007646	1	3	5	5	SLOPE STABILIZATION	75.00	85.32	10.32	-	250.00
S-MA70007648	1	2	4	4	SLOPE STABILIZATION	80.00	87.20	7.20	-	125.00
S-MA70008060	1	1	4	4	SEWER CLEANING	0.00	139.84	139.84	-	-
					SLOPE STABILIZATION	120.00	139.84	19.84	-	125.00
S-MA70008123	1	1	3	3	SEWER CLEANING	12.00	50.00	38.00	-	-
					SLOPE REGRADING	0.00	50.26	50.26	-	100.00
S-MA70008559	2	4	4	4	SLOPE STABILIZATION	0.00	9.60	9.60	-	125.00
S-MA70008562	4	1	1	4	6-EXTERNAL POINT REPAIRS	38.00	55.94	17.94	43.50	-
S-MA70008591	2	5	4	5	EROSION CONTROL	0.00	19.31	19.31	-	100.00
S-MA70008652	2	3	2	3	EROSION CONTROL	0.00	10.24	10.24	-	100.00
S-MA70008731	1	3	3	3	SLOPE REGRADING	15.00	31.56	16.56	-	100.00
S-MA70009397	1	1	5	5	SLOPE STABILIZATION	18.00	27.20	9.20	-	250.00
S-MA70011066	2	3	3	2	SEWER CLEANING	0.00	46.60	46.60	-	-
S-MA70011068	3	3	3	3	EROSION CONTROL	95.00	102.10	7.10	-	100.00
S-MA70011095	3	4	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	38.78	38.78	72.57	-
					EROSION CONTROL	25.00	38.80	13.80	-	100.00
					SLOPE REGRADING	20.00	38.80	18.80	-	100.00
S-MA70011100	3	3	3	3	EROSION CONTROL	0.00	34.20	34.20	-	100.00
S-MA70011102	4	2	4	4	6-EXTERNAL POINT REPAIRS	40.00	64.00	24.00	53.80	-
					SLOPE STABILIZATION	40.00	64.00	24.00	-	125.00
S-MA70011104	2	4	4	4	EROSION CONTROL	20.00	39.57	19.57	-	100.00
S-MA70011115	1	1	4	4	SEWER CLEANING	0.00	33.85	33.85	-	-
					SLOPE STABILIZATION	25.00	33.85	8.85	-	125.00
S-MA70011167	1	2	4	4	SLOPE REGRADING	50.00	80.00	30.00	-	100.00
S-MA70011369	3	4	4	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	89.83	89.83	214.70	-
S-MA70011372	3	2	3	3	SLOPE STABILIZATION	40.00	73.90	33.90	-	125.00
S-MA70011382	4	3	4	4	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	14.50	14.50	69.02	-
					SLOPE STABILIZATION	1.00	15.50	14.50	-	125.00
S-MA70011823	2	1	4	4	SLOPE REGRADING	0.00	20.10	20.10	-	100.00
S-MA70012111	3	1	2	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	57.55	57.55	116.72	-
S-MA70012690	5	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	52.89	52.89	23.54	-
					SLOPE STABILIZATION	50.00	52.89	2.89	-	125.00
S-MA70014674	1	1	3	3	SEWER CLEANING	0.00	22.20	22.20	-	-
					SLOPE REGRADING	0.00	22.20	22.20	-	100.00
S-MA70015994	5	1	1	5	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	16.80	16.80	50.24	-

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA70016004	5	4	3	4	1-STABILIZATION (MAN ENTRY)	0.00	13.20	13.20	26.40	-
					EROSION CONTROL	30.00	51.50	21.50	-	100.00
					SEWER CLEANING	0.00	51.50	51.50	-	-
S-MA70016005	3	4	4	4	SLOPE STABILIZATION	0.00	42.60	42.60	-	125.00
S-MA70016115	1	3	4	4	SLOPE STABILIZATION	40.00	108.63	68.63	-	125.00
S-MA70016174	1	1	3	3	SLOPE REGRADING	0.00	56.70	56.70	-	100.00
S-MA70016460	1	3	4	2	1-STABILIZATION (MAN ENTRY)	0.00	25.50	25.50	-	-
					SEWER CLEANING	0.00	31.20	31.20	-	-
S-MA70017186	1	1	4	3	SLOPE REGRADING	10.00	21.50	11.50	-	100.00
S-MA70017556	3	3	4	4	SLOPE REGRADING	25.00	38.00	13.00	-	100.00
S-MA70017579	3	1	4	4	1-STABILIZATION (MAN ENTRY)	0.00	26.74	26.74	53.48	-
					SLOPE STABILIZATION	0.00	26.74	26.74	-	125.00
S-MA70017585	1	2	4	4	SEWER CLEANING	0.00	55.45	55.45	-	-
					SLOPE STABILIZATION	25.00	55.45	30.45	-	125.00
S-MA70017667	3	1	4	4	SLOPE STABILIZATION	22.00	23.08	1.08	-	125.00
S-MA70017688	1	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	39.21	39.21	26.07	-
					SLOPE STABILIZATION	10.00	39.21	29.21	-	125.00
S-MA70017694	2	1	5	5	SLOPE STABILIZATION	0.00	34.80	34.80	-	250.00
S-MA70017866	1	3	4	4	SEWER CLEANING	0.00	61.26	61.26	-	-
					SLOPE STABILIZATION	45.00	61.26	16.26	-	125.00
S-MA70018393	0	0	0	0	2-FULL SEGMENT RENOVATION (RELINING)	0.00	3.70	3.70	8.66	-
S-MA70019277	3	3	3	3	EROSION CONTROL	0.00	34.60	34.60	-	100.00
S-MA70019337	2	5	3	2	SEWER CLEANING	0.00	61.50	61.50	-	-
S-MA70019346	3	5	3	5	EROSION CONTROL	0.00	21.50	21.50	-	100.00
					SEWER CLEANING	0.00	6.10	6.10	-	-
S-MA70019489	3	3	4	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	53.78	53.78	130.35	-
S-MA70019662	3	4	2	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	62.60	62.60	79.62	-
S-MA70019763	2	3	4	4	EROSION CONTROL	0.00	16.47	16.47	-	100.00
					SLOPE REGRADING	0.00	16.47	16.47	-	100.00
S-MA70019766	3	3	4	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	77.41	77.41	74.17	-
S-MA70019979	5	4	3	4	1-STABILIZATION (MAN ENTRY)	0.00	66.40	66.40	132.80	-
S-MA70021229	1	1	4	4	SLOPE STABILIZATION	15.00	88.94	73.94	-	125.00
S-MA70021246	1	5	3	5	EROSION CONTROL	0.00	74.88	74.88	-	100.00
					SEWER CLEANING	0.00	74.88	74.88	-	-
S-MA70022226	1	1	4	4	SLOPE STABILIZATION	0.00	32.60	32.60	-	125.00
S-MA70022370	1	4	4	1	SEWER CLEANING	0.00	25.83	25.83	-	-
					SLOPE STABILIZATION	0.00	25.83	25.83	-	125.00
S-MA70022480	1	4	4	4	SEWER CLEANING	0.00	122.38	122.38	-	-
					SLOPE STABILIZATION	100.00	122.38	22.38	-	125.00

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S-MA70022563	1	1	4	4	SLOPE STABILIZATION	30.00	39.60	9.60	-	125.00
S-MA70023153	2	3	4	4	SLOPE REGRADING	0.00	43.00	43.00	-	100.00
S-MA70023285	1	1	2	2	SEWER CLEANING	0.00	47.47	47.47	-	-
S-MA70023892	1	4	4	4	EROSION CONTROL	30.00	45.60	15.60	-	100.00
					SLOPE REGRADING	25.00	45.60	20.60	-	100.00
S-MA70024441	1	4	4	4	SEWER CLEANING	0.00	103.50	103.50	-	-
					SLOPE STABILIZATION	80.00	103.50	23.50	-	125.00
S-MA70028445	4	3	4	4	6-EXTERNAL POINT REPAIRS	0.00	16.00	16.00	35.50	-
						12.50	13.50	1.00	13.00	-
					SLOPE STABILIZATION	0.00	16.00	16.00	-	125.00
S-MA70028476	5	1	2	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	60.81	60.81	26.39	-
S-MA70028480	2	3	3	3	EROSION CONTROL	15.00	29.30	14.30	-	100.00
S-MA70029012	1	4	4	4	SEWER CLEANING	0.00	23.50	23.50	-	-
					SLOPE STABILIZATION	0.00	23.50	23.50	-	125.00
S-MA70029924	1	1	4	4	SEWER CLEANING	0.00	20.51	20.51	-	-
					SLOPE STABILIZATION	0.00	20.51	20.51	-	125.00
S-MA70030181	3	4	5	5	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	125.00	125.00	93.00	-
					SLOPE STABILIZATION	54.70	64.70	10.00	-	250.00
S-MA70030182	1	4	5	5	REMOVE CONCRETE AT INVERT	0.00	5.50	5.50	-	-
					SLOPE STABILIZATION	0.00	5.50	5.50	-	250.00
S-MA70031499	1	3	5	5	SLOPE STABILIZATION	0.00	16.60	16.60	-	250.00
S-MA70031713	1	5	4	5	SLOPE STABILIZATION	0.00	3.51	3.51	-	125.00
S-MA70031819	2	1	3	3	SLOPE REGRADING	0.00	45.10	45.10	-	100.00
S-MA70032231	2	2	5	5	SLOPE REGRADING	80.00	122.90	42.90	-	500.00
S-MA70032285	5	5	3	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	34.64	34.64	35.68	-
					EROSION CONTROL	35.00	40.60	5.60	-	100.00
S-MA70032567	2	2	4	4	SLOPE STABILIZATION	76.00	86.15	10.15	-	125.00
S-MA70033504	2	4	4	4	SLOPE STABILIZATION	0.00	20.38	20.38	-	125.00
S-MA70033535	1	4	4	4	EROSION CONTROL	14.00	24.60	10.60	-	100.00
					SLOPE REGRADING	14.00	24.60	10.60	-	100.00
S-MA70039670	1	1	4	4	SLOPE STABILIZATION	30.00	68.50	38.50	-	125.00
S-MA70041371	4	2	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	18.52	18.52	47.83	-
S-MA70041411	5	2	4	5	6-EXTERNAL POINT REPAIRS	5.80	12.00	6.20	20.80	-
					SLOPE STABILIZATION	5.80	12.00	6.20	-	125.00
S-MA70041421	1	5	4	5	SEWER CLEANING	0.00	57.90	57.90	-	-
					SLOPE STABILIZATION	45.00	57.91	12.91	-	125.00
S-MA70041564	3	1	4	3	SLOPE REGRADING	30.70	45.70	15.00	-	100.00

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA70041572	1	3	5	5	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	23.87	23.87	100.70	-
					SEWER CLEANING	0.00	23.87	23.87	-	-
					SLOPE STABILIZATION	0.00	23.87	23.87	-	250.00
S-MA70041784	3	2	2	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	17.30	17.30	17.48	-
S-MA70041830	2	2	4	4	SLOPE STABILIZATION	15.00	24.99	9.99	-	125.00
S-MA70041926	3	1	4	4	SLOPE STABILIZATION	0.00	23.30	23.30	-	125.00
S-MA70044563	3	3	2	3	EROSION CONTROL	23.00	25.62	2.62	-	100.00
S-MA70044846	4	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	40.79	40.79	41.21	-
					SLOPE STABILIZATION	0.00	40.79	40.79	-	125.00
S-MA70047759	5	1	5	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	36.09	36.09	42.40	-
					OBSTRUCTION REMOVAL	22.00	36.09	14.09	-	-
					SLOPE STABILIZATION	0.00	36.09	36.09	-	250.00
S-MA70049736	1	2	3	3	SLOPE REGRADING	90.00	101.60	11.60	-	100.00
S-MA70052164	1	1	3	3	SLOPE REGRADING	10.00	40.00	30.00	-	100.00
S-MA70052301	1	3	2	3	EROSION CONTROL	80.00	86.16	6.16	-	100.00
S-MA70053445	1	3	2	3	EROSION CONTROL	68.00	70.73	2.73	-	100.00
S-MA70053466	1	4	4	4	EROSION CONTROL	15.00	33.40	18.40	-	100.00
					SLOPE REGRADING	15.00	33.40	18.40	-	100.00
S-MA70053500	1	1	4	4	SEWER CLEANING	0.00	34.59	34.59	-	-
					SLOPE STABILIZATION	0.00	34.59	34.59	-	125.00
S-MA70053508	3	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	21.70	21.70	16.44	-
					SLOPE STABILIZATION	0.00	21.70	21.70	-	125.00
S-MA70058126	2	1	4	4	SLOPE REGRADING	30.00	60.30	30.30	-	100.00
S-MA70062167	1	1	4	4	SEWER CLEANING	51.40	52.40	1.00	-	-
					SLOPE REGRADING	0.00	52.40	52.40	-	100.00
S-MA70068974	2	1	4	4	SLOPE STABILIZATION	40.00	54.10	14.10	-	125.00
S-MA70069313	1	1	4	4	SLOPE REGRADING	15.00	35.72	20.72	-	100.00
S-MA70070656	1	2	3	3	SLOPE REGRADING	70.00	99.70	29.70	-	100.00
S-MA70074230	1	1	4	4	SLOPE STABILIZATION	60.00	80.60	20.60	-	125.00
S-MA70078949	1	1	4	4	SLOPE STABILIZATION	90.00	105.99	15.99	-	125.00
S-MA70082045	1	3	3	3	EROSION CONTROL	0.00	8.80	8.80	-	100.00
					SEWER CLEANING	0.00	8.80	8.80	-	-
S-MA70087426	1	1	5	5	SEWER CLEANING	12.00	19.87	7.87	-	-
					SLOPE STABILIZATION	0.00	19.87	19.87	-	250.00
S-MA70087433	2	2	4	4	SLOPE REGRADING	40.00	55.60	15.60	-	100.00
S-MA70087882	1	3	5	5	SLOPE STABILIZATION	0.00	24.80	24.80	-	50.00
S-MA70095041	1	1	4	4	SLOPE STABILIZATION	0.00	84.40	84.40	-	125.00
S-MA70095075	1	1	4	4	SLOPE STABILIZATION	15.00	26.35	11.35	-	125.00
S-MA70097441	3	1	3	3	SLOPE REGRADING	0.00	44.20	44.20	-	100.00

ASSET_NUMBER	ICG	ECG	SCG	SPG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
S-MA70103641	1	3	4	4	SEWER CLEANING	0.00	44.86	44.86	-	-
					SLOPE STABILIZATION	0.00	44.86	44.86	-	125.00
S-MA70105998	3	3	4	4	SLOPE REGRADING	10.00	33.80	23.80	-	100.00
S-MA70106467	1	1	3	3	SLOPE REGRADING	0.00	38.80	38.80	-	100.00
S-MA70109007	3	3	3	3	EROSION CONTROL	0.00	21.90	21.90	-	100.00
S-MA70109053	1	3	3	3	SLOPE REGRADING	10.00	20.80	10.80	-	100.00
S-MA70109067	1	3	3	3	EROSION CONTROL	10.00	21.00	11.00	-	100.00
S-MA70109899	2	4	5	5	EROSION CONTROL	0.00	35.77	35.77	-	100.00
					SLOPE REGRADING	0.00	35.77	35.77	-	100.00
S-MA70114957	1	1	2	2	SEWER CLEANING	0.00	7.60	7.60	-	-
Grand Total									4,772.17	36,650.00

Appendix D

Prioritized Assignment of Rehabilitation Treatments by SPG and OCF

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
5	195.30	S-MA70017694	2	1	5	SLOPE STABILIZATION	0.00	34.80	34.80	-	**250.00**
	40.00	S-MA60021014	1	5	5	EROSION CONTROL	60.00	80.00	20.00	-	**500.00**
						SLOPE STABILIZATION	60.00	80.00	20.00	-	**500.00**
		S-MA70007646	1	3	5	SLOPE STABILIZATION	75.00	85.32	10.32	-	**250.00**
		S-MA70019346	3	5	3	EROSION CONTROL	0.00	21.50	21.50	-	**100.00**
						SEWER CLEANING	0.00	6.10	6.10	-	-
		S-MA70047759	5	1	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	36.09	36.09	**42.40**	-
						OBSTRUCTION REMOVAL	22.00	36.09	14.09	-	-
						SLOPE STABILIZATION	0.00	36.09	36.09	-	**250.00**
	39.90	S-MA20000065	1	4	5	OBSTRUCTION REMOVAL	0.00	22.90	22.90	-	-
						SLOPE STABILIZATION	0.00	22.90	22.90	-	**250.00**
	34.50	S-MA60006745	5	1	3	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	15.80	15.80	**47.02**	-
	33.00	S-MA20003886	5	1	4	2-FULL SEGMENT RENOVATION (RELINING)	92.50	119.30	26.80	**67.21**	-
		S-MA232-0063	3	4	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	143.90	143.90	**257.04**	-
						EROSION CONTROL	135.00	149.40	14.40	-	**100.00**
						SLOPE STABILIZATION	130.00	149.40	19.40	-	**250.00**
		S-MA40000750	1	4	5	SLOPE STABILIZATION	85.00	114.07	29.07	-	**250.00**
		S-MA70031713	1	5	4	SLOPE STABILIZATION	0.00	3.51	3.51	-	**125.00**
	31.00	S-MA50014761	3	1	5	SLOPE STABILIZATION	35.00	56.34	21.34	-	**250.00**
		S-MA70006845	2	4	5	SLOPE STABILIZATION	50.00	60.00	10.00	-	**250.00**
	19.00	S-MA70032231	2	2	5	SLOPE REGRADING	80.00	122.90	42.90	-	**500.00**
	16.00	S-MA50013076	1	5	4	EROSION CONTROL	19.00	21.20	2.20	-	**100.00**
	13.00	S-MA20002394	5	1	1	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	32.05	32.05	**114.22**	-
	10.80	S-MA50002903	2	4	5	SLOPE STABILIZATION	0.00	22.50	22.50	-	**250.00**
	8.50	S-MA60007249	5	5	4	1-STABILIZATION (MAN ENTRY)	98.20	99.60	1.40	**2.80**	**125.00**
						3-TRENCHLESS POINT REPAIR	97.20	100.60	3.40	**15.10**	**125.00**
						SLOPE STABILIZATION	98.20	126.25	28.05	-	**125.00**
		S-MA70007642	1	3	5	SLOPE STABILIZATION	60.00	89.13	29.13	-	**250.00**
	7.00	S-MA50015464	2	5	4	EROSION CONTROL	0.00	9.40	9.40	-	**100.00**
		S-MA70109899	2	4	5	EROSION CONTROL	0.00	35.77	35.77	-	**100.00**
						SLOPE REGRADING	0.00	35.77	35.77	-	**100.00**
	6.50	S-MA60012432	1	4	5	CB REPAIR	14.90	27.80	12.90	-	-
						SEWER CLEANING	0.00	27.80	27.80	-	-
						SLOPE STABILIZATION	14.90	27.80	12.90	-	**250.00**
		S-MA70007351	1	5	5	EROSION CONTROL	50.00	61.00	11.00	-	**250.00**
						SLOPE STABILIZATION	45.00	61.00	16.00	-	**250.00**
	5.00	S-MA70028476	5	1	2	2-FULL SEGMENT RENOVATION (RELINING)	0.00	60.81	60.81	**26.39**	-
	3.50	S-MA50010691	1	5	4	EROSION CONTROL	25.00	32.80	7.80	-	**100.00**

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
	3.10	S-MA70008591	2	5	4	EROSION CONTROL	0.00	19.31	19.31	-	**100.00**
	2.50	S-MA20011467	2	5	4	EROSION CONTROL	50.00	60.80	10.80	-	**100.00**
		S-MA40000014	5	1	4	3-TRENCHLESS POINT REPAIR	0.00	6.50	6.50	**23.10**	-
						5-FULL SEGMENT REPLACEMENT (RENEWAL)	77.00	94.20	17.20	**49.41**	-
		S-MA50015411	2	5	4	EROSION CONTROL	26.00	30.91	4.91	-	**100.00**
						SLOPE STABILIZATION	0.00	30.91	30.91	-	**125.00**
		S-MA60023323	5	5	5	6-EXTERNAL POINT REPAIRS	17.00	18.20	1.20	**13.30**	**500.00**
						SLOPE STABILIZATION	0.00	25.73	25.73	-	**500.00**
		S-MA70007444	5	3	3	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	103.40	103.40	**80.90**	-
	2.00	S-MA20000078	5	5	1	2-FULL SEGMENT RENOVATION (RELINING)	0.00	57.21	57.21	**25.10**	-
						SLOPE STABILIZATION	47.90	57.21	9.31	-	**125.00**
		S-MA20000088	5	3	1	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	96.60	96.60	**71.30**	-
		S-MA20007097	1	5	5	SLOPE STABILIZATION	0.00	54.62	54.62	-	**125.00**
		S-MA20009774	1	5	4	EROSION CONTROL	10.00	15.10	5.10	-	**100.00**
						SLOPE STABILIZATION	0.00	26.80	26.80	-	**125.00**
		S-MA20009806	1	5	5	EROSION CONTROL	20.00	22.54	2.54	-	**125.00**
						SLOPE STABILIZATION	0.00	22.54	22.54	-	**125.00**
		S-MA232-0034	4	5	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	28.91	28.91	**11.44**	-
						SLOPE STABILIZATION	0.00	28.91	28.91	-	**125.00**
		S-MA232-0035	5	2	4	6-EXTERNAL POINT REPAIRS	11.70	22.80	11.10	**28.15**	-
						SLOPE STABILIZATION	11.00	22.80	11.80	-	**125.00**
		S-MA40001338	3	3	5	1-STABILIZATION (MAN ENTRY)	8.60	9.60	1.00	**2.00**	-
						SLOPE STABILIZATION	0.00	14.03	14.03	-	**250.00**
		S-MA40001341	3	3	5	SLOPE STABILIZATION	0.00	18.40	18.40	-	**250.00**
		S-MA40001409	3	3	5	6-EXTERNAL POINT REPAIRS	12.00	14.00	2.00	**14.50**	**250.00**
						SLOPE STABILIZATION	0.00	14.00	14.00	-	**250.00**
		S-MA50002566	5	3	4	6-EXTERNAL POINT REPAIRS	12.00	17.60	5.60	**19.90**	-
						SLOPE REGRADING	0.00	16.09	16.09	-	**100.00**
		S-MA70032285	5	5	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	34.64	34.64	**35.68**	-
						EROSION CONTROL	35.00	40.60	5.60	-	**100.00**
		S-MA70041411	5	2	4	6-EXTERNAL POINT REPAIRS	5.80	12.00	6.20	**20.80**	-
						SLOPE STABILIZATION	5.80	12.00	6.20	-	**125.00**
	1.50	S-MA20011468	5	3	3	6-EXTERNAL POINT REPAIRS	27.00	33.00	6.00	**20.50**	-
	1.00	S-MA20009804	3	5	5	2-FULL SEGMENT RENOVATION (RELINING)	0.00	23.47	23.47	**10.13**	**125.00**
						EROSION CONTROL	0.00	23.47	23.47	-	**125.00**
						SLOPE REGRADING	10.00	23.47	13.47	-	**125.00**
		S-MA20009860	1	1	5	SLOPE STABILIZATION	0.00	23.01	23.01	-	**250.00**

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA20009935	5	5	5	6-EXTERNAL POINT REPAIRS	5.00	6.00	1.00	**13.00**	**125.00**
						SLOPE STABILIZATION	0.00	10.00	10.00	**-**	**125.00**
		S-MA20009953	1	1	5	SLOPE STABILIZATION	0.00	15.37	15.37	**-**	**250.00**
		S-MA20010505	1	4	5	SLOPE STABILIZATION	0.00	19.82	19.82	**-**	**125.00**
	0.00	S-MA00017100	3	5	5	SLOPE STABILIZATION	180.00	200.23	20.23	**-**	**500.00**
		S-MA20000064	1	5	5	SLOPE STABILIZATION	35.00	53.68	18.68	**-**	**250.00**
		S-MA20007260	1	5	5	SEWER CLEANING	0.00	28.80	28.80	**-**	**-**
						SLOPE STABILIZATION	60.00	84.66	24.66	**-**	**250.00**
		S-MA20008800	3	5	3	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	20.28	20.28	**45.21**	**-**
		S-MA2000896	4	5	4	1-STABILIZATION (MAN ENTRY)	16.00	21.30	5.30	**10.60**	**-**
						6-EXTERNAL POINT REPAIRS	32.00	34.51	2.51	**17.27**	**-**
						SLOPE STABILIZATION	0.00	33.10	33.10	**-**	**125.00**
		S-MA20014505	1	2	5	SLOPE STABILIZATION	25.00	61.86	36.86	**-**	**500.00**
		S-MA232-0064	3	5	5	EROSION CONTROL	0.00	20.00	20.00	**-**	**100.00**
						SLOPE REGRADING	0.00	20.00	20.00	**-**	**100.00**
		S-MA40000289	5	1	4	6-EXTERNAL POINT REPAIRS	13.50	26.00	12.50	**34.25**	**-**
						SLOPE STABILIZATION	13.50	26.00	12.50	**-**	**125.00**
		S-MA40001339	1	3	5	EROSION CONTROL	50.00	65.00	15.00	**-**	**100.00**
						SLOPE STABILIZATION	40.00	65.00	25.00	**-**	**250.00**
		S-MA40001340	2	3	5	SLOPE STABILIZATION	40.00	65.15	25.15	**-**	**500.00**
		S-MA40001432	3	3	5	6-EXTERNAL POINT REPAIRS	0.00	17.10	17.10	**42.07**	**250.00**
		S-MA40005212	3	5	4	EROSION CONTROL	10.00	21.90	11.90	**-**	**100.00**
						SLOPE REGRADING	10.00	21.90	11.90	**-**	**100.00**
		S-MA50008393	1	4	5	SLOPE STABILIZATION	60.00	78.66	18.66	**-**	**250.00**
		S-MA50011163	1	5	5	SLOPE STABILIZATION	0.00	20.48	20.48	**-**	**250.00**
		S-MA50017691	1	4	5	SLOPE STABILIZATION	0.00	8.40	8.40	**-**	**250.00**
		S-MA50017699	2	4	5	SLOPE STABILIZATION	0.00	5.80	5.80	**-**	**500.00**
		S-MA50018567	5	5	4	6-EXTERNAL POINT REPAIRS	23.50	29.30	5.80	**22.86**	**-**
						EROSION CONTROL	20.00	29.30	9.30	**-**	**100.00**
		S-MA60001546	1	5	4	SLOPE STABILIZATION	10.00	24.38	14.38	**-**	**125.00**
		S-MA60004165	3	5	5	SEWER CLEANING	0.00	37.92	37.92	**-**	**-**
						SLOPE STABILIZATION	0.00	37.92	37.92	**-**	**250.00**
		S-MA60006747	3	5	5	SLOPE STABILIZATION	0.00	8.88	8.88	**-**	**250.00**
		S-MA60013422	1	3	5	SEWER CLEANING	50.00	65.60	15.60	**-**	**-**
						SLOPE STABILIZATION	0.00	65.60	65.60	**-**	**250.00**
		S-MA60020193	1	1	4	SEWER CLEANING	0.00	153.72	153.72	**-**	**-**
						SLOPE STABILIZATION	100.00	153.72	53.72	**-**	**125.00**
		S-MA70000751	1	1	5	SLOPE STABILIZATION	160.00	195.00	35.00	**-**	**250.00**
		S-MA70006325	1	4	5	SEWER CLEANING	0.00	95.43	95.43	**-**	**-**

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
						SLOPE STABILIZATION	50.00	95.43	45.43	-	**250.00**
		S-MA70007461	1	3	5	SLOPE STABILIZATION	0.00	15.60	15.60	-	**250.00**
		S-MA70009397	1	1	5	SLOPE STABILIZATION	18.00	27.20	9.20	-	**250.00**
		S-MA70015994	5	1	1	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	16.80	16.80	**50.24**	-
		S-MA70021246	1	5	3	EROSION CONTROL	0.00	74.88	74.88	-	**100.00**
						SEWER CLEANING	0.00	74.88	74.88	-	-
		S-MA70030181	3	4	5	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	125.00	125.00	**93.00**	-
						SLOPE STABILIZATION	54.70	64.70	10.00	-	**250.00**
		S-MA70030182	1	4	5	REMOVE CONCRETE AT INVERT	0.00	5.50	5.50	-	-
						SLOPE STABILIZATION	0.00	5.50	5.50	-	**250.00**
		S-MA70031499	1	3	5	SLOPE STABILIZATION	0.00	16.60	16.60	-	**250.00**
		S-MA70041421	1	5	4	SEWER CLEANING	0.00	57.90	57.90	-	-
						SLOPE STABILIZATION	45.00	57.91	12.91	-	**125.00**
		S-MA70041572	1	3	5	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	23.87	23.87	**100.70**	-
							0.00	23.87	23.87	-	-
						SLOPE STABILIZATION	0.00	23.87	23.87	-	**250.00**
		S-MA70087426	1	1	5	SEWER CLEANING	12.00	19.87	7.87	-	-
						SLOPE STABILIZATION	0.00	19.87	19.87	-	**250.00**
		S-MA70087882	1	3	5	SLOPE STABILIZATION	0.00	24.80	24.80	-	**50.00**
		S-MA20003886	5	1	4	1-STABILIZATION (MAN ENTRY)	0.00	92.50	92.50	**185.00**	-
4.00	79.05	S-MA70044846	4	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	40.79	40.79	**41.21**	-
						SLOPE STABILIZATION	0.00	40.79	40.79	-	**125.00**
	40.00	S-MA50008789	2	4	4	EROSION CONTROL	60.70	67.30	6.60	-	**100.00**
						SEWER CLEANING	0.00	67.30	67.30	-	-
						SLOPE REGRADING	60.70	67.30	6.60	-	**100.00**
		S-MA60013599	1	4	4	SLOPE STABILIZATION	0.00	55.37	55.37	-	**125.00**
		S-MA70000991	1	3	4	SLOPE STABILIZATION	40.00	71.40	31.40	-	**125.00**
		S-MA70006655	1	4	4	SLOPE STABILIZATION	0.00	47.31	47.31	-	**125.00**
		S-MA70008060	1	1	4	SEWER CLEANING	0.00	139.84	139.84	-	-
						SLOPE STABILIZATION	120.00	139.84	19.84	-	**125.00**
		S-MA70017579	3	1	4	1-STABILIZATION (MAN ENTRY)	0.00	26.74	26.74	**53.48**	-
						SLOPE STABILIZATION	0.00	26.74	26.74	-	**125.00**
		S-MA70019979	5	4	3	1-STABILIZATION (MAN ENTRY)	0.00	66.40	66.40	**132.80**	-
		S-MA70033535	1	4	4	EROSION CONTROL	14.00	24.60	10.60	-	**100.00**
						SLOPE REGRADING	14.00	24.60	10.60	-	**100.00**
		S-MA70041926	3	1	4	SLOPE STABILIZATION	0.00	23.30	23.30	-	**125.00**
		S-MA70087433	2	2	4	SLOPE REGRADING	40.00	55.60	15.60	-	**100.00**
		S-MA70105998	3	3	4	SLOPE REGRADING	10.00	33.80	23.80	-	**100.00**

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
	33.00	S-MA50011492	4	1	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	35.01	35.01	**65.94**	**-**
						SLOPE REGRADING	20.00	35.00	15.00	**-**	**100.00**
		S-MA70011095	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	38.78	38.78	**72.57**	**-**
						EROSION CONTROL	25.00	38.80	13.80	**-**	**100.00**
						SLOPE REGRADING	20.00	38.80	18.80	**-**	**100.00**
		S-MA70011115	1	1	4	SEWER CLEANING	0.00	33.85	33.85	**-**	**-**
						SLOPE STABILIZATION	25.00	33.85	8.85	**-**	**125.00**
		S-MA70041371	4	2	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	18.52	18.52	**47.83**	**-**
	31.00	S-MA00017645	3	1	4	SLOPE STABILIZATION	0.00	36.50	36.50	**-**	**125.00**
		S-MA70032567	2	2	4	SLOPE STABILIZATION	76.00	86.15	10.15	**-**	**125.00**
	24.00	S-MA00017988	1	4	4	EROSION CONTROL	15.00	22.50	7.50	**-**	**100.00**
						SLOPE REGRADING	10.00	22.58	12.58	**-**	**100.00**
		S-MA70016005	3	4	4	SLOPE STABILIZATION	0.00	42.60	42.60	**-**	**125.00**
		S-MA70017556	3	3	4	SLOPE REGRADING	25.00	38.00	13.00	**-**	**100.00**
	19.00	S-MA20000077	4	3	1	6-EXTERNAL POINT REPAIRS	51.90	53.60	1.70	**15.89**	**-**
							63.50	66.00	2.50	**17.25**	**-**
						EROSION CONTROL	51.80	65.70	13.90	**-**	**100.00**
	16.00	S-MA70019763	2	3	4	EROSION CONTROL	0.00	16.47	16.47	**-**	**100.00**
						SLOPE REGRADING	0.00	16.47	16.47	**-**	**100.00**
		S-MA70023892	1	4	4	EROSION CONTROL	30.00	45.60	15.60	**-**	**100.00**
						SLOPE REGRADING	25.00	45.60	20.60	**-**	**100.00**
		S-MA70058126	2	1	4	SLOPE REGRADING	30.00	60.30	30.30	**-**	**100.00**
	7.00	S-MA70023153	2	3	4	SLOPE REGRADING	0.00	43.00	43.00	**-**	**100.00**
	6.50	S-MA70007561	3	1	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	48.40	48.40	**16.12**	**-**
						SLOPE STABILIZATION	35.00	48.40	13.40	**-**	**125.00**
	5.50	S-MA70003216	4	3	4	1-STABILIZATION (MAN ENTRY)	19.10	19.20	0.10	**0.10**	**-**
	5.00	S-MA50014591	2	4	4	5-FULL SEGMENT REPLACEMENT (RENEWAL)	27.60	45.31	17.71	**51.88**	**-**
						SEWER CLEANING	22.20	44.30	22.10	**-**	**-**
		S-MA70017667	3	1	4	SLOPE STABILIZATION	22.00	23.08	1.08	**-**	**125.00**
		S-MA70053466	1	4	4	EROSION CONTROL	15.00	33.40	18.40	**-**	**100.00**
						SLOPE REGRADING	15.00	33.40	18.40	**-**	**100.00**
		S-MA70069313	1	1	4	SLOPE REGRADING	15.00	35.72	20.72	**-**	**100.00**
	3.50	S-MA70011823	2	1	4	SLOPE REGRADING	0.00	20.10	20.10	**-**	**100.00**
	2.50	S-MA60001609	4	3	3	6-EXTERNAL POINT REPAIRS	58.00	62.11	4.11	**19.98**	**-**
						EROSION CONTROL	55.00	62.11	7.11	**-**	**100.00**
		S-MA70011104	2	4	4	EROSION CONTROL	20.00	39.57	19.57	**-**	**100.00**
	2.00	S-MA232-0038	1	3	4	EROSION CONTROL	10.00	12.20	2.20	**-**	**100.00**
		S-MA70011167	1	2	4	SLOPE REGRADING	50.00	80.00	30.00	**-**	**100.00**

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		S-MA70012690	5	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	52.89	52.89	**23.54**	**-**
						SLOPE STABILIZATION	50.00	52.89	2.89	**-**	**125.00**
		S-MA70041830	2	2	4	SLOPE STABILIZATION	15.00	24.99	9.99	**-**	**125.00**
	1.50	S-MA20005604	2	4	2	3-TRENCHLESS POINT REPAIR	48.40	52.60	4.20	**13.30**	**-**
						EROSION CONTROL	101.60	105.61	4.01	**-**	**100.00**
						SEWER CLEANING	0.00	52.60	52.60	**-**	**-**
		S-MA70008559	2	4	4	SLOPE STABILIZATION	0.00	9.60	9.60	**-**	**125.00**
	0.00	S-MA00000120	1	2	4	SEWER CLEANING	0.00	77.50	77.50	**-**	**-**
						SLOPE STABILIZATION	25.00	77.50	52.50	**-**	**125.00**
		S-MA00000385	1	3	4	SLOPE STABILIZATION	95.00	128.00	33.00	**-**	**125.00**
		S-MA00017633	1	2	4	SLOPE STABILIZATION	0.00	17.33	17.33	**-**	**125.00**
		S-MA00017926	1	1	4	SEWER CLEANING	3.90	67.40	63.50	**-**	**-**
						SLOPE STABILIZATION	0.00	68.70	68.70	**-**	**125.00**
		S-MA00017939	1	1	4	SLOPE STABILIZATION	0.00	45.30	45.30	**-**	**125.00**
		S-MA00017967	1	3	4	SEWER CLEANING	0.00	13.10	13.10	**-**	**-**
						SLOPE STABILIZATION	0.00	13.10	13.10	**-**	**125.00**
		S-MA20000107	3	1	1	6-EXTERNAL POINT REPAIRS	54.10	61.60	7.50	**25.75**	**-**
		S-MA20002277	3	4	1	EROSION CONTROL	10.00	21.30	11.30	**-**	**100.00**
		S-MA20002806	3	4	4	SEWER CLEANING	75.00	96.32	21.32	**-**	**-**
						SLOPE STABILIZATION	75.00	96.32	21.32	**-**	**125.00**
		S-MA20008519	1	4	4	SEWER CLEANING	0.00	24.83	24.83	**-**	**-**
						SLOPE STABILIZATION	0.00	24.83	24.83	**-**	**125.00**
		S-MA20010431	1	4	4	SLOPE STABILIZATION	0.00	20.82	20.82	**-**	**125.00**
		S-MA20010432	1	4	3	SEWER CLEANING	0.00	10.10	10.10	**-**	**-**
						SLOPE REGRADING	0.00	10.10	10.10	**-**	**100.00**
		S-MA20013332	1	1	4	SLOPE STABILIZATION	170.00	191.34	21.34	**-**	**125.00**
		S-MA20013630	3			6-EXTERNAL POINT REPAIRS	20.80	59.36	38.56	**78.55**	**-**
						SLOPE STABILIZATION	20.20	43.60	23.40	**-**	**125.00**
		S-MA40000143	1	3	4	SLOPE STABILIZATION	0.00	15.50	15.50	**-**	**125.00**
		S-MA40000202	3	1	4	1-STABILIZATION (MAN ENTRY)	20.20	21.20	1.00	**1.00**	**-**
						2-FULL SEGMENT RENOVATION (RELINING)	0.00	25.30	25.30	**18.42**	**-**
						SLOPE STABILIZATION	0.00	25.30	25.30	**-**	**125.00**
		S-MA40000244	1	3	4	SLOPE STABILIZATION	0.00	20.00	20.00	**-**	**125.00**
		S-MA40000250	2	1	4	SLOPE STABILIZATION	20.00	27.20	7.20	**-**	**125.00**
		S-MA40000284	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	28.40	28.40	**54.34**	**-**
						SLOPE STABILIZATION	0.00	28.40	28.40	**-**	**125.00**
		S-MA40003056	4	3	3	6-EXTERNAL POINT REPAIRS	53.00	65.00	12.00	**33.40**	**-**
						SLOPE REGRADING	53.00	65.00	12.00	**-**	**100.00**

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		S-MA40006872	1	3	4	6-EXTERNAL POINT REPAIRS	65.00	79.28	14.28	**37.28**	**-**
						SLOPE STABILIZATION	60.00	79.28	19.28	**-**	**125.00**
		S-MA40011011	2	1	4	SLOPE REGRADING	30.00	41.50	11.50	**-**	**100.00**
		S-MA50008353	3	4	4	1-STABILIZATION (MAN ENTRY)	37.70	40.00	2.30	**4.60**	**-**
						SLOPE STABILIZATION	20.00	43.80	23.80	**-**	**125.00**
		S-MA50008850	2	3	4	SLOPE STABILIZATION	20.00	30.50	10.50	**-**	**125.00**
		S-MA50010420	1	3	4	SLOPE STABILIZATION	150.00	190.70	40.70	**-**	**125.00**
		S-MA50012073	2	3	4	SLOPE STABILIZATION	0.00	31.20	31.20	**-**	**125.00**
		S-MA50014432	3	3	1	6-EXTERNAL POINT REPAIRS	73.60	77.60	4.00	**19.80**	**-**
						EROSION CONTROL	73.60	77.60	4.00	**-**	**100.00**
		S-MA50015374	3	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	29.60	29.60	**26.70**	**-**
						SLOPE STABILIZATION	0.00	29.60	29.60	**-**	**125.00**
		S-MA60001604	3	3	4	6-EXTERNAL POINT REPAIRS	45.00	67.67	22.67	**51.54**	**-**
						SLOPE STABILIZATION	45.00	67.67	22.67	**-**	**125.00**
		S-MA60003741	3	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	33.10	33.10	**39.26**	**-**
						SLOPE STABILIZATION	0.00	33.10	33.10	**-**	**125.00**
		S-MA60003875	1	3	4	SEWER CLEANING	10.00	25.21	15.21	**-**	**-**
						SLOPE STABILIZATION	0.00	25.00	25.00	**-**	**125.00**
		S-MA60012037	1	1	4	SLOPE STABILIZATION	20.00	39.49	19.49	**-**	**125.00**
		S-MA60021034	1	1	4	SLOPE REGRADING	95.00	118.41	23.41	**-**	**100.00**
		S-MA60021687	1	4	4	SEWER CLEANING	0.00	46.19	46.19	**-**	**-**
		S-MA60022526	4	3	2	6-EXTERNAL POINT REPAIRS	57.30	63.63	6.33	**23.76**	**-**
		S-MA70005806	1	2	4	SEWER CLEANING	0.00	53.59	53.59	**-**	**-**
						SLOPE STABILIZATION	26.00	53.59	27.59	**-**	**125.00**
		S-MA70007427	1	1	4	SLOPE STABILIZATION	50.00	116.66	66.66	**-**	**125.00**
		S-MA70007473	3	2	4	SLOPE STABILIZATION	0.00	39.20	39.20	**-**	**125.00**
		S-MA70007510	3	1	4	3-TRENCHLESS POINT REPAIR	0.00	10.00	10.00	**34.90**	**-**
						SLOPE STABILIZATION	0.00	27.20	27.20	**-**	**125.00**
		S-MA70007547	1	1	4	SEWER CLEANING	0.00	72.62	72.62	**-**	**-**
							60.00	72.62	12.62	**-**	**125.00**
		S-MA70007551	1	1	4	SLOPE STABILIZATION	30.00	58.70	28.70	**-**	**125.00**
		S-MA70007648	1	2	4	SLOPE STABILIZATION	80.00	87.20	7.20	**-**	**125.00**
		S-MA70008562	4	1	1	6-EXTERNAL POINT REPAIRS	38.00	55.94	17.94	**43.50**	**-**
		S-MA70011102	4	2	4	6-EXTERNAL POINT REPAIRS	40.00	64.00	24.00	**53.80**	**-**
						SLOPE STABILIZATION	40.00	64.00	24.00	**-**	**125.00**
		S-MA70011382	4	3	4	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	14.50	14.50	**69.02**	**-**
						SLOPE STABILIZATION	1.00	15.50	14.50	**-**	**125.00**
		S-MA70016004	5	4	3	1-STABILIZATION (MAN ENTRY)	0.00	13.20	13.20	**26.40**	**-**

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						EROSION CONTROL	30.00	51.50	21.50	-	**100.00**
						SEWER CLEANING	0.00	51.50	51.50	-	-
		S-MA70016115	1	3	4	SLOPE STABILIZATION	40.00	108.63	68.63	-	**125.00**
		S-MA70017585	1	2	4	SEWER CLEANING	0.00	55.45	55.45	-	-
						SLOPE STABILIZATION	25.00	55.45	30.45	-	**125.00**
		S-MA70017688	1	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	39.21	39.21	**26.07**	-
						SLOPE STABILIZATION	10.00	39.21	29.21	-	**125.00**
		S-MA70017866	1	3	4	SEWER CLEANING	0.00	61.26	61.26	-	-
						SLOPE STABILIZATION	45.00	61.26	16.26	-	**125.00**
		S-MA70019662	3	4	2	2-FULL SEGMENT RENOVATION (RELINING)	0.00	62.60	62.60	**79.62**	-
		S-MA70021229	1	1	4	SLOPE STABILIZATION	15.00	88.94	73.94	-	**125.00**
		S-MA70022226	1	1	4	SLOPE STABILIZATION	0.00	32.60	32.60	-	**125.00**
		S-MA70022480	1	4	4	SEWER CLEANING	0.00	122.38	122.38	-	-
						SLOPE STABILIZATION	100.00	122.38	22.38	-	**125.00**
		S-MA70022563	1	1	4	SLOPE STABILIZATION	30.00	39.60	9.60	-	**125.00**
		S-MA70024441	1	4	4	SEWER CLEANING	0.00	103.50	103.50	-	-
						SLOPE STABILIZATION	80.00	103.50	23.50	-	**125.00**
		S-MA70028445	4	3	4	6-EXTERNAL POINT REPAIRS	0.00	16.00	16.00	**35.50**	-
							12.50	13.50	1.00	**13.00**	-
						SLOPE STABILIZATION	0.00	16.00	16.00	-	**125.00**
		S-MA70029012	1	4	4	SEWER CLEANING	0.00	23.50	23.50	-	-
						SLOPE STABILIZATION	0.00	23.50	23.50	-	**125.00**
		S-MA70029924	1	1	4	SEWER CLEANING	0.00	20.51	20.51	-	-
						SLOPE STABILIZATION	0.00	20.51	20.51	-	**125.00**
		S-MA70033504	2	4	4	SLOPE STABILIZATION	0.00	20.38	20.38	-	**125.00**
		S-MA70039670	1	1	4	SLOPE STABILIZATION	30.00	68.50	38.50	-	**125.00**
		S-MA70053500	1	1	4	SEWER CLEANING	0.00	34.59	34.59	-	-
						SLOPE STABILIZATION	0.00	34.59	34.59	-	**125.00**
		S-MA70053508	3	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	21.70	21.70	**16.44**	-
						SLOPE STABILIZATION	0.00	21.70	21.70	-	**125.00**
		S-MA70062167	1	1	4	SEWER CLEANING	51.40	52.40	1.00	-	-
						SLOPE REGRADING	0.00	52.40	52.40	-	**100.00**
		S-MA70068974	2	1	4	SLOPE STABILIZATION	40.00	54.10	14.10	-	**125.00**
		S-MA70074230	1	1	4	SLOPE STABILIZATION	60.00	80.60	20.60	-	**125.00**
			1	1	4	SLOPE STABILIZATION	90.00	105.99	15.99	-	**125.00**
		S-MA70095041	1	1	4	SLOPE STABILIZATION	0.00	84.40	84.40	-	**125.00**
		S-MA70095075	1	1	4	SLOPE STABILIZATION	15.00	26.35	11.35	-	**125.00**
		S-MA70103641	1	3	4	SEWER CLEANING	0.00	44.86	44.86	-	-

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
						SLOPE STABILIZATION	0.00	44.86	44.86	-	**125.00**
		S-MA70018393	0	0	0	2-FULL SEGMENT RENOVATION (RELINING)	0.00	3.70	3.70	**8.66**	-
3	552.00	S-MA70049736	1	2	3	SLOPE REGRADING	90.00	101.60	11.60	-	**100.00**
	40.00	S-MA70011369	3	4	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	89.83	89.83	**214.70**	-
		S-MA70017186	1	1	4	SLOPE REGRADING	10.00	21.50	11.50	-	**100.00**
		S-MA70019489	3	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	53.78	53.78	**130.35**	-
	33.00	S-MA50011491	3	1	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	96.52	96.52	**173.89**	-
		S-MA70019277	3	3	3	EROSION CONTROL	0.00	34.60	34.60	-	**100.00**
	31.00	S-MA20020018	3	2	3	SLOPE REGRADING	40.00	53.87	13.87	-	**100.00**
	24.00	S-MA70041564	3	1	4	SLOPE REGRADING	30.70	45.70	15.00	-	**100.00**
	7.00	S-MA232-0056	1	1	3	SEWER CLEANING	0.00	67.70	67.70	-	-
						SLOPE REGRADING	50.00	67.70	17.70	-	**100.00**
	6.50	S-MA20003569	2	3	2	EROSION CONTROL	85.00	91.05	6.05	-	**100.00**
		S-MA50017305	3	2	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	31.20	31.20	**32.58**	-
		S-MA70044563	3	3	2	EROSION CONTROL	23.00	25.62	2.62	-	**100.00**
	5.00	S-MA60022654	2	3	1	EROSION CONTROL	157.00	167.00	10.00	-	**100.00**
		S-MA70011068	3	3	3	EROSION CONTROL	95.00	102.10	7.10	-	**100.00**
	3.50	S-MA70006168	2	1	3	SLOPE REGRADING	0.00	46.49	46.49	-	**100.00**
	2.50	S-MA70019766	3	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	77.41	77.41	**74.17**	-
		S-MA70041784	3	2	2	2-FULL SEGMENT RENOVATION (RELINING)	0.00	17.30	17.30	**17.48**	-
		S-MA70053445	1	3	2	EROSION CONTROL	68.00	70.73	2.73	-	**100.00**
		S-MA70109007	3	3	3	EROSION CONTROL	0.00	21.90	21.90	-	**100.00**
		S-MA70109067	1	3	3	EROSION CONTROL	10.00	21.00	11.00	-	**100.00**
	2.00	S-MA20000157	3	1	1	3-TRENCHLESS POINT REPAIR	0.00	42.72	42.72	**98.88**	-
		S-MA70031819	2	1	3	SLOPE REGRADING	0.00	45.10	45.10	-	**100.00**
		S-MA70052301	1	3	2	EROSION CONTROL	80.00	86.16	6.16	-	**100.00**
	1.00	S-MA20010515	1	3	2	SEWER CLEANING	0.00	22.47	22.47	-	-
						SLOPE REGRADING	12.47	22.47	10.00	-	**100.00**
	0.00	S-MA00000073	1	2	3	SLOPE REGRADING	0.00	80.80	80.80	-	**100.00**
		S-MA00017098	3	0	0	2-FULL SEGMENT RENOVATION (RELINING)	0.00	350.60	350.60	**824.90**	-
		S-MA20000072	1	3	1	EROSION CONTROL	0.00	11.40	11.40	-	**100.00**
						SEWER CLEANING	0.00	11.40	11.40	-	-
		S-MA20002395	2	3	1	SEWER CLEANING	0.00	32.30	32.30	-	-
		S-MA20006898	1	1	1	SEWER CLEANING	0.00	3.20	3.20	-	-
		S-MA20010513	1	3	2	SEWER CLEANING	0.00	11.90	11.90	-	-
						SLOPE REGRADING	0.00	11.90	11.90	-	**100.00**
		S-MA20013203	1	1	3	SEWER CLEANING	0.00	39.78	39.78	-	-

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
						SLOPE REGRADING	0.00	39.78	39.78	-	**100.00**
		S-MA20014087	2	1	3	SLOPE REGRADING	60.00	71.60	11.60	-	**100.00**
		S-MA20014095	1	1	3	SEWER CLEANING	0.00	58.10	58.10	-	-
						SLOPE REGRADING	40.00	58.10	18.10	-	**100.00**
		S-MA40000355	1	3	1	EROSION CONTROL	0.00	3.60	3.60	-	**100.00**
		S-MA50015373	3	3	4	2-FULL SEGMENT RENOVATION (RELINING)	0.00	43.30	43.30	**36.98**	-
		S-MA50018093	3	2	3	SLOPE REGRADING	0.00	25.90	25.90	-	**100.00**
		S-MA60003296	3	3	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	17.98	17.98	**14.39**	-
						SEWER CLEANING	0.00	17.98	17.98	-	-
						SLOPE REGRADING	0.00	17.98	17.98	-	**100.00**
		S-MA60003371	1	3	3	SLOPE REGRADING	30.00	42.60	12.60	-	**100.00**
		S-MA60016840	3	2	3	2-FULL SEGMENT RENOVATION (RELINING)	0.00	35.80	35.80	**31.35**	-
						SLOPE REGRADING	0.00	35.80	35.80	-	**100.00**
		S-MA60022470	2	1	3	SEWER CLEANING	2.00	69.90	67.90	-	-
						SLOPE REGRADING	10.00	50.00	40.00	-	**100.00**
		S-MA70001233	1	3	3	EROSION CONTROL	0.00	18.40	18.40	-	**100.00**
		S-MA70004387	1	1	3	SLOPE REGRADING	20.00	26.33	6.33	-	**100.00**
		S-MA70007543	1	3	3	EROSION CONTROL	0.00	26.90	26.90	-	**100.00**
		S-MA70008123	1	1	3	SEWER CLEANING	12.00	50.00	38.00	-	-
						SLOPE REGRADING	0.00	50.26	50.26	-	**100.00**
		S-MA70008652	2	3	2	EROSION CONTROL	0.00	10.24	10.24	-	**100.00**
		S-MA70008731	1	3	3	SLOPE REGRADING	15.00	31.56	16.56	-	**100.00**
		S-MA70011100	3	3	3	EROSION CONTROL	0.00	34.20	34.20	-	**100.00**
		S-MA70011372	3	2	3	SLOPE STABILIZATION	40.00	73.90	33.90	-	**125.00**
		S-MA70012111	3	1	2	2-FULL SEGMENT RENOVATION (RELINING)	0.00	57.55	57.55	**116.72**	-
		S-MA70014674	1	1	3	SEWER CLEANING	0.00	22.20	22.20	-	-
						SLOPE REGRADING	0.00	22.20	22.20	-	**100.00**
		S-MA70016174	1	1	3	SLOPE REGRADING	0.00	56.70	56.70	-	**100.00**
		S-MA70028480	2	3	3	EROSION CONTROL	15.00	29.30	14.30	-	**100.00**
		S-MA70052164	1	1	3	SLOPE REGRADING	10.00	40.00	30.00	-	**100.00**
		S-MA70070656	1	2	3	SLOPE REGRADING	70.00	99.70	29.70	-	**100.00**
		S-MA70082045	1	3	3	EROSION CONTROL	0.00	8.80	8.80	-	**100.00**
						SEWER CLEANING	0.00	8.80	8.80	-	-
		S-MA70097441	3	1	3	SLOPE REGRADING	0.00	44.20	44.20	-	**100.00**
		S-MA70106467	1	1	3	SLOPE REGRADING	0.00	38.80	38.80	-	**100.00**
		S-MA70109053	1	3	3	SLOPE REGRADING	10.00	20.80	10.80	-	**100.00**
2.00	40.00	S-MA70016460	1	3	4	1-STABILIZATION (MAN ENTRY)	0.00	25.50	25.50	-	-
						SEWER CLEANING	0.00	31.20	31.20	-	-

SPG	OCF	ASSET NUMBER	ICG	ECG	SCG	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA70023285	1	1	2	SEWER CLEANING	0.00	47.47	47.47	-	-
	27.60	S-MA70011066	2	3	3	SEWER CLEANING	0.00	46.60	46.60	-	-
	8.50	S-MA40002011	2	2	3	ROOTS REMOVAL	0.00	37.10	37.10	-	-
	2.50	S-MA50013561	3	2	3	OBSTRUCTION REMOVAL	0.00	10.00	10.00	-	-
	2.00	S-MA50002498	2	1	3	SLOPE STABILIZATION	0.00	6.00	6.00	-	**125.00**
	0.00	S-MA20003873	1	1	1	SEWER CLEANING	0.00	62.31	62.31	-	-
		S-MA20008520	2	4	4	SEWER CLEANING	0.00	68.53	68.53	-	-
		S-MA20011477	1	2	2	SEWER CLEANING	0.00	36.78	36.78	-	-
		S-MA60023328	2	1	1	OBSTRUCTION REMOVAL	0.00	8.89	8.89	-	-
		S-MA70000304	1	1	4	SEWER CLEANING	0.00	27.30	27.30	-	-
		S-MA70006919	2	1	1	SEWER CLEANING	53.50	61.00	7.50	-	-
		S-MA70007540	2	1	4	SEWER CLEANING	0.00	115.20	115.20	-	-
		S-MA70019337	2	5	3	SEWER CLEANING	0.00	61.50	61.50	-	-
		S-MA70114957	1	1	2	SEWER CLEANING	0.00	7.60	7.60	-	-
1.00	6.50	S-MA70022370	1	4	4	SEWER CLEANING	0.00	25.83	25.83	-	-
						SLOPE STABILIZATION	0.00	25.83	25.83	-	**125.00**
	0.00	S-MA00017914	1	4	4	SEWER CLEANING	0.00	37.41	37.41	-	-
		S-MA20003870	1	1	1	SEWER CLEANING	0.00	3.50	3.50	-	-
Grand Total										**4,772.17**	**36,650.00**

Appendix E

Prioritized Assignment of Rehabilitation Treatments by SPG and Cumulative Total of ICG and SCG

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
5	**10**	S-MA20009935	6-EXTERNAL POINT REPAIRS	5.00	6.00	1.00	**13.00**	**125.00**
			SLOPE STABILIZATION	0.00	10.00	10.00	**-**	**125.00**
		S-MA60023323	6-EXTERNAL POINT REPAIRS	17.00	18.20	1.20	**13.30**	**500.00**
			SLOPE STABILIZATION	0.00	25.73	25.73	**-**	**500.00**
		S-MA70047759	2-FULL SEGMENT RENOVATION (RELINING)	0.00	36.09	36.09	**42.40**	**-**
			SLOPE STABILIZATION	0.00	36.09	36.09	**-**	**250.00**
	9	S-MA20003886	1-STABILIZATION (MAN ENTRY)	0.00	92.50	92.50	**185.00**	**-**
			2-FULL SEGMENT RENOVATION (RELINING)	92.50	119.30	26.80	**67.21**	**-**
		S-MA232-0035	6-EXTERNAL POINT REPAIRS	11.70	22.80	11.10	**28.15**	**-**
			SLOPE STABILIZATION	11.00	22.80	11.80	**-**	**125.00**
		S-MA40000014	3-TRENCHLESS POINT REPAIR	0.00	6.50	6.50	**23.10**	**-**
			5-FULL SEGMENT REPLACEMENT (RENEWAL)	77.00	94.20	17.20	**49.41**	**-**
		S-MA40000289	6-EXTERNAL POINT REPAIRS	13.50	26.00	12.50	**34.25**	**-**
			SLOPE STABILIZATION	13.50	26.00	12.50	**-**	**125.00**
		S-MA50002566	6-EXTERNAL POINT REPAIRS	12.00	17.60	5.60	**19.90**	**-**
			SLOPE REGRADING	0.00	16.09	16.09	**-**	**100.00**
		S-MA50018567	6-EXTERNAL POINT REPAIRS	23.50	29.30	5.80	**22.86**	**-**
		S-MA60007249	1-STABILIZATION (MAN ENTRY)	98.20	99.60	1.40	**2.80**	**125.00**
			3-TRENCHLESS POINT REPAIR	97.20	100.60	3.40	**15.10**	**125.00**
			SLOPE STABILIZATION	98.20	126.25	28.05	**-**	**125.00**
		S-MA70041411	6-EXTERNAL POINT REPAIRS	5.80	12.00	6.20	**20.80**	**-**
			SLOPE STABILIZATION	5.80	12.00	6.20	**-**	**125.00**
	8	S-MA00017100	SLOPE STABILIZATION	180.00	200.23	20.23	**-**	**500.00**
		S-MA20008967	1-STABILIZATION (MAN ENTRY)	16.00	21.30	5.30	**10.60**	**-**
			6-EXTERNAL POINT REPAIRS	32.00	34.51	2.51	**17.27**	**-**
			SLOPE STABILIZATION	0.00	33.10	33.10	**-**	**125.00**
		S-MA20009804	2-FULL SEGMENT RENOVATION (RELINING)	0.00	23.47	23.47	**10.13**	**125.00**
			SLOPE REGRADING	10.00	23.47	13.47	**-**	**125.00**
		S-MA20011468	6-EXTERNAL POINT REPAIRS	27.00	33.00	6.00	**20.50**	**-**
		S-MA232-0034	2-FULL SEGMENT RENOVATION (RELINING)	0.00	28.91	28.91	**11.44**	**-**
			SLOPE STABILIZATION	0.00	28.91	28.91	**-**	**125.00**
		S-MA232-0063	2-FULL SEGMENT RENOVATION (RELINING)	0.00	143.90	143.90	**257.04**	**-**
			SLOPE STABILIZATION	130.00	149.40	19.40	**-**	**250.00**
		S-MA232-0064	SLOPE REGRADING	0.00	20.00	20.00	**-**	**100.00**
		S-MA40001338	1-STABILIZATION (MAN ENTRY)	8.60	9.60	1.00	**2.00**	**-**
			SLOPE STABILIZATION	0.00	14.03	14.03	**-**	**250.00**
		S-MA40001341	SLOPE STABILIZATION	0.00	18.40	18.40	**-**	**250.00**

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA40001409	6-EXTERNAL POINT REPAIRS	12.00	14.00	2.00	**14.50**	**250.00**
			SLOPE STABILIZATION	0.00	14.00	14.00	**-**	**250.00**
		S-MA40001432	6-EXTERNAL POINT REPAIRS	0.00	17.10	17.10	**42.07**	**250.00**
		S-MA50014761	SLOPE STABILIZATION	35.00	56.34	21.34	**-**	**250.00**
		S-MA60004165	SLOPE STABILIZATION	0.00	37.92	37.92	**-**	**250.00**
		S-MA60006745	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	15.80	15.80	**47.02**	**-**
		S-MA60006747	SLOPE STABILIZATION	0.00	8.88	8.88	**-**	**250.00**
		S-MA70007444	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	103.40	103.40	**80.90**	**-**
		S-MA70030181	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	125.00	125.00	**93.00**	**-**
			SLOPE STABILIZATION	54.70	64.70	10.00	**-**	**250.00**
		S-MA70032285	2-FULL SEGMENT RENOVATION (RELINING)	0.00	34.64	34.64	**35.68**	**-**
	7	S-MA40001340	SLOPE STABILIZATION	40.00	65.15	25.15	**-**	**500.00**
		S-MA40005212	SLOPE REGRADING	10.00	21.90	11.90	**-**	**100.00**
		S-MA50002903	SLOPE STABILIZATION	0.00	22.50	22.50	**-**	**250.00**
		S-MA50017699	SLOPE STABILIZATION	0.00	5.80	5.80	**-**	**500.00**
		S-MA70006845	SLOPE STABILIZATION	50.00	60.00	10.00	**-**	**250.00**
		S-MA70017694	SLOPE STABILIZATION	0.00	34.80	34.80	**-**	**250.00**
		S-MA70028476	2-FULL SEGMENT RENOVATION (RELINING)	0.00	60.81	60.81	**26.39**	**-**
		S-MA70032231	SLOPE REGRADING	80.00	122.90	42.90	**-**	**500.00**
		S-MA70109899	SLOPE REGRADING	0.00	35.77	35.77	**-**	**100.00**
	6	S-MA20000064	SLOPE STABILIZATION	35.00	53.68	18.68	**-**	**250.00**
		S-MA20000065	SLOPE STABILIZATION	0.00	22.90	22.90	**-**	**250.00**
		S-MA20000078	2-FULL SEGMENT RENOVATION (RELINING)	0.00	57.21	57.21	**25.10**	**-**
			SLOPE STABILIZATION	47.90	57.21	9.31	**-**	**125.00**
		S-MA20000088	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	96.60	96.60	**71.30**	**-**
		S-MA20002394	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	32.05	32.05	**114.22**	**-**
		S-MA20007097	SLOPE STABILIZATION	0.00	54.62	54.62	**-**	**125.00**
		S-MA20007260	SLOPE STABILIZATION	60.00	84.66	24.66	**-**	**250.00**
		S-MA20008800	2A-AUGMENTED RENOVATION (F.S. LINING W/EPR)	0.00	20.28	20.28	**45.21**	**-**
		S-MA20009806	SLOPE STABILIZATION	0.00	22.54	22.54	**-**	**125.00**
		S-MA20009860	SLOPE STABILIZATION	0.00	23.01	23.01	**-**	**250.00**
		S-MA20009953	SLOPE STABILIZATION	0.00	15.37	15.37	**-**	**250.00**
		S-MA20010505	SLOPE STABILIZATION	0.00	19.82	19.82	**-**	**125.00**
		S-MA20014505	SLOPE STABILIZATION	25.00	61.86	36.86	**-**	**500.00**
		S-MA40000750	SLOPE STABILIZATION	85.00	114.07	29.07	**-**	**250.00**
		S-MA40001339	SLOPE STABILIZATION	40.00	65.00	25.00	**-**	**250.00**
		S-MA50008393	SLOPE STABILIZATION	60.00	78.66	18.66	**-**	**250.00**

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA50011163	SLOPE STABILIZATION	0.00	20.48	20.48	-	**250.00**
		S-MA50015411	SLOPE STABILIZATION	0.00	30.91	30.91	-	**125.00**
		S-MA50017691	SLOPE STABILIZATION	0.00	8.40	8.40	-	**250.00**
		S-MA60012432	SLOPE STABILIZATION	14.90	27.80	12.90	-	**250.00**
		S-MA60013422	SLOPE STABILIZATION	0.00	65.60	65.60	-	**250.00**
		S-MA60021014	SLOPE STABILIZATION	60.00	80.00	20.00	-	**500.00**
		S-MA70000751	SLOPE STABILIZATION	160.00	195.00	35.00	-	**250.00**
		S-MA70006325	SLOPE STABILIZATION	50.00	95.43	45.43	-	**250.00**
		S-MA70007351	SLOPE STABILIZATION	45.00	61.00	16.00	-	**250.00**
		S-MA70007461	SLOPE STABILIZATION	0.00	15.60	15.60	-	**250.00**
		S-MA70007642	SLOPE STABILIZATION	60.00	89.13	29.13	-	**250.00**
		S-MA70007646	SLOPE STABILIZATION	75.00	85.32	10.32	-	**250.00**
		S-MA70009397	SLOPE STABILIZATION	18.00	27.20	9.20	-	**250.00**
		S-MA70015994	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	16.80	16.80	**50.24**	-
		S-MA70030182	SLOPE STABILIZATION	0.00	5.50	5.50	-	**250.00**
		S-MA70031499	SLOPE STABILIZATION	0.00	16.60	16.60	-	**250.00**
		S-MA70041572	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	23.87	23.87	**100.70**	-
			SLOPE STABILIZATION	0.00	23.87	23.87	-	**250.00**
		S-MA70087426	SLOPE STABILIZATION	0.00	19.87	19.87	-	**250.00**
		S-MA70087882	SLOPE STABILIZATION	0.00	24.80	24.80	-	**50.00**
	5	S-MA20009774	SLOPE STABILIZATION	0.00	26.80	26.80	-	**125.00**
		S-MA60001546	SLOPE STABILIZATION	10.00	24.38	14.38	-	**125.00**
		S-MA60020193	SLOPE STABILIZATION	100.00	153.72	53.72	-	**125.00**
		S-MA70031713	SLOPE STABILIZATION	0.00	3.51	3.51	-	**125.00**
		S-MA70041421	SLOPE STABILIZATION	45.00	57.91	12.91	-	**125.00**
4	**9**	S-MA70012690	2-FULL SEGMENT RENOVATION (RELINING)	0.00	52.89	52.89	**23.54**	-
			SLOPE STABILIZATION	50.00	52.89	2.89	-	**125.00**
	8	S-MA50011492	2-FULL SEGMENT RENOVATION (RELINING)	0.00	35.01	35.01	**65.94**	-
			SLOPE REGRADING	20.00	35.00	15.00	-	**100.00**
		S-MA70003216	1-STABILIZATION (MAN ENTRY)	19.10	19.20	0.10	**0.10**	-
		S-MA70011102	6-EXTERNAL POINT REPAIRS	40.00	64.00	24.00	**53.80**	-
			SLOPE STABILIZATION	40.00	64.00	24.00	-	**125.00**
		S-MA70011382	5-FULL SEGMENT REPLACEMENT (RENEWAL)	0.00	14.50	14.50	**69.02**	-
			SLOPE STABILIZATION	1.00	15.50	14.50	-	**125.00**
		S-MA70016004	1-STABILIZATION (MAN ENTRY)	0.00	13.20	13.20	**26.40**	-
		S-MA70019979	1-STABILIZATION (MAN ENTRY)	0.00	66.40	66.40	**132.80**	-
		S-MA70028445	6-EXTERNAL POINT REPAIRS	0.00	16.00	16.00	**35.50**	-
				12.50	13.50	1.00	**13.00**	-

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
			SLOPE STABILIZATION	0.00	16.00	16.00	-	**125.00**
		S-MA70041371	2-FULL SEGMENT RENOVATION (RELINING)	0.00	18.52	18.52	**47.83**	-
		S-MA70044846	2-FULL SEGMENT RENOVATION (RELINING)	0.00	40.79	40.79	**41.21**	-
			SLOPE STABILIZATION	0.00	40.79	40.79	-	**125.00**
	7	S-MA00017645	SLOPE STABILIZATION	0.00	36.50	36.50	-	**125.00**
		S-MA20002806	SLOPE STABILIZATION	75.00	96.32	21.32	-	**125.00**
		S-MA40000202	1-STABILIZATION (MAN ENTRY)	20.20	21.20	1.00	**1.00**	-
			2-FULL SEGMENT RENOVATION (RELINING)	0.00	25.30	25.30	**18.42**	-
			SLOPE STABILIZATION	0.00	25.30	25.30	-	**125.00**
		S-MA40000284	2-FULL SEGMENT RENOVATION (RELINING)	0.00	28.40	28.40	**54.34**	-
			SLOPE STABILIZATION	0.00	28.40	28.40	-	**125.00**
		S-MA40003056	6-EXTERNAL POINT REPAIRS	53.00	65.00	12.00	**33.40**	-
			SLOPE REGRADING	53.00	65.00	12.00	-	**100.00**
		S-MA50008353	1-STABILIZATION (MAN ENTRY)	37.70	40.00	2.30	**4.60**	-
			SLOPE STABILIZATION	20.00	43.80	23.80	-	**125.00**
		S-MA50015374	2-FULL SEGMENT RENOVATION (RELINING)	0.00	29.60	29.60	**26.70**	-
			SLOPE STABILIZATION	0.00	29.60	29.60	-	**125.00**
		S-MA60001604	6-EXTERNAL POINT REPAIRS	45.00	67.67	22.67	**51.54**	-
			SLOPE STABILIZATION	45.00	67.67	22.67	-	**125.00**
		S-MA60001609	6-EXTERNAL POINT REPAIRS	58.00	62.11	4.11	**19.98**	-
		S-MA60003741	2-FULL SEGMENT RENOVATION (RELINING)	0.00	33.10	33.10	**39.26**	-
			SLOPE STABILIZATION	0.00	33.10	33.10	-	**125.00**
		S-MA70007473	SLOPE STABILIZATION	0.00	39.20	39.20	-	**125.00**
		S-MA70007510	3-TRENCHLESS POINT REPAIR	0.00	10.00	10.00	**34.90**	-
			SLOPE STABILIZATION	0.00	27.20	27.20	-	**125.00**
		S-MA70007561	2-FULL SEGMENT RENOVATION (RELINING)	0.00	48.40	48.40	**16.12**	-
			SLOPE STABILIZATION	35.00	48.40	13.40	-	**125.00**
		S-MA70011095	2-FULL SEGMENT RENOVATION (RELINING)	0.00	38.78	38.78	**72.57**	-
			SLOPE REGRADING	20.00	38.80	18.80	-	**100.00**
		S-MA70016005	SLOPE STABILIZATION	0.00	42.60	42.60	-	**125.00**
		S-MA70017556	SLOPE REGRADING	25.00	38.00	13.00	-	**100.00**
		S-MA70017579	1-STABILIZATION (MAN ENTRY)	0.00	26.74	26.74	**53.48**	-
			SLOPE STABILIZATION	0.00	26.74	26.74	-	**125.00**
		S-MA70017667	SLOPE STABILIZATION	22.00	23.08	1.08	-	**125.00**
		S-MA70041926	SLOPE STABILIZATION	0.00	23.30	23.30	-	**125.00**
		S-MA70053508	2-FULL SEGMENT RENOVATION (RELINING)	0.00	21.70	21.70	**16.44**	-
			SLOPE STABILIZATION	0.00	21.70	21.70	-	**125.00**

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA70105998	SLOPE REGRADING	10.00	33.80	23.80	-	**100.00**
	6	S-MA40000250	SLOPE STABILIZATION	20.00	27.20	7.20	-	**125.00**
		S-MA40011011	SLOPE REGRADING	30.00	41.50	11.50	-	**100.00**
		S-MA50008789	SLOPE REGRADING	60.70	67.30	6.60	-	**100.00**
		S-MA50008850	SLOPE STABILIZATION	20.00	30.50	10.50	-	**125.00**
		S-MA50012073	SLOPE STABILIZATION	0.00	31.20	31.20	-	**125.00**
		S-MA50014591	5-FULL SEGMENT REPLACEMENT (RENEWAL)	27.60	45.31	17.71	**51.88**	-
		S-MA60022526	6-EXTERNAL POINT REPAIRS	57.30	63.63	6.33	**23.76**	-
		S-MA70008559	SLOPE STABILIZATION	0.00	9.60	9.60	-	**125.00**
		S-MA70011823	SLOPE REGRADING	0.00	20.10	20.10	-	**100.00**
		S-MA70019763	SLOPE REGRADING	0.00	16.47	16.47	-	**100.00**
		S-MA70023153	SLOPE REGRADING	0.00	43.00	43.00	-	**100.00**
		S-MA70032567	SLOPE STABILIZATION	76.00	86.15	10.15	-	**125.00**
		S-MA70033504	SLOPE STABILIZATION	0.00	20.38	20.38	-	**125.00**
		S-MA70041830	SLOPE STABILIZATION	15.00	24.99	9.99	-	**125.00**
		S-MA70058126	SLOPE REGRADING	30.00	60.30	30.30	-	**100.00**
		S-MA70068974	SLOPE STABILIZATION	40.00	54.10	14.10	-	**125.00**
		S-MA70087433	SLOPE REGRADING	40.00	55.60	15.60	-	**100.00**
	5	S-MA00000120	SLOPE STABILIZATION	25.00	77.50	52.50	-	**125.00**
		S-MA00000385	SLOPE STABILIZATION	95.00	128.00	33.00	-	**125.00**
		S-MA00017633	SLOPE STABILIZATION	0.00	17.33	17.33	-	**125.00**
		S-MA00017926	SLOPE STABILIZATION	0.00	68.70	68.70	-	**125.00**
		S-MA00017939	SLOPE STABILIZATION	0.00	45.30	45.30	-	**125.00**
		S-MA00017967	SLOPE STABILIZATION	0.00	13.10	13.10	-	**125.00**
		S-MA00017988	SLOPE REGRADING	10.00	22.58	12.58	-	**100.00**
		S-MA20000077	6-EXTERNAL POINT REPAIRS	51.90	53.60	1.70	**15.89**	-
				63.50	66.00	2.50	**17.25**	-
		S-MA20008519	SLOPE STABILIZATION	0.00	24.83	24.83	-	**125.00**
		S-MA20010431	SLOPE STABILIZATION	0.00	20.82	20.82	-	**125.00**
		S-MA20013332	SLOPE STABILIZATION	170.00	191.34	21.34	-	**125.00**
		S-MA40000143	SLOPE STABILIZATION	0.00	15.50	15.50	-	**125.00**
		S-MA40000244	SLOPE STABILIZATION	0.00	20.00	20.00	-	**125.00**
		S-MA40006872	6-EXTERNAL POINT REPAIRS	65.00	79.28	14.28	**37.28**	-
			SLOPE STABILIZATION	60.00	79.28	19.28	-	**125.00**
		S-MA50010420	SLOPE STABILIZATION	150.00	190.70	40.70	-	**125.00**
		S-MA60003875	SLOPE STABILIZATION	0.00	25.00	25.00	-	**125.00**
		S-MA60012037	SLOPE STABILIZATION	20.00	39.49	19.49	-	**125.00**
		S-MA60013599	SLOPE STABILIZATION	0.00	55.37	55.37	-	**125.00**
		S-MA60021034	SLOPE REGRADING	95.00	118.41	23.41	-	**100.00**

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA70000991	SLOPE STABILIZATION	40.00	71.40	31.40	-	**125.00**
		S-MA70005806	SLOPE STABILIZATION	26.00	53.59	27.59	-	**125.00**
		S-MA70006655	SLOPE STABILIZATION	0.00	47.31	47.31	-	**125.00**
		S-MA70007427	SLOPE STABILIZATION	50.00	116.66	66.66	-	**125.00**
		S-MA70007547	SLOPE STABILIZATION	60.00	72.62	12.62	-	**125.00**
		S-MA70007551	SLOPE STABILIZATION	30.00	58.70	28.70	-	**125.00**
		S-MA70007648	SLOPE STABILIZATION	80.00	87.20	7.20	-	**125.00**
		S-MA70008060	SLOPE STABILIZATION	120.00	139.84	19.84	-	**125.00**
		S-MA70008562	6-EXTERNAL POINT REPAIRS	38.00	55.94	17.94	**43.50**	-
		S-MA70011115	SLOPE STABILIZATION	25.00	33.85	8.85	-	**125.00**
		S-MA70011167	SLOPE REGRADING	50.00	80.00	30.00	-	**100.00**
		S-MA70016115	SLOPE STABILIZATION	40.00	108.63	68.63	-	**125.00**
		S-MA70017585	SLOPE STABILIZATION	25.00	55.45	30.45	-	**125.00**
		S-MA70017688	2-FULL SEGMENT RENOVATION (RELINING)	0.00	39.21	39.21	**26.07**	-
			SLOPE STABILIZATION	10.00	39.21	29.21	-	**125.00**
		S-MA70017866	SLOPE STABILIZATION	45.00	61.26	16.26	-	**125.00**
		S-MA70019662	2-FULL SEGMENT RENOVATION (RELINING)	0.00	62.60	62.60	**79.62**	-
		S-MA70021229	SLOPE STABILIZATION	15.00	88.94	73.94	-	**125.00**
		S-MA70022226	SLOPE STABILIZATION	0.00	32.60	32.60	-	**125.00**
		S-MA70022370	SLOPE STABILIZATION	0.00	25.83	25.83	-	**125.00**
		S-MA70022480	SLOPE STABILIZATION	100.00	122.38	22.38	-	**125.00**
		S-MA70022563	SLOPE STABILIZATION	30.00	39.60	9.60	-	**125.00**
		S-MA70023892	SLOPE REGRADING	25.00	45.60	20.60	-	**100.00**
		S-MA70024441	SLOPE STABILIZATION	80.00	103.50	23.50	-	**125.00**
		S-MA70029012	SLOPE STABILIZATION	0.00	23.50	23.50	-	**125.00**
		S-MA70029924	SLOPE STABILIZATION	0.00	20.51	20.51	-	**125.00**
		S-MA70033535	SLOPE REGRADING	14.00	24.60	10.60	-	**100.00**
		S-MA70039670	SLOPE STABILIZATION	30.00	68.50	38.50	-	**125.00**
		S-MA70053466	SLOPE REGRADING	15.00	33.40	18.40	-	**100.00**
		S-MA70053500	SLOPE STABILIZATION	0.00	34.59	34.59	-	**125.00**
		S-MA70062167	SLOPE REGRADING	0.00	52.40	52.40	-	**100.00**
		S-MA70069313	SLOPE REGRADING	15.00	35.72	20.72	-	**100.00**
		S-MA70074230	SLOPE STABILIZATION	60.00	80.60	20.60	-	**125.00**
		S-MA70078949	SLOPE STABILIZATION	90.00	105.99	15.99	-	**125.00**
		S-MA70095041	SLOPE STABILIZATION	0.00	84.40	84.40	-	**125.00**
		S-MA70095075	SLOPE STABILIZATION	15.00	26.35	11.35	-	**125.00**
		S-MA70103641	SLOPE STABILIZATION	0.00	44.86	44.86	-	**125.00**
	4	S-MA20000107	6-EXTERNAL POINT REPAIRS	54.10	61.60	7.50	**25.75**	-

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA20005604	3-TRENCHLESS POINT REPAIR	48.40	52.60	4.20	**13.30**	**-**
		S-MA20010432	SLOPE REGRADING	0.00	10.10	10.10	**-**	**100.00**
		S-MA50014432	6-EXTERNAL POINT REPAIRS	73.60	77.60	4.00	**19.80**	**-**
	3	S-MA20013630	6-EXTERNAL POINT REPAIRS	20.80	59.36	38.56	**78.55**	**-**
			SLOPE STABILIZATION	20.20	43.60	23.40	**-**	**125.00**
		S-MA70018393	2-FULL SEGMENT RENOVATION (RELINING)	0.00	3.70	3.70	**8.66**	**-**
3	**7**	S-MA50011491	2-FULL SEGMENT RENOVATION (RELINING)	0.00	96.52	96.52	**173.89**	**-**
		S-MA50015373	2-FULL SEGMENT RENOVATION (RELINING)	0.00	43.30	43.30	**36.98**	**-**
		S-MA70011369	2-FULL SEGMENT RENOVATION (RELINING)	0.00	89.83	89.83	**214.70**	**-**
		S-MA70019489	2-FULL SEGMENT RENOVATION (RELINING)	0.00	53.78	53.78	**130.35**	**-**
		S-MA70019766	2-FULL SEGMENT RENOVATION (RELINING)	0.00	77.41	77.41	**74.17**	**-**
		S-MA70041564	SLOPE REGRADING	30.70	45.70	15.00	**-**	**100.00**
	6	S-MA20020018	SLOPE REGRADING	40.00	53.87	13.87	**-**	**100.00**
		S-MA50017305	2-FULL SEGMENT RENOVATION (RELINING)	0.00	31.20	31.20	**32.58**	**-**
		S-MA50018093	SLOPE REGRADING	0.00	25.90	25.90	**-**	**100.00**
		S-MA60003296	2-FULL SEGMENT RENOVATION (RELINING)	0.00	17.98	17.98	**14.39**	**-**
			SLOPE REGRADING	0.00	17.98	17.98	**-**	**100.00**
		S-MA60016840	2-FULL SEGMENT RENOVATION (RELINING)	0.00	35.80	35.80	**31.35**	**-**
			SLOPE REGRADING	0.00	35.80	35.80	**-**	**100.00**
		S-MA70011372	SLOPE STABILIZATION	40.00	73.90	33.90	**-**	**125.00**
		S-MA70097441	SLOPE REGRADING	0.00	44.20	44.20	**-**	**100.00**
	5	S-MA20014087	SLOPE REGRADING	60.00	71.60	11.60	**-**	**100.00**
		S-MA50002498	SLOPE STABILIZATION	0.00	6.00	6.00	**-**	**125.00**
		S-MA60022470	SLOPE REGRADING	10.00	50.00	40.00	**-**	**100.00**
		S-MA70006168	SLOPE REGRADING	0.00	46.49	46.49	**-**	**100.00**
		S-MA70012111	2-FULL SEGMENT RENOVATION (RELINING)	0.00	57.55	57.55	**116.72**	**-**
		S-MA70017186	SLOPE REGRADING	10.00	21.50	11.50	**-**	**100.00**
		S-MA70031819	SLOPE REGRADING	0.00	45.10	45.10	**-**	**100.00**
		S-MA70041784	2-FULL SEGMENT RENOVATION (RELINING)	0.00	17.30	17.30	**17.48**	**-**
	4	S-MA00000073	SLOPE REGRADING	0.00	80.80	80.80	**-**	**100.00**
		S-MA20000157	3-TRENCHLESS POINT REPAIR	0.00	42.72	42.72	**98.88**	**-**
		S-MA20013203	SLOPE REGRADING	0.00	39.78	39.78	**-**	**100.00**
		S-MA20014095	SLOPE REGRADING	40.00	58.10	18.10	**-**	**100.00**
		S-MA232-0056	SLOPE REGRADING	50.00	67.70	17.70	**-**	**100.00**
		S-MA60003371	SLOPE REGRADING	30.00	42.60	12.60	**-**	**100.00**
		S-MA70004387	SLOPE REGRADING	20.00	26.33	6.33	**-**	**100.00**

SPG	ICG+SCG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET	END OFFSET	QUANTITY	PIPE REHAB COST ($K)	GEO TREATMENT COSTS ($K)
		S-MA70008123	SLOPE REGRADING	0.00	50.26	50.26	**-**	**100.00**
		S-MA70008731	SLOPE REGRADING	15.00	31.56	16.56	**-**	**100.00**
		S-MA70014674	SLOPE REGRADING	0.00	22.20	22.20	**-**	**100.00**
		S-MA70016174	SLOPE REGRADING	0.00	56.70	56.70	**-**	**100.00**
		S-MA70049736	SLOPE REGRADING	90.00	101.60	11.60	**-**	**100.00**
		S-MA70052164	SLOPE REGRADING	10.00	40.00	30.00	**-**	**100.00**
		S-MA70070656	SLOPE REGRADING	70.00	99.70	29.70	**-**	**100.00**
		S-MA70106467	SLOPE REGRADING	0.00	38.80	38.80	**-**	**100.00**
		S-MA70109053	SLOPE REGRADING	10.00	20.80	10.80	**-**	**100.00**
	3	S-MA00017098	2-FULL SEGMENT RENOVATION (RELINING)	0.00	350.60	350.60	**824.90**	**-**
		S-MA20010513	SLOPE REGRADING	0.00	11.90	11.90	**-**	**100.00**
		S-MA20010515	SLOPE REGRADING	12.47	22.47	10.00	**-**	**100.00**
Grand Total							**4,772.17**	**30,850.00**

Appendix F

Prioritized Assignment of Service Treatments by SPG and Cumulative Total of Service CG and ECG

SPG	ServCG+ECG	ASSET_NUMBER	WORK_TYPE_NAME	START OFFSET (m)	END OFFSET (m)	QUANTITY (m)	SMS EST COST ($K)	GEO TREATMENT COSTS ($K)
5	10	S-MA50018567	EROSION CONTROL	20.00	29.30	9.30	-	**100.00**
		S-MA70032285	EROSION CONTROL	35.00	40.60	5.60	-	**100.00**
	8	S-MA20009804	EROSION CONTROL	0.00	23.47	23.47	-	**125.00**
		S-MA40005212	EROSION CONTROL	10.00	21.90	11.90	-	**100.00**
		S-MA60004165	SEWER CLEANING	0.00	37.92	37.92	-	-
	7	S-MA20011467	EROSION CONTROL	50.00	60.80	10.80	-	**100.00**
		S-MA50015411	EROSION CONTROL	26.00	30.91	4.91	-	**100.00**
		S-MA60021014	EROSION CONTROL	60.00	80.00	20.00	-	**500.00**
		S-MA70008591	EROSION CONTROL	0.00	19.31	19.31	-	**100.00**
		S-MA70019346	EROSION CONTROL	0.00	21.50	21.50	-	**100.00**
			SEWER CLEANING	0.00	6.10	6.10	-	-
		S-MA70030182	REMOVE CONCRETE AT INVERT	0.00	5.50	5.50	-	-
	6	S-MA20007260	SEWER CLEANING	0.00	28.80	28.80	-	-
		S-MA20009774	EROSION CONTROL	10.00	15.10	5.10	-	**100.00**
		S-MA20009806	EROSION CONTROL	20.00	22.54	2.54	-	**125.00**
		S-MA232-0064	EROSION CONTROL	0.00	20.00	20.00	-	**100.00**
		S-MA50010691	EROSION CONTROL	25.00	32.80	7.80	-	**100.00**
		S-MA50013076	EROSION CONTROL	19.00	21.20	2.20	-	**100.00**
		S-MA50015464	EROSION CONTROL	0.00	9.40	9.40	-	**100.00**
		S-MA70007351	EROSION CONTROL	50.00	61.00	11.00	-	**250.00**
		S-MA70021246	EROSION CONTROL	0.00	74.88	74.88	-	**100.00**
			SEWER CLEANING	0.00	74.88	74.88	-	-
		S-MA70041421	SEWER CLEANING	0.00	57.90	57.90	-	-
	5	S-MA20000065	OBSTRUCTION REMOVAL	0.00	22.90	22.90	-	-
		S-MA232-0063	EROSION CONTROL	135.00	149.40	14.40	-	**100.00**
		S-MA60012432	SEWER CLEANING	0.00	27.80	27.80	-	-
		S-MA70006325	SEWER CLEANING	0.00	95.43	95.43	-	-
		S-MA70109899	EROSION CONTROL	0.00	35.77	35.77	-	**100.00**
	4	S-MA40001339	EROSION CONTROL	50.00	65.00	15.00	-	**100.00**
		S-MA60013422	SEWER CLEANING	50.00	65.60	15.60	-	-
		S-MA70041572	SEWER CLEANING	0.00	23.87	23.87	-	-
		S-MA70047759	OBSTRUCTION REMOVAL	22.00	36.09	14.09	-	-
	2	S-MA60020193	SEWER CLEANING	0.00	153.72	153.72	-	-
		S-MA70087426	SEWER CLEANING	12.00	19.87	7.87	-	-
4	7	S-MA20002277	EROSION CONTROL	10.00	21.30	11.30	-	**100.00**
		S-MA20002806	SEWER CLEANING	75.00	96.32	21.32	-	-
		S-MA20005604	EROSION CONTROL	101.60	105.61	4.01	-	**100.00**
			SEWER CLEANING	0.00	52.60	52.60	-	-
		S-MA60001609	EROSION CONTROL	55.00	62.11	7.11	-	**100.00**
		S-MA70011095	EROSION CONTROL	25.00	38.80	13.80	-	**100.00**

	6	S-MA50008789	EROSION CONTROL	60.70	67.30	6.60	-	**100.00**
			SEWER CLEANING	0.00	67.30	67.30	-	-
		S-MA50014432	EROSION CONTROL	73.60	77.60	4.00	-	**100.00**
		S-MA50014591	SEWER CLEANING	22.20	44.30	22.10	-	-
		S-MA70011104	EROSION CONTROL	20.00	39.57	19.57	-	**100.00**
	5	S-MA00017988	EROSION CONTROL	15.00	22.50	7.50	-	**100.00**
		S-MA20008519	SEWER CLEANING	0.00	24.83	24.83	-	-
		S-MA20010432	SEWER CLEANING	0.00	10.10	10.10	-	-
		S-MA60021687	SEWER CLEANING	0.00	46.19	46.19	-	-
		S-MA70016004	EROSION CONTROL	30.00	51.50	21.50	-	**100.00**
			SEWER CLEANING	0.00	51.50	51.50	-	-
		S-MA70019763	EROSION CONTROL	0.00	16.47	16.47	-	**100.00**
		S-MA70022370	SEWER CLEANING	0.00	25.83	25.83	-	-
		S-MA70022480	SEWER CLEANING	0.00	122.38	122.38	-	-
		S-MA70023892	EROSION CONTROL	30.00	45.60	15.60	-	**100.00**
		S-MA70024441	SEWER CLEANING	0.00	103.50	103.50	-	-
		S-MA70029012	SEWER CLEANING	0.00	23.50	23.50	-	-
		S-MA70033535	EROSION CONTROL	14.00	24.60	10.60	-	**100.00**
		S-MA70053466	EROSION CONTROL	15.00	33.40	18.40	-	**100.00**
	4	S-MA00017967	SEWER CLEANING	0.00	13.10	13.10	-	-
		S-MA20000077	EROSION CONTROL	51.80	65.70	13.90	-	**100.00**
		S-MA232-0038	EROSION CONTROL	10.00	12.20	2.20	-	**100.00**
		S-MA60003875	SEWER CLEANING	10.00	25.21	15.21	-	-
		S-MA70017866	SEWER CLEANING	0.00	61.26	61.26	-	-
		S-MA70103641	SEWER CLEANING	0.00	44.86	44.86	-	-
	3	S-MA00000120	SEWER CLEANING	0.00	77.50	77.50	-	-
		S-MA70005806	SEWER CLEANING	0.00	53.59	53.59	-	-
		S-MA70017585	SEWER CLEANING	0.00	55.45	55.45	-	-
	2	S-MA00017926	SEWER CLEANING	3.90	67.40	63.50	-	-
		S-MA70007547	SEWER CLEANING	0.00	72.62	72.62	-	-
		S-MA70008060	SEWER CLEANING	0.00	139.84	139.84	-	-
			SEWER CLEANING	0.00	33.85	33.85	-	-
		S-MA70029924	SEWER CLEANING	0.00	20.51	20.51	-	-
		S-MA70053500	SEWER CLEANING	0.00	34.59	34.59	-	-
		S-MA70062167	SEWER CLEANING	51.40	52.40	1.00	-	-
3	**6**	S-MA60003296	SEWER CLEANING	0.00	17.98	17.98	-	-
		S-MA70011068	EROSION CONTROL	95.00	102.10	7.10	-	**100.00**
		S-MA70011100	EROSION CONTROL	0.00	34.20	34.20	-	**100.00**
		S-MA70019277	EROSION CONTROL	0.00	34.60	34.60	-	**100.00**
		S-MA70044563	EROSION CONTROL	23.00	25.62	2.62	-	**100.00**
		S-MA70109007	EROSION CONTROL	0.00	21.90	21.90	-	**100.00**
	5	S-MA20003569	EROSION CONTROL	85.00	91.05	6.05	-	**100.00**

		S-MA70008652	EROSION CONTROL	0.00	10.24	10.24	-	**100.00**
		S-MA70028480	EROSION CONTROL	15.00	29.30	14.30	-	**100.00**
		S-MA70053445	EROSION CONTROL	68.00	70.73	2.73	-	**100.00**
	4	S-MA20000072	EROSION CONTROL	0.00	11.40	11.40	-	**100.00**
			SEWER CLEANING	0.00	11.40	11.40	-	-
		S-MA20002395	SEWER CLEANING	0.00	32.30	32.30	-	-
		S-MA20010513	SEWER CLEANING	0.00	11.90	11.90	-	-
		S-MA20010515	SEWER CLEANING	0.00	22.47	22.47	-	-
		S-MA40000355	EROSION CONTROL	0.00	3.60	3.60	-	**100.00**
		S-MA60022654	EROSION CONTROL	157.00	167.00	10.00	-	**100.00**
		S-MA70001233	EROSION CONTROL	0.00	18.40	18.40	-	**100.00**
		S-MA70007543	EROSION CONTROL	0.00	26.90	26.90	-	**100.00**
		S-MA70052301	EROSION CONTROL	80.00	86.16	6.16	-	**100.00**
		S-MA70082045	EROSION CONTROL	0.00	8.80	8.80	-	**100.00**
			SEWER CLEANING	0.00	8.80	8.80	-	-
		S-MA70109067	EROSION CONTROL	10.00	21.00	11.00	-	**100.00**
	3	S-MA60022470	SEWER CLEANING	2.00	69.90	67.90	-	-
	2	S-MA20006898	SEWER CLEANING	0.00	3.20	3.20	-	-
		S-MA20013203	SEWER CLEANING	0.00	39.78	39.78	-	-
		S-MA20014095	SEWER CLEANING	0.00	58.10	58.10	-	-
		S-MA232-0056	SEWER CLEANING	0.00	67.70	67.70	-	-
		S-MA70008123	SEWER CLEANING	12.00	50.00	38.00	-	-
		S-MA70014674	SEWER CLEANING	0.00	22.20	22.20	-	-
2	**6**	S-MA70016460	SEWER CLEANING	0.00	31.20	31.20	-	-
		S-MA70019337	SEWER CLEANING	0.00	61.50	61.50	-	-
	5	S-MA20008520	SEWER CLEANING	0.00	68.53	68.53	-	-
		S-MA50013561	OBSTRUCTION REMOVAL	0.00	10.00	10.00	-	-
	4	S-MA40002011	ROOTS REMOVAL	0.00	37.10	37.10	-	-
		S-MA70011066	SEWER CLEANING	0.00	46.60	46.60	-	-
	3	S-MA20011477	SEWER CLEANING	0.00	36.78	36.78	-	-
		S-MA60023328	OBSTRUCTION REMOVAL	0.00	8.89	8.89	-	-
		S-MA70006919	SEWER CLEANING	53.50	61.00	7.50	-	-
	2	S-MA20003873	SEWER CLEANING	0.00	62.31	62.31	-	-
		S-MA70000304	SEWER CLEANING	0.00	27.30	27.30	-	-
		S-MA70007540	SEWER CLEANING	0.00	115.20	115.20	-	-
		S-MA70023285	SEWER CLEANING	0.00	47.47	47.47	-	-
		S-MA70114957	SEWER CLEANING	0.00	7.60	7.60	-	-
1	**7**	S-MA00017914	SEWER CLEANING	0.00	37.41	37.41	-	-
	2	S-MA20003870	SEWER CLEANING	0.00	3.50	3.50	-	-
Grand Total							-	**5,800.00**