Municipality of Jasper

Tactical Level Asset Management Study (Phase 2) – Water Distribution, Wastewater Collection, and Roadways

- Interim

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Executive Summary

In December 2015, the Municipality of Jasper completed a Strategic Level Asset Management Report. This was a desktop analysis based on theoretical service life of the infrastructure assets. The strategic level analysis determined a long-range funding plan designed to provide the senior administration and Council guidance on capital renewal programming needs to attain infrastructure sustainability.

This report provides the next asset management phase, which is a Tactical Level assessment and analysis. It is more detailed involving a field level assessment of the infrastructure assets and a lifecycle modeling analysis designed to maximize the value for taxpayers while ensuring infrastructure sustainability over time. It was completed for the Roadways (i.e. streets and sidewalks), wastewater collection (i.e. sanitary and storm pipes, manholes, and catch basins), and water distribution (i.e. pipes and valves)

The results of the tactical level analysis determined a short-range detailed works program for every infrastructure segment and determined the long-range funding plan required to deliver infrastructure sustainability. The following table presents the summary of both the short-range and long-range funding needs.

	Tactical				Strategic	Historic	Difference
Asset Group	Short-Term (5 Year) Needs Total (M$)	Short-Term (5 Year) Needs Annual (M$/yr)	Long-Term Sustainabiliity Needs Annual (M$/yr)	Reserve Fund Annual Accumulation (+) building; (-) drawing (M$/yr)	Long-Term Sustainabiliity Needs Projection (M$/yr)	Current Budget Allocation (M$/yr)	Sustainability to Budget Surplus (+); Deficit (-) (M$/yr)
Roadways							
- Streets	$2.660	$0.532	$0.230				
- Sidewalks	$0.375	$0.075	$0.074				
Sub-Total	$3.035	$0.607	$0.304	-$0.303	$1.220	$0.710	$0.406
Wastewater							
- Collection	$0.636	$0.127	$0.201				
- Treatment	TBD	TBD	$0.415				
Sub-Total	$0.636	$0.127	$0.616	$0.489	$0.730	$0.130	-$0.486
Water							
- Distribution	$2.500	$0.500	$1.309				
- Treatment	TBD	TBD	$0.332				
Sub-Total	$2.500	$0.500	$1.641	$1.141	$0.940	$0.310	-$1.331
Total	**$6.171**	**$1.234**	**$2.561**	**$1.327**	**$2.890**	**$1.150**	**-$1.411**

The roadways streets have the most immediate need with a pavement open surface texture that can largely be addressed by a cost effective a mid-life preservation (i.e. micro-surfacing) treatment. The sanitary piping has some immediate needs that again could largely be addressed by cost effective mid-life (i.e. cured in place liner) treatment. However, the greater needs for both the sanitary and storm water collection system are expected in approximately 30-40 years respectively. The water distribution system is in relatively good condition given the age of the cast-iron piping network. However, the associated valves are running on a different lifecycle than the pipes they are connected too. The model is forecasting the risk of valve failure and allocating expenditures on associated emergency repair. As a result, valve repairs are the water main short-term expenditure needs. Water main replacement is expected to begin in approximately 14 years from now.

Overall, the Municipality should be spending $1.234 Million/year for the short-term (i.e. 5 years) in capital renewal programming for the roadways, wastewater (storm and sanitary), and water infrastructure groups. However, to meet the long-term sustainability needs, the Municipality should be investing a total of $2.561 Million/year. Such should be a consideration for external grant funding, tax and utility rates, and reserve funds.

Moving forward, the Municipality should be updating their infrastructure inventory GIS records. They should be developing maintenance management system to track associated works. They should be repeating the tactical level analysis every 2-4 years with greater focus on the water distribution system.

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Appendix A – Condition Assessment Criteria

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1. Introduction

In December 2015, the Strategic Asset Management Study was completed. It was a desktop study utilizing existing Tangible Capital Assets (TCA) and Geographic Information Systems (GIS) data, along with theoretical service life and replacement cost data, to develop a long-range funding plan for each asset group. The following table presents the Long-Range Funding Plan from the previous Strategic level report. Overall, it illustrates that the current budget allocation for infrastructure renewal is $2.54 Million/yr. The projected budget allocation to address the infrastructure deficit ranges between $5.85 Million/year and $7.02 Million/year. The purpose of these findings at the strategic level was to prepare the Municipality of Jasper for capital renewal funding in their annual budget programming.

Table 1 – Long Range Funding Plan (Strategic Level Study) - 2016

			Conventional		Preservation Enhanced	
Asset Group	**Replacement Cost ($M)**	**Current Budget Allocation ($M/yr)**	**Backlog ($M)**	**Capital Renewal Needs ($M/yr)**	**Backlog ($M)**	**Capital Renewal Needs ($M/yr)**
Roadways	57.10	0.71	4.07	1.41	4.52	1.22
Water	45.70	0.31	6.25	0.94	6.25	0.94
Sanitary	41.60	0.11	1.29	0.89	3.90	0.52
Storm Water	31.00	0.02	-	0.82	0.01	0.21
Land improvements	4.20	0.11	0.97	0.20	0.97	0.20
Buildings	75.40	1.05	8.59	1.73	8.59	1.73
Machinery	5.00	0.18	1.61	0.38	1.61	0.38
Vehicles	8.90	0.05	3.35	0.65	3.35	0.65
TOTAL	**268.90**	**2.54**	**26.13**	**7.02**	**29.20**	**5.85**

Note * Shaded cells indicate preservation enhancements not currently explored in these asset groups

The purpose of this study is to provide more detailed analysis in to the state of the infrastructure including field level condition assessment. Then a lifecycle optimization analysis would be completed to determine a detailed program strategy for each infrastructure segment in the network. Even though the analysis works long-term (i.e. 20-40 year), the developed detailed program strategy is short-term (i.e. 5 year). After that, reassessment should be completed to consider the actual changes to the infrastructure condition state over time. This is often referred to as a tactical level analysis.

The first stage of the Tactical level analysis was completed for the Roadways (i.e. streets and sidewalks), Water (i.e. piping and valves), Sanitary (piping and manholes), and Storm Water (piping, manholes, and catch basins) asset groups. A different approach to treatment facilities, buildings, machinery, and vehicles will be completed later in a separate analysis.

2. Condition Assessment and Lifecycle Analysis Process

Condition rating criteria was developed for each infrastructure (i.e. asset) group. The criteria were based in part on other industry criteria practices. However, it was tailored to the Municipal of Jasper. The condition rating criteria defined for the Municipality of Jasper's infrastructure groups is contained in Appendix A. The following table summarizes the condition types assessed for each infrastructure group.

Table 2 – Condition Types

Infrastructure Group	Condition Type
Roadways (Streets)	Rutting
	Lineal Cracking
	Fatigue Cracking (reflection of structural failure)
	Surface Condition (i.e. ravelling and open surface texture)
	Grade (curb and gutter loss due to historic overlays)
Sidewalks	Cracking
	Spalling (i.e. open surface texture)
Water Mains	Structural Pipes (remaining wall thickness)
	Structural Valves
	Capacity (Noted for 4" pipe mains)
Sanitary Mains	Structural (NASSCO PACP Grade)
	O & M (NASSCO PACP Grade)
	Capacity (As per CCTV assessment)
Sanitary Manholes	Structural (NASSCO PACP Grade)
	O & M (NASSCO PACP Grade)
	Capacity (As per CCTV assessment)
Storm Mains	Structural (NASSCO PACP Grade)
	O & M (NASSCO PACP Grade)
	Capacity (As per CCTV assessment)
Storm Manholes & Catch Basins	Structural (NASSCO PACP Grade)
	O & M (NASSCO PACP Grade)
	Capacity (As per CCTV assessment)

The fundamental component of condition assessment criteria for each infrastructure group is <u>severity</u> and <u>extent</u>. Severity is a defined measure of the level of deterioration (i.e. minor, moderate, major, and severe). The extent is the proportion of the infrastructure segment surface area within each of the defined severity levels. As example, the following table illustrates the water main structural assessment based on the measured remaining wall thickness.

Table 3 – Water Main Structural Assessment Criteria

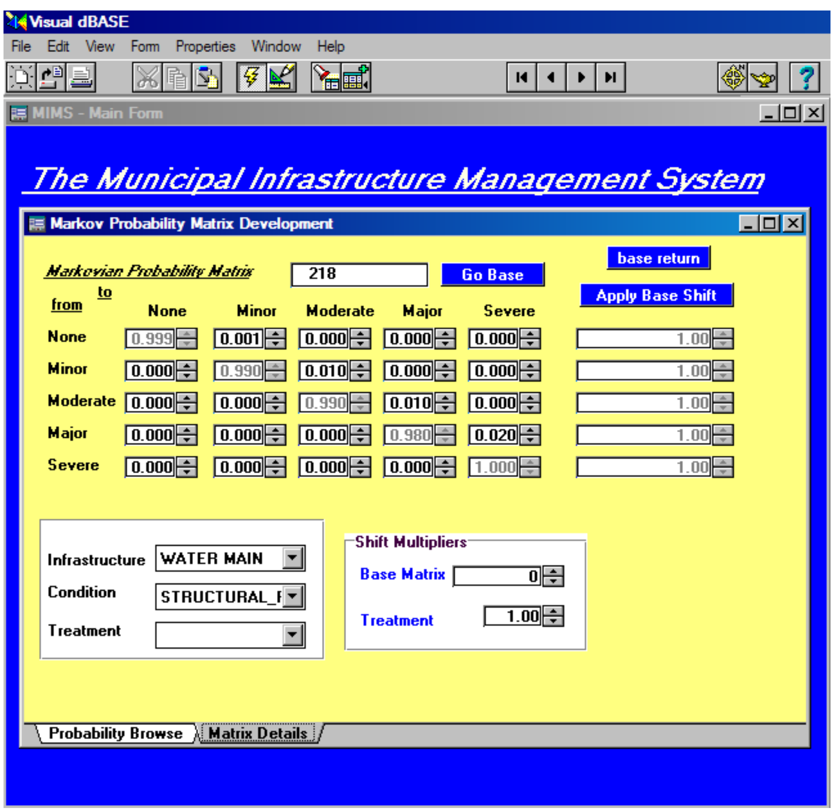
Severity Level	Criteria	Extent (%)
None	Remaining Wall Thickness = 80%-90%	Contractor Reports
Minor	Remaining Wall Thickness = 50%-80%	"
Moderate	Remaining Wall Thickness = 20%-50%	"
Major	Remaining Wall Thickness = 5%-20%	"
Severe	Remaining Wall Thickness = 0%-5%	"

Deterioration probability matrices are developed for each condition type. Historic data measurements were in part used to develop the deterioration rates and probability of moving from one severity level to another. The following figure illustrates the framework of deterioration probabilities. The following figure illustrates the deterioration probability matrix for the Jasper Water Main Structural (i.e. remaining wall thickness) condition type.

Table 4 – Deterioration Probability Matrix Framework

		To: None	Minor	Mod.	Major	Severe	**Total**
From:	None	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	1.0
	Minor	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}	1.0
	Mod.	P_{31}	P_{32}	P_{33}	P_{34}	P_{35}	1.0
	Major	P_{41}	P_{42}	P_{43}	P_{44}	P_{45}	1.0
	Severe	P_{51}	P_{52}	P_{53}	P_{54}	P_{55}	1.0

Figure 1 – Deterioration Probability Matrix – Jasper Water Main Structural Condition



Markovian Probabilistic Modelling principles use the measured severity and extent data with deterioration probabilities to forecast condition deterioration over time (i.e. several years). The following figure illustrates the Markovian deterioration calculation process.

Figure 2 – Markovian Simulated Condition Extent Calculation

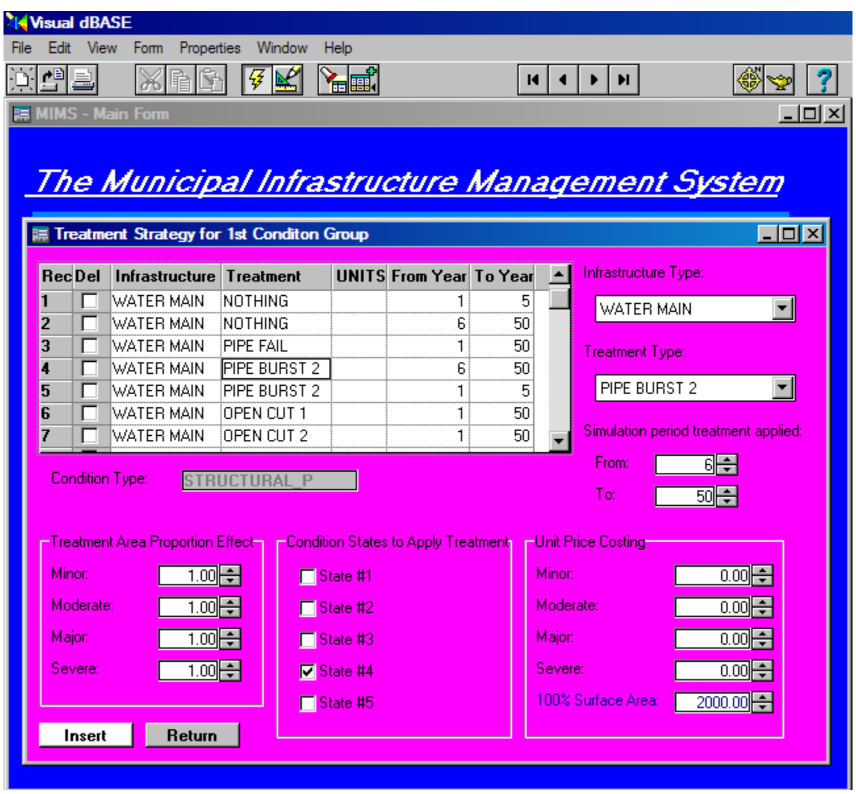
	Extent Levels within each Severity Rating					
Year	None	Minor	Moderate	Major	Severe	Index
Y_0	E_{01}	E_{02}	E_{03}	E_{04}	E_{05}	I_0
Y_1	$E_{01}*P_{1}$ + $E_{02}*P_{21}$ + $E_{03}*P_{31}$ + $E_{04}*P_{41}$ + $E_{05}*P_{51}$	$E_{01}*P_{12}$ + $E_{02}*P_{22}$ + $E_{03}*P_{32}$ + $E_{04}*P_{42}$ + $E_{05}*P_{52}$	$E_{01}*P_{13}$ + $E_{02}*P_{23}$ + $E_{03}*P_{33}$ + $E_{04}*P_{43}$ + $E_{05}*P_{53}$	$E_{01}*P_{14}$ + $E_{02}*P_{24}$ + $E_{03}*P_{34}$ + $E_{04}*P_{44}$ + $E_{05}*P_{54}$	$E_{01}*P_{15}$ + $E_{02}*P_{25}$ + $E_{03}*P_{35}$ + $E_{04}*P_{45}$ + $E_{05}*P_{55}$	I_1

During the lifecycle simulation period, the modelled severity-extent forecasts are indexed to five condition states:

- 1 – very good
- 2 – good
- 3 – fair
- 4 – poor
- 5 – very poor

This is used to trigger treatment options at various stages in the infrastructure lifecycle. The following figure illustrates the water main “Pipe Busting” treatment option.

Figure 3 – Jasper Water Main – Pipe Bursting Treatment Option



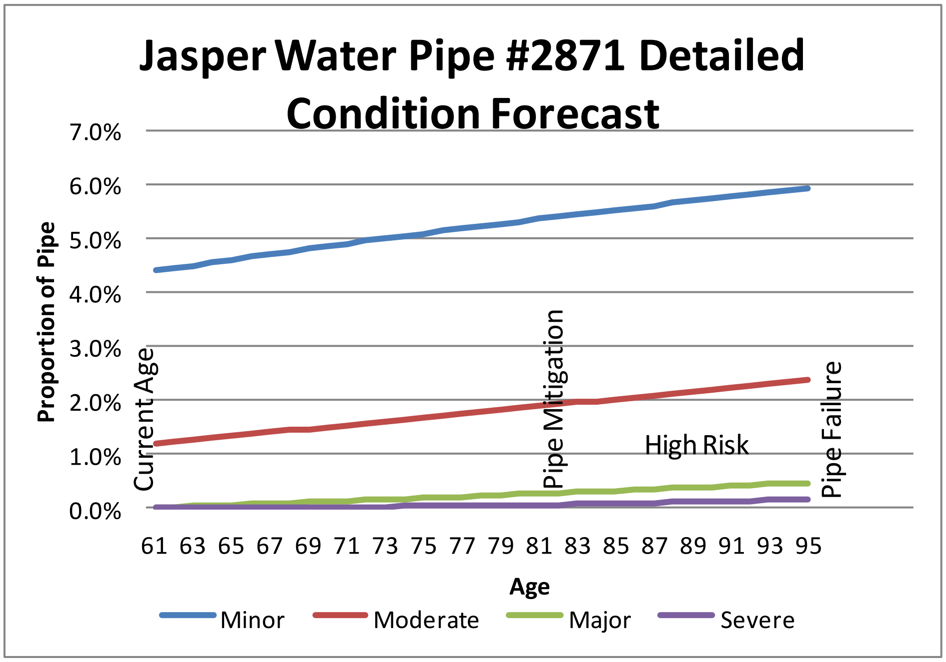
In this example, the pipe bursting option is triggered in condition state “4”. Condition state “5” would be failure of the pipe. Condition state 4 triggers remediation at a point in the lifecycle just prior to high risk of failure.

During the condition assessment process, pipe #2871 was assessed using electromagnetic technology. The assessment computed the structural rating based on severity-extent measurements of the pitting (i.e. remaining wall thickness). During the field testing, a portion of the pipe was extracted for physical verification of the electronic data measurements. The following figure illustrates a photo of the pipe sample noting the pitting within the pipe.

Figure 4 – Jasper Water Main #2871

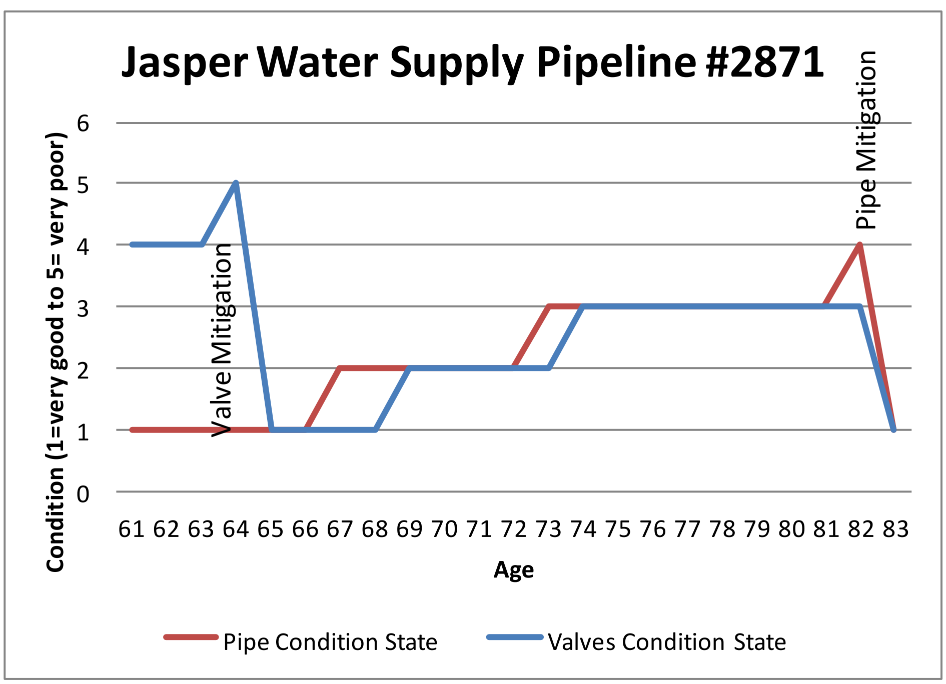
Pipe segment #2871 is a 61 year old cast-iron 150 mm (6”) water main. It is located in Patricia Circle. Overall, the pipe is in reasonably good condition. It has approximately 5-6% of the surface area pitted. The majority is in the minor severity grouping (i.e. 50-80% remaining wall thickness). There is no major or sever pitting. Starting from the measured condition state in year 61, the following figure shows the Markovian performance prediction for this pipe segment. The pipe may likely reach the end of its service life in 30-35 years from today. However, it would be prudent to address remediation ahead of the high risk period (i.e. 20-25 years from today).

Figure 5 – Severity Level Performance Prediction - Water Main #2871



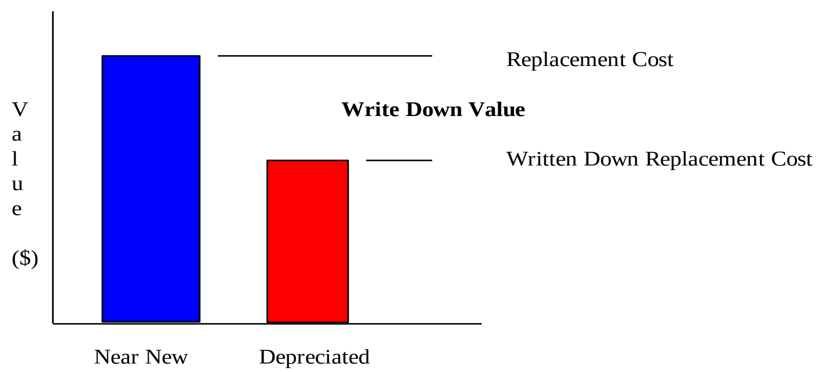
The following figure illustrates the condition state modelled over time with the treatment options applied. In this example, the graph shows two condition parameters; one for the pipe and the other for the valves. Today, the pipe is still in a very good (state 1) condition state. The associated valves along the line are projecting near the end of its service life and showing they will be replaced soon, or have been recently replaced. The pipe is showing reaching a poor (state 4) condition state in approximately 20 years from now. The modeling treatment strategy forecasted a "Pipe Bursting" treatment at this time, which reset the condition state of the pipe and associated valves to a very good (state 1) condition state.

Figure 6 – Condition State Performance Prediction - Water Main #2871



The current and modelled infrastructure condition is reported by the physical condition state (i.e. 1-5) for each of the condition types (i.e. fatigue cracking, etc.). The condition is also measured as monetary performance. This is the asset write-down-value (WDV). There is a relationship between condition state and WDV. The more deteriorated the infrastructure segment, the more depreciated the asset is and the higher the resulting WDV. This provides a dollar to dollar comparison between expenders or investment in the infrastructure asset to what the asset is worth. It enables the Municipality to determine if it is getting a positive Return on Infrastructure Investment (ROII).

Figure 7 – Write-Down-Value Illustration



The lifecycle modeling analysis completes the above example analysis for all the other infrastructure segments and for each infrastructure group (i.e. roadways, sidewalks, water mains, sanitary pipes, sanitary manholes, and storm manholes & catch basins). The condition assessment for the roadways and sidewalks was completed for each infrastructure in the infrastructure inventory. In some cases, we added segments that were missing from the inventory (i.e. GIS) system. The other infrastructure groups included only a sample of the network that was assessed. Then based on the pipe age and material type, a condition assessment was correlated for the remaining pipes that were not assessed. Our compiled data notes which pipes were physically assessed and which were rated based on a correlation.

Even though the modeling process is looking in the long-range horizon (i.e. 20-40 years), the focus for maintenance and capital programming purposes will be the short-range horizon (i.e. 5 year). It would be expected condition assessments be repeated in 2-4 year increments.

The same analysis process is applied to the sewer mains, manholes & catch basins, roadways (streets) and sidewalks.

3. Current State of the Infrastructure

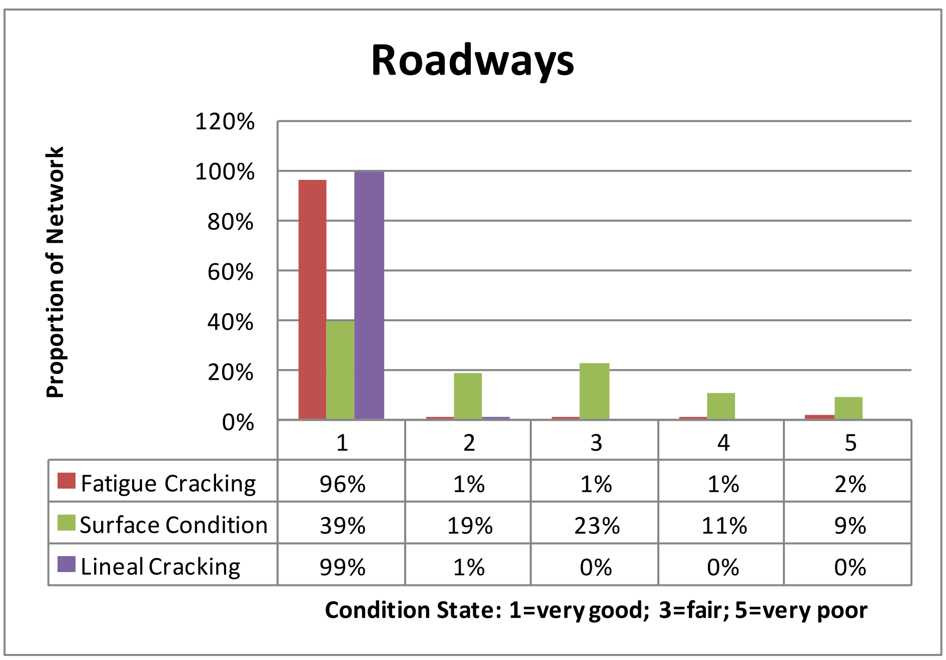
As a precursor to the tactical level analysis, this section presents the current state of the infrastructure. This is as per the field level condition assessments completed in the summer of 2016. This provides some understanding taken in the infrastructure renewal strategy.

3.1 Roadways (Streets - Pavement)

The following figure illustrates the current contrition state for the roadways network. It illustrates the proportion of the network in each of the five condition states (i.e. 1=very good; 3=fair; 5=very poor). This is illustrated for the fatigue cracking, surface condition, and lineal cracking condition types. Not shown on the graph is rutting and grade. These were also assessed in the field but with negligible issues. As such, rutting and grade are noted in a very good condition state.

Overall, the roadways are in fairly good condition. They are structurally sound with no indication of subsurface failure. The primary concern is poor to very poor surface condition on approximately 20 percent of the roadways. The surface is beginning to ravel. This is a loss of binder around the aggregate and the roadways are taking on an exposed aggregate appearance. In some cases, this has progressed to a loss of aggregate and eventual potholes. Timely remediation could seal the surfaces to a near new condition state. However, if deterioration progresses, then full pavement rehabilitation will be required at five times the cost of preventative maintenance such as a micro-surface. Roadways are in a timely sensitive stage in its lifecycle. Deferral of works could significantly increase the cost to renew this infrastructure group.

Figure 8 – Roadways State of the Infrastructure



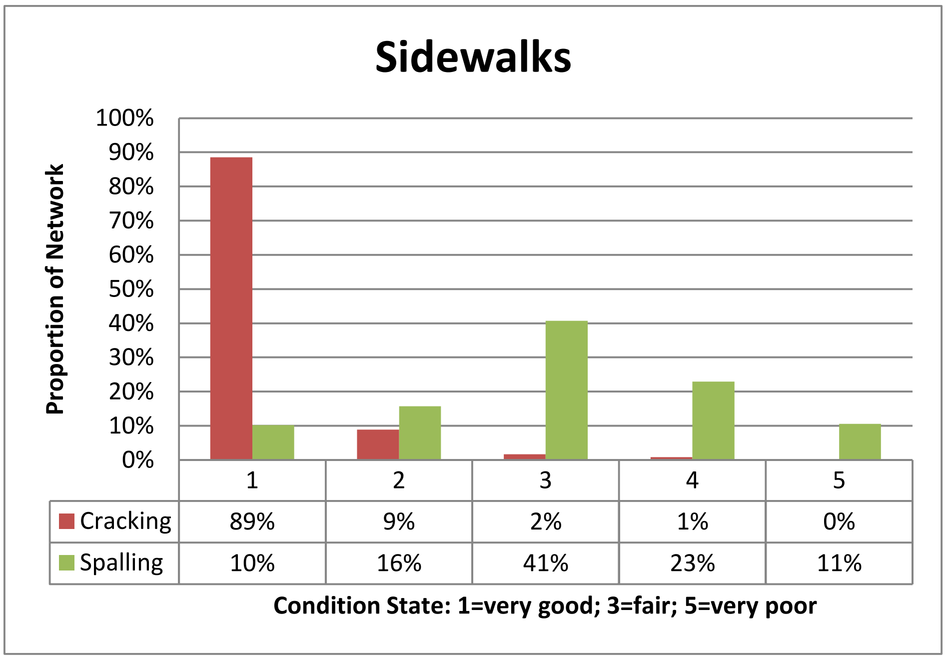
	1	2	3	4	5
Fatigue Cracking	96%	1%	1%	1%	2%
Surface Condition	39%	19%	23%	11%	9%
Lineal Cracking	99%	1%	0%	0%	0%

3.2 Sidewalks (Concrete)

The following figure illustrates the current contrition state for the sidewalks network. It illustrates the proportion of the network in each of the five condition states (i.e. 1=very good; 3=fair; 5=very poor). This is illustrated for the cracking and spalling condition types.

Overall, the sidewalks are in fairly good condition. They are structurally sound with no indication of subsurface failure. This is shown by very little cracking and heaving. The primary concern is the poor to very poor spalling on approximately 34 percent of the sidewalks. This is often a result of the aggregate quality and/or salts used for roadway de-icing. On inspection, it was observed that some of the newer sidewalks were spalling quicker than the older sidewalks. This is an indication that quality control may have changed over recent years.

Figure 9 – Sidewalks State of the Infrastructure



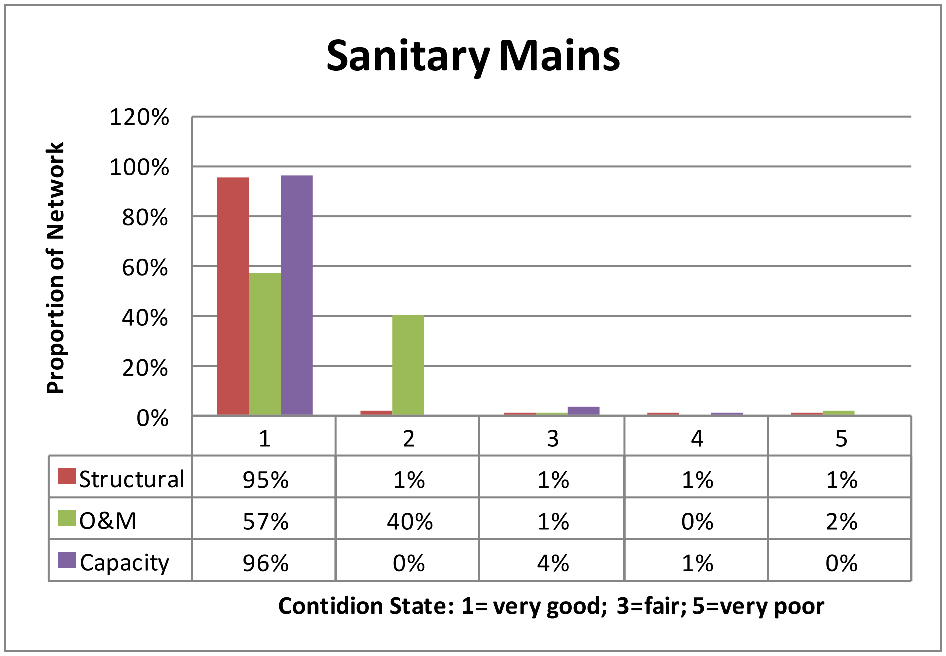
3.3 Wastewater Collection (Sanitary, Storm, Manholes and Catch Basins)

The wastewater collection infrastructure group was assessed as per the following sub-categories:

- Sanitary Mains
- Storm Mains
- Sanitary Manholes
- Storm Manholes and Catch Basins

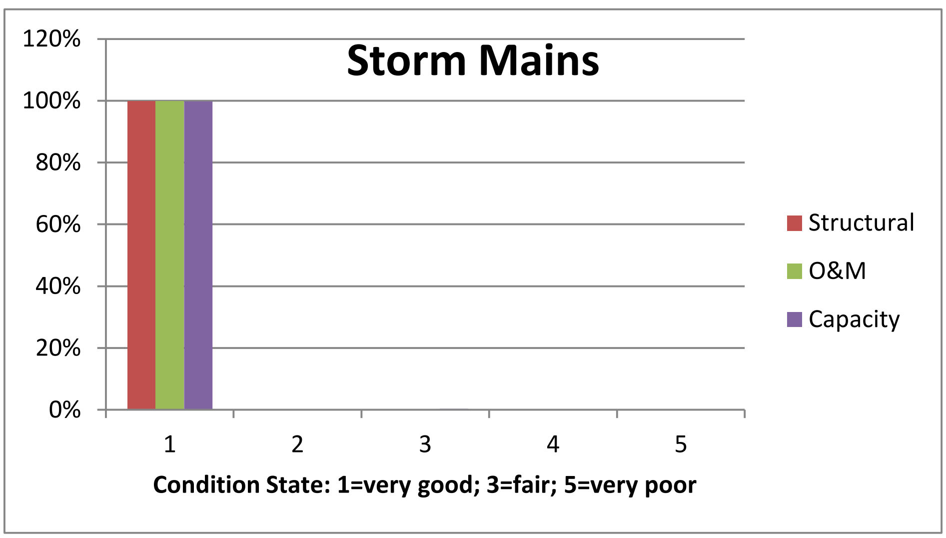
The following figures present the Sanitary Mains and Storm Mains state of the infrastructure. The sanitary mains network appears to be in a good condition state. Approximately 2 percent of the network may have a structural concern requiring some form of attention. The more significant issues are operations and maintenance (i.e. O&M) relating to build up of scale along the pipe wall and roots infiltrating through pipe joints. Alternatively, the storm mains network appears to be in very good condition from both the structural and O&M perspective. This is likely related to the nature of the sanitary effluent, due to its corrosiveness and nutrient content.

Figure 10 – Sanitary Mains State of the Infrastructure



	1	2	3	4	5
Structural	95%	1%	1%	1%	1%
O&M	57%	40%	1%	0%	2%
Capacity	96%	0%	4%	1%	0%

Figure 11 – Storm Mains State of the Infrastructure



The following figures presents the Sanitary Manholes and Storm Mains & Catch Basins state of the infrastructure. Both groupings appear to be in a very good condition state.

Figure 12 – Sanitary Manholes State of the Infrastructure

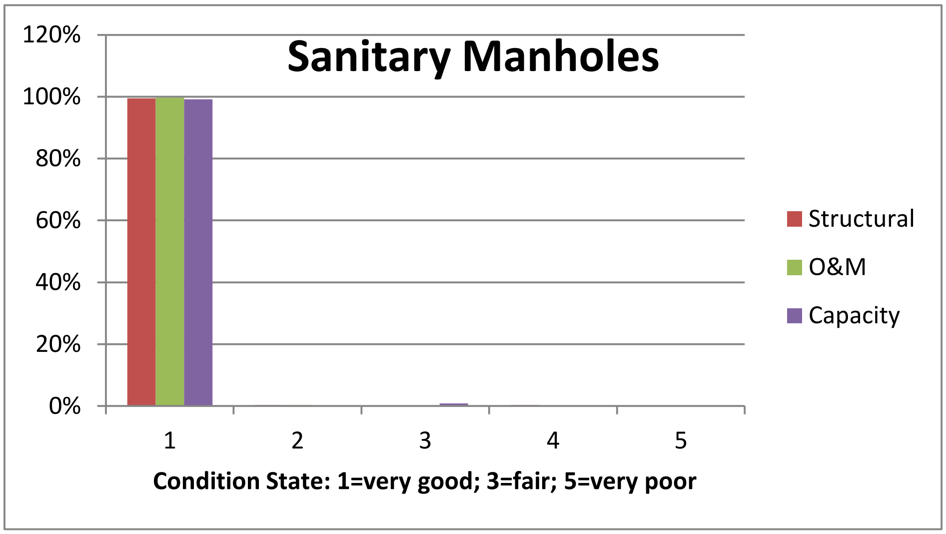
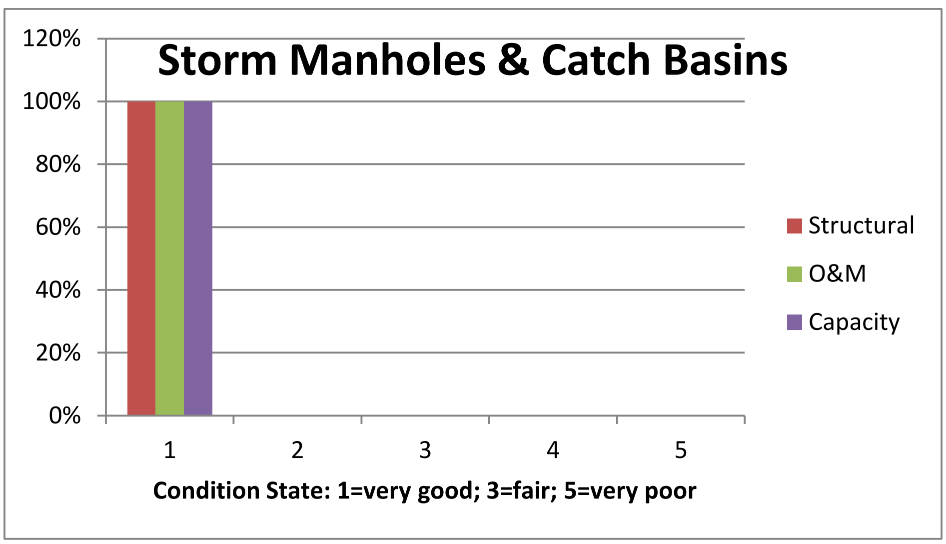


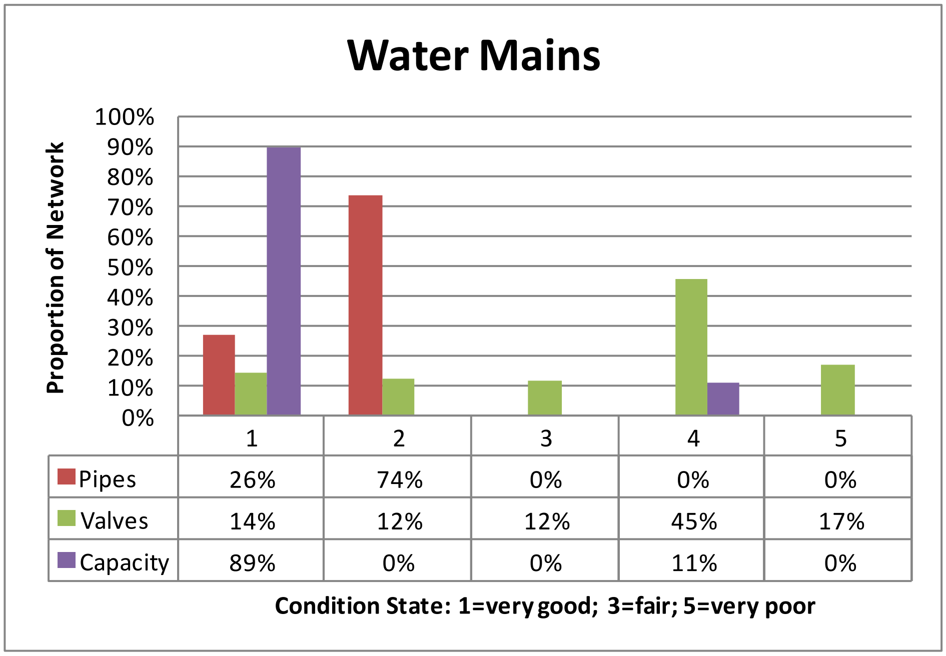
Figure 13 – Storm Manholes & Catch Basins State of the Infrastructure



3.4 Water Distribution (Pipes and Valves)

The following figure presents the Water Mains state of the infrastructure. Water mains were the most challenging infrastructure group in acquiring condition data. The municipality had very little information on the pipe break history. Most occurrences were noted around valve failures, not necessarily the pipe. Very good pipe condition data was however attained for one 61 year old cast iron pipe segment (#2871) in Patricia Circle. This was the correlation sample for the rest of the network. At this time it was noted some recent valve/hydrant replacements on Patricia Circle. A valve assembly was also being replaced on pipe segment #2871 concurrent with the data gathering. This provided some indication that the service life of the water main valves was shorter than the pipe segments. This was a factor in the tactical level analysis moving forward.

Figure 14 – Water Mains State of the Infrastructure



	1	2	3	4	5
Pipes	26%	74%	0%	0%	0%
Valves	14%	12%	12%	45%	17%
Capacity	89%	0%	0%	11%	0%

Figure 15 – Patricia Circle Water Main Pipe #2871 Valve Assembly Replacement (Year 2016)

4. Tactical Asset Management

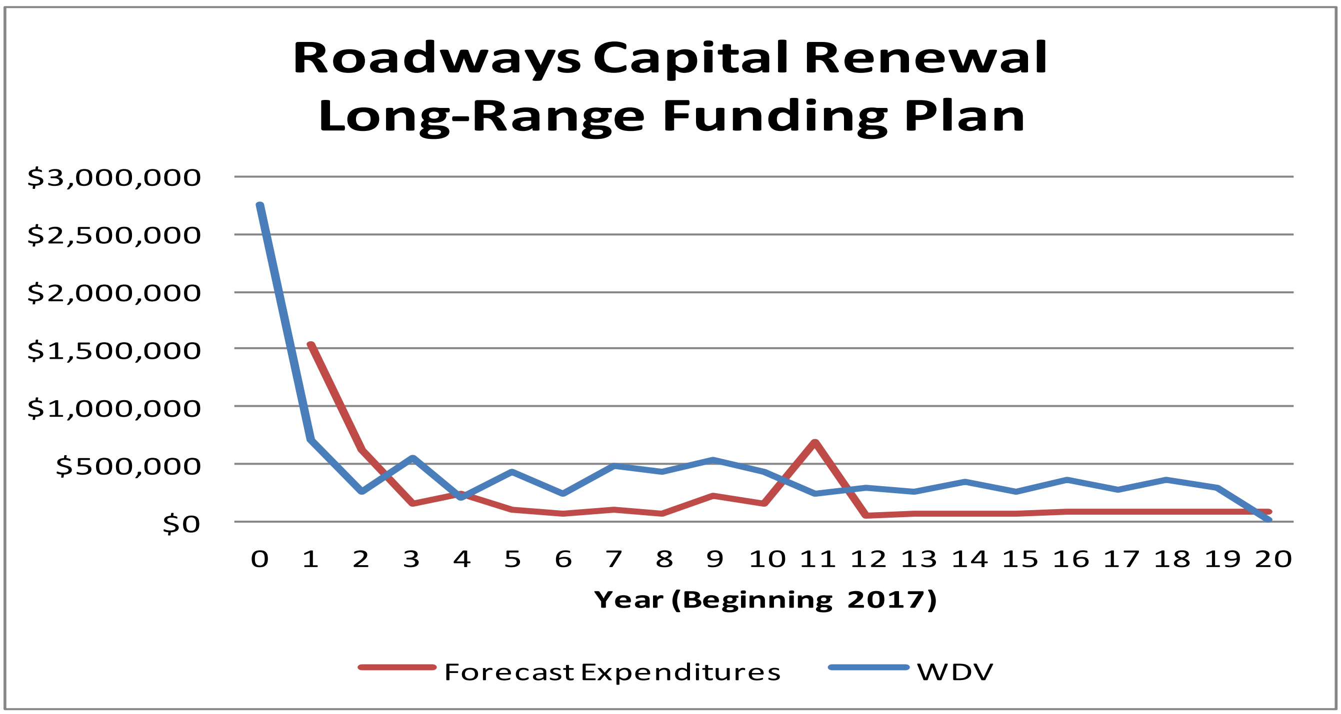
The tactical level analysis begins with the current state of the infrastructure and models the deterioration over time. During the optimization modeling analysis, alternative maintenance and renewal treatments are triggered as appropriate to do so within the infrastructure lifecycle. The analysis is completed for every segment within each infrastructure group.

The objective is to develop a plan that will proactively sustain the infrastructure over its lifecycle while minimizing costs.

4.1 Roadways (Streets)

As presented earlier in the State of the Infrastructure section, open surface texture is the primary condition distress. As a result, the optimal scenario is triggering an aggressive micro-surfacing program in the short-term (5-year) horizon; along with some resurfacing (i.e. repaving) where the level of deterioration has accelerated. The following figure summarizes the projected spending over the 20-year horizon.

Figure 16 – Roadways Long-Range Funding Projection



The following table measures the effectiveness of the proposed spending in the short-term (i.e. 5-year) and long-term (i.e. 20-year) horizons. The short term has more capital renewal spending due to the backlog of mitigating the pavement's open-surface texture. In the short-term the Municipality should be in a position to be investing in capital renewal estimated at approximately $532,000/year. With this spending is a significant improvement in the roadways condition state estimated at 9-17%/year in the short term and 3-5%/year in the long term. This is indicative of the ROII, which demonstrates a significantly greater improvement in the asset value given the maintenance and renewal investment.

Table 5 – Roadways Performance Summary

Roadways	Optimization 5-year	Optimization 20-year
Program Expenditures		
- Total Period Expenditure (M$)	$2.662	$4.607
- Annualized Expenditure (M$/yr)	$0.532	$0.230
Monetary Performance		
- WDV (initial)	$2.759	$2.759
- WDV (End)	$0.427	$0.012
Improved Perf (+)	$2.332	$2.747
Annual Perf Change (M$/yr)	$0.466	$0.137
	17%	5%
Condition State/Index		
- Index (initial)	14	14
- Index (End)	8	7
Improved Condition (+)	6	7
Annual Condition Change (/yr)	1.2	0.4
Annual Condition Change (%/yr)	9%	3%
ROII - Annualized (%/yr)	188%	160%
- (100% = Stabilization Level)		

Within the five-year horizon, the following table summarizes the annualized cost broken out by maintenance (i.e. patching and crack filling), micro-surfacing, and resurfacing. The initial five years are relatively aggressive at a projected spending of $532,000/yr.

Table 6 – Roadways Five-Year (2017-2021) Maintenance and Renewal Summary

Treatment Activity	Length (m)	Cost ($/yr)
Maintenance		$30,000
Micro-Surfacing (i.e. Micro-Seal)	16,009	$340,000
Resurfacing (i.e. Repaving)	1,446	$162,000
Average Annual Cost		**$532,000**
Total Cost Over 5-Years		**$2,660,000**

The micro-surfacing (sometimes called micro-sealing) treatment is new to the municipality of Jasper. It is a unique blend of manufactured aggregate fines, emulsion, and portland cement applied in a thin 7 mm lift; much thinner than a typical 50 mm asphalt concrete resurfacing lift. The final product looks similar to a new asphalt concrete surface. It is very effective at mitigating the open surface texture. It has some minor effect on the fatigue cracking. However, if the roadway is too deteriorated, then a conventional resurfacing operation is required. However, the cost of resurfacing is approximately four-times the cost of micro-surfacing. The following figure illustrates a typical micro-surfacing operation.

Figure 17 – Micro-Surfacing

The following tables list the specific road segments targeted for Micro-Surfacing and Resurfacing in the five-year horizon. Included is the condition state for the existing and modelled condition for each of the major distresses. The condition rating score is as follows:

- 1 – very good
- 2 – good
- 3 – fair
- 4 – poor
- 5 – very poor

As observed in the tables, below, micro-surfacing is predominately being generated for fair to poor surface condition. The resurfacing is primarily being generated for poor to very poor fatigue cracking and very poor surface condition.

Table 7– Five-Year (2017-2021) Roadways Micro-Surfacing Segment Listing

SEGMENT_ID	LOCATION	AGE	LENGTH	YEAR	TREATMENT	COST	Fatigue Cracking	Surface Condition	Lineal Crackintg
30EB	Connaught Drive North	1994	204	3	MICRO SEAL	$ 32,795	1	3	2
30EB	Connaught Drive North	1994	204	3	MICRO SEAL	$ 32,795	1	3	2
30EE	Connaught Drive North of Sawri	1994	546	3	MICRO SEAL	$ 43,888	1	3	2
3110	Geikie Street 100 Block	2010	204	2	MICRO SEAL	$ 15,684	1	3	1
3111	Patricia Street 100 Block	1991	202	1	MICRO SEAL	$ 14,544	1	3	1
3114	Aspen Ave	1991	44	1	MICRO SEAL	$ 3,168	1	3	1
3115	Aspen Ave	1991	49	1	MICRO SEAL	$ 3,528	1	3	1
3117	Geikie Street 200 Block North	2010	62	2	MICRO SEAL	$ 4,780	1	3	1
3118	Geikie Street 200 Block middle	2010	67	1	MICRO SEAL	$ 4,824	1	3	1
3119	Geikie Street 200 Block South	2010	45	1	MICRO SEAL	$ 3,240	1	3	1
311A	Patricia Street 200 Block	1991	175	1	MICRO SEAL	$ 12,667	1	3	1
311E	Balsam Ave	1975	43	5	MICRO SEAL	$ 3,713	1	3	1
311F	Balsam Ave	2000	44	5	MICRO SEAL	$ 3,800	1	3	1
3121	Geikie Steet 300 Block North	2010	46	1	MICRO SEAL	$ 3,312	1	3	1
3122	Geikie Street 300 Block South	2010	117	1	MICRO SEAL	$ 8,424	1	3	1
3128	Patricia Street 300 Block	1991	162	1	MICRO SEAL	$ 14,774	1	3	1
3129	Geikie Street 400 Block	1991	222	1	MICRO SEAL	$ 26,725	1	4	1
3130	Elm Ave	1991	44	1	MICRO SEAL	$ 3,185	1	3	1
3131	Elm Ave	1991	44	1	MICRO SEAL	$ 3,185	1	3	1
3132	Patricia Street 400 Block	1991	222	1	MICRO SEAL	$ 37,339	1	5	1
313C	Bonhome Street 200 Block middl	1970	131	1	MICRO SEAL	$ 9,457	1	3	1
313D	Aspen Ave	1991	21	3	MICRO SEAL	$ 1,684	1	3	1
313E	Aspen Ave	1991	68	3	MICRO SEAL	$ 5,453	1	3	1
313F	Aspen Ave	1991	63	3	MICRO SEAL	$ 5,052	1	3	1
3140	Bonhomme St inbetween Aspen Cr	1970	86	1	MICRO SEAL	$ 6,225	1	3	1
3146	Bonhomme St 200 Block South	1977	269	1	MICRO SEAL	$ 29,698	1	4	1
3149	Colin Cresent	2000	47	2	MICRO SEAL	$ 3,594	1	3	1
314A	Colin Cresent	2000	60	2	MICRO SEAL	$ 4,588	1	3	1
314B	Colin Cresent	2000	69	2	MICRO SEAL	$ 5,276	1	3	1
314C	Colin Cresent	2000	81	2	MICRO SEAL	$ 6,193	1	3	1
314D	Colin Cresent	2000	52	2	MICRO SEAL	$ 3,976	1	3	1
314E	Pyramid Lk Rd 500 Block - Bonh	1977	159	1	MICRO SEAL	$ 11,448	1	3	1
314F	Pyramid Lk Rd 300 Block - Bonh	1977	159	1	MICRO SEAL	$ 11,448	1	3	1
3150	Elm Ave	1991	51	1	MICRO SEAL	$ 3,672	1	3	1
3151	Elm Ave	1991	50	2	MICRO SEAL	$ 3,862	1	3	2
3152	Elm Ave. between Turret and Bo	1991	160	1	MICRO SEAL	$ 11,520	1	3	1
3153	Patricia Street	1991	105	4	MICRO SEAL	$ 9,362	1	3	1
315E	Pyramid Lk Rd 600 Block - Bonh	1977	72	1	MICRO SEAL	$ 5,184	1	4	1
3161	Pyramid Lk Rd 700 Block - Bonh	1977	189	1	MICRO SEAL	$ 22,680	1	5	1
3162	Maligne Ave	2007	117	1	MICRO SEAL	$ 8,491	1	4	1
3163	Turret Street	2003	185	5	MICRO SEAL	$ 16,453	1	3	1
3165	Pyramid LkRd 800 Block North -	1977	77	1	MICRO SEAL	$ 9,240	1	5	1
3166	Pyramid Lk Rd 800 Block South	1977	122	1	MICRO SEAL	$ 8,901	1	3	1
316E	Pine Ave	1977	58	1	MICRO SEAL	$ 4,176	1	4	1
316F	Pine Ave	1977	45	1	MICRO SEAL	$ 3,257	1	4	1
317C	Geikie Street 500 Block	1991	198	1	MICRO SEAL	$ 21,859	1	4	1
3187	Larch Ave	2007	38	2	MICRO SEAL	$ 3,583	1	3	1
318B	Pine Ave	1977	58	1	MICRO SEAL	$ 4,209	1	4	1
318C	Pine Ave	1977	43	1	MICRO SEAL	$ 3,121	1	4	1
3190	Pine Ave	1977	44	1	MICRO SEAL	$ 3,222	1	3	1
3191	Geikie Street 800 Block	1991	240	1	MICRO SEAL	$ 63,360	1	5	1
3192	Geikie Street 800 Block South	1994	85	1	MICRO SEAL	$ 10,304	1	5	1
3193	Geikie Street 700 Block North	1991	201	1	MICRO SEAL	$ 24,224	1	5	1
3194	Geikie Street 600 Block	1991	145	1	MICRO SEAL	$ 24,471	1	5	1
3195	Hazel Ave	2002	45	1	MICRO SEAL	$ 3,240	1	3	1
3196	Hazel Ave	2002	43	1	MICRO SEAL	$ 3,096	1	3	1
3197	Patricia Street 600 Block Nort	1991	52	1	MICRO SEAL	$ 3,744	1	3	1

Table 8 – Five-Year (2017-2021) Roadways Micro-Surfacing Segment Listing

SEGMENT_ID	LOCATION	AGE	LENGTH	YEAR	TREATMENT	COST	Fatigue Cracking	Surface Condition	Lineal Crackintg
3198	Patricia Street 600 Block Sout	1991	222	1	MICRO SEAL	$ 15,984	1	3	1
3199	Hazel Ave	2002	54	5	MICRO SEAL	$ 4,802	1	3	1
319A	Spruce Ave Roadway Surfaces	2000	48	1	MICRO SEAL	$ 3,456	1	4	1
319B	Spruce Ave	2000	46	1	MICRO SEAL	$ 3,327	1	4	1
319C	Spruce Ave	2000	44	1	MICRO SEAL	$ 3,176	1	3	1
319D	Spruce Ave	2000	50	1	MICRO SEAL	$ 3,610	1	3	1
319F	Pine Ave. between Patricia and	1975	44	1	MICRO SEAL	$ 3,168	1	3	1
31A0	Pine Ave	1975	43	1	MICRO SEAL	$ 3,113	1	3	1
31A1	Pine Ave	1974	44	1	MICRO SEAL	$ 3,168	1	3	1
31AA	Patricia Street 700 Block	1991	371	1	MICRO SEAL	$ 44,734	1	4	1
31AB	Patricia Street 800 Block	1991	209	1	MICRO SEAL	$ 16,177	2	3	1
31AE	Geikie Street 900 Block North	1994	134	1	MICRO SEAL	$ 9,648	1	3	1
31AF	Geikie Street 900 Block South	1994	56	1	MICRO SEAL	$ 4,032	1	3	1
31B2	Patricia Street 900 Block	1991	190	1	MICRO SEAL	$ 14,095	3	3	2
31B3	Willow Ave	1997	46	1	MICRO SEAL	$ 3,312	1	3	1
31B4	Willow Ave	1997	144	3	MICRO SEAL	$ 11,547	1	3	1
31B5	Pyramid Lk Rd 900 Block	1977	245	1	MICRO SEAL	$ 29,903	1	4	2
31BE	Patricia Ave 1000 East	1979	202	1	MICRO SEAL	$ 33,936	1	5	1
31BF	Patricia street 1000 middle	2010	84	1	MICRO SEAL	$ 14,112	1	5	1
31C3	Patricia Cresent	1980	45	4	MICRO SEAL	$ 3,814	1	3	1
31C4	Brewster Cresent	1980	36	2	MICRO SEAL	$ 2,768	1	3	1
31C5	Patricia Cresent	1980	397	4	MICRO SEAL	$ 33,651	1	3	1
31CF	Connaught Dr West	1981	262	2	MICRO SEAL	$ 40,062	1	3	1
31D0	Connaught Dr West to Sleepy Ho	1981	23	2	MICRO SEAL	$ 3,517	1	3	1
31D2	Hwy 93A	2000	95	4	MICRO SEAL	$ 8,059	1	3	1
31D3	Hwy 93A Rail Crossing	2000	32	5	MICRO SEAL	$ 2,846	1	3	1
31D4	Hwy 93A	2000	50	5	MICRO SEAL	$ 4,447	1	3	1
31D5	Hwy 93A	2000	98	5	MICRO SEAL	$ 8,715	1	3	1
31D8	S Block	1972	81	1	MICRO SEAL	$ 6,610	1	3	1
31D9	S Block	1972	222	2	MICRO SEAL	$ 16,973	1	3	1
31DA	S Block	1972	495	1	MICRO SEAL	$ 59,400	1	4	1
31DB	Compound Road	1972	136	1	MICRO SEAL	$ 9,792	1	4	1
31DD	Compound road	1972	128	1	MICRO SEAL	$ 46,080	1	5	1
31DF	Compound road	1972	198	1	MICRO SEAL	$ 52,272	1	5	1
3203	Tonquin Street	1977	134	1	MICRO SEAL	$ 12,221	1	4	1
3204	Turret Street	1996	131	1	MICRO SEAL	$ 9,432	1	3	1
37BD	Alley between Geikie and Patri	1955	151	1	MICRO SEAL	$ 10,570	1	4	1
38CB	Elm Ave	1991	44	1	MICRO SEAL	$ 3,168	1	3	1
38E7	Pine Ave	1975	44	1	MICRO SEAL	$ 3,185	1	3	1
391B	Connaught Dr Sawridge	1981	251	4	MICRO SEAL	$ 42,604	1	3	1
3924	Cedar Ave	1991	43	2	MICRO SEAL	$ 3,296	1	3	1
3926	Cedar Ave Roadway Surfaces	1991	46	2	MICRO SEAL	$ 3,526	1	3	1
3927	Pyramid Ave	1997	78	1	MICRO SEAL	$ 20,622	1	5	1
3928	Pyramid Ave	1997	64	1	MICRO SEAL	$ 16,950	1	5	1
3929	Pyramid Ave	1997	86	1	MICRO SEAL	$ 22,737	1	5	1
392B	Connaught Dr 400 Block	1981	145	2	MICRO SEAL	$ 27,757	1	3	1
392F	Connaught Dr 700 Block	1981	367	4	MICRO SEAL	$ 62,210	1	3	1
3930	Connaught Dr 800 Block	1981	208	4	MICRO SEAL	$ 35,258	1	3	1
3931	Connaught Dr 900 Block	1981	265	2	MICRO SEAL	$ 40,520	1	3	1
3932	Miette Ave	1994	87	1	MICRO SEAL	$ 12,528	1	3	1
3934	Miette Ave	1994	64	1	MICRO SEAL	$ 9,216	1	3	1
3935	Miette Ave	1994	66	1	MICRO SEAL	$ 9,504	1	3	1
3936	Miette Ave	1994	65	1	MICRO SEAL	$ 9,360	1	3	1
3937	Miette Ave	1994	117	1	MICRO SEAL	$ 21,386	1	4	1
393D	Miette Ave	1994	213	1	MICRO SEAL	$112,464	1	5	1
393E	Miette Ave	1994	29	1	MICRO SEAL	$ 4,176	1	3	1
3940	Hazel Ave	2002	54	5	MICRO SEAL	$ 4,802	1	3	1
3941	Pyramid Ave	1997	67	1	MICRO SEAL	$ 17,744	1	5	1
3946	Bonhomme St 200 Block North	1970	56	1	MICRO SEAL	$ 6,742	1	4	1

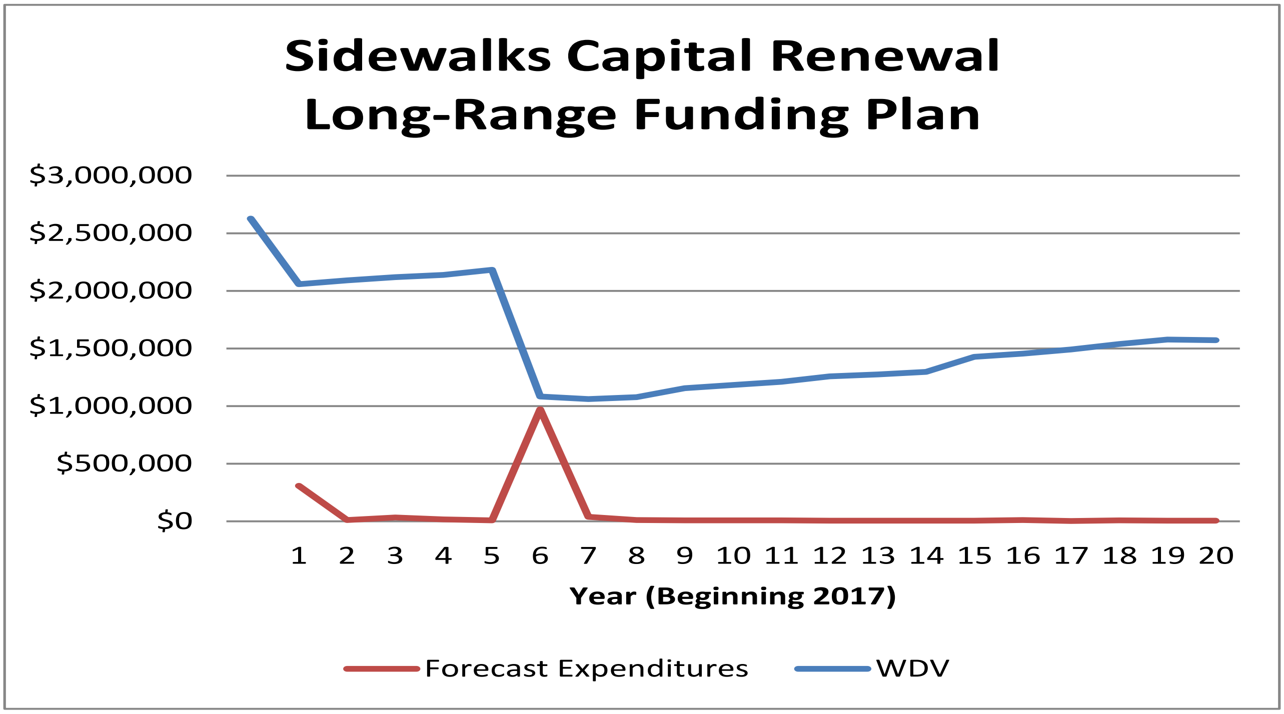
Table 9 – Five-Year (2017-2021) Roadways Resurfacing Segment Listing

SEGMENT_ID	LOCATION	AGE	LENGTH	YEAR	TREATMENT	COST	Fatigue Cracking	Surface Condition	Lineal Cracking
311B	Balsam Ave	2000	44	1	RESURFACE	$ 21,120	5	4	1
311C	Balsam Ave	2000	50	1	RESURFACE	$ 24,000	5	4	1
31DC	Compound road	1972	388	1	RESURFACE	$186,240	1	5	1
38C8	Aspen Cresent	1975	345	1	RESURFACE	$165,600	5	3	1
38E6	80 Block Geikie	1975	377	2	RESURFACE	$180,960	4	3	1
391C	Connaught Dr 90 Block	1981	242	2	RESURFACE	$232,320	4	4	2

4.2 Sidewalks (Concrete)

As presented earlier in the State of the Infrastructure section, spalling is the primary condition distress. As a result, the optimal scenario is initiating surface treatment in the form of bonded overlays and diamond grinding & thin-bituminous-surfacing in the short-term (5-year) horizon. The following figure summarizes the projected spending over the 20-year horizon. This is indicating a spike of renewal in year 6.

Figure 18 – Sidewalk Long-Range Funding Projection



The following table measures the effectiveness of the proposed spending in the short-term (i.e. 5-year) and long-term (i.e. 20-year) horizons. In the short-term the Municipality should be in a position to invest approximately $75,000/year. With this spending is a positive improvement in the sidewalk condition state estimated at 3-4%/year in the short term and 2%/year in the long term. This is indicative of the ROII, which demonstrates a significantly greater improvement in the asset value given the maintenance and renewal investment.

Table 10 – Sidewalk Performance Summary

Sidewalks	Optimization 5-year	Optimization 20-year
Program Expenditures		
- Total Period Expenditure (M$)	$0.375	$1.475
- Annualized Expenditure (M$/yr)	$0.075	$0.074
Monetary Performance		
- WDV (initial)	$2.628	$2.628
- WDV (End)	$2.184	$1.571
Improved Perf (+)	$0.444	$1.057
Annual Perf Change (M$/yr)	$0.089	$0.053
	3%	2%
Condition State/Index		
- Index (initial)	21	21
- Index (End)	17	14
Improved Condition (+)	4	7
Annual Condition Change (/yr)	0.8	0.4
Annual Condition Change (%/yr)	4%	2%
ROII - Annualized (%/yr)	218%	172%
- (100% = Stabilization Level)		

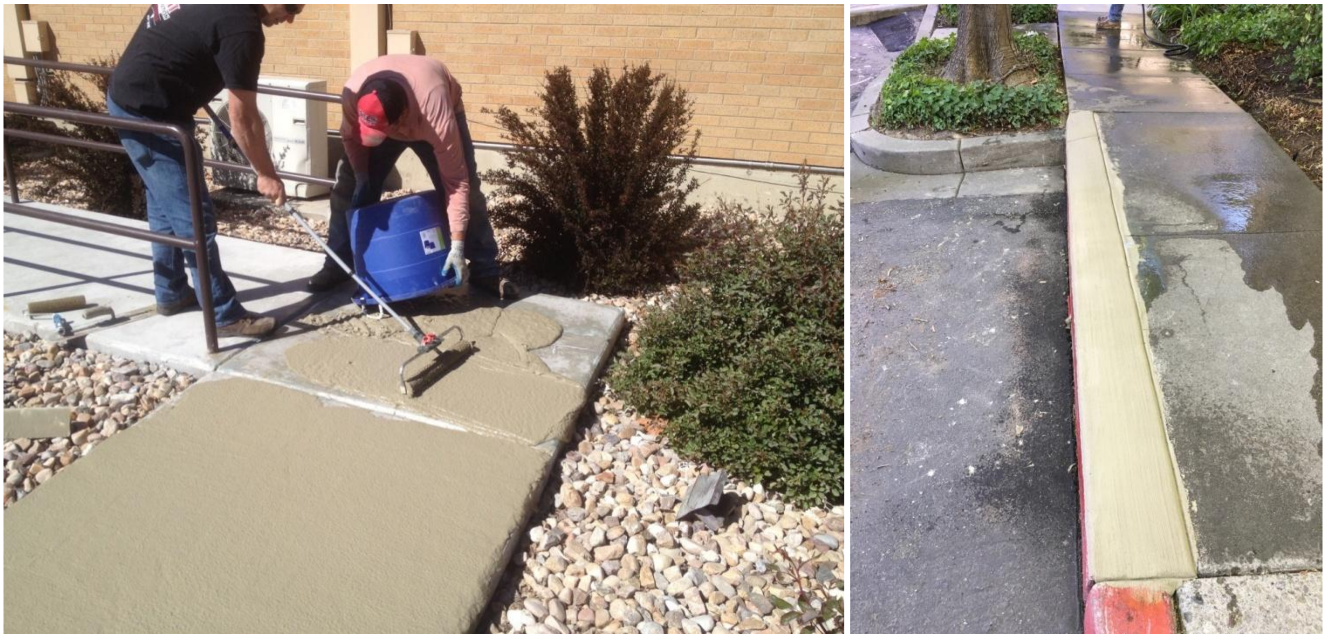
Within the five-year horizon, the following table summarizes the annualized cost broken out by maintenance (i.e. patching and grinding), bonded overlays, and grinding & thin-bituminous-surfacing (also referred to as micro-surfacing). It is a relatively light program. However, as this is a relatively new approach to the Municipality, it may be considered a trial period. Year six is projecting more need for sidewalk renewal, which is not included in the expenditure estimates below. Due to the well maintained sidewalk state, the need for trip-edge grinding is relatively insignificant. There still may be need for some unexpected surface maintenance services.

Table 11 – Sidewalk Five-Year (2017-2021) Maintenance and Renewal Summary

Treatment Activity	Length (m)	Cost ($/yr)
Maintenance (Grinding and Patching)		$0
Bonded Overlay	2,548	$12,000
Diamond Grinding & Thin-Bituminous-Surface	2,648	$13,000
Average Annual Cost		**$75,000**
Total Cost over 5-Years		**$375,000**

In our lifecycle optimization analysis, we are bringing forward two treatments the Municipality may not be familiar with. One is a bonded overlay, which is a thin epoxy that bonds to the existing concrete. It can be applied to the entire sidewalk surface. However, we bring this treatment in as a spot repair of cracks and spalling. It works well for both the sidewalk surface and curb repairs.

Figure 19 – Bonded Overlay



Then we bring forward diamond grinding of the major cracks to level the surface followed by application of a thin-bituminous-surface indicative of a micro-surface. This we apply to the full length of the sidewalk. The ascetic quality of the diamond grinding & thin-bituminous-surface below is better than the bonded overlay above. However, it does cost more and not appropriate for smaller spot repairs. The diamond grinding & thin-bituminous-surface treatment will complement well with the roadways (streets) micro-surfacing program; where the works for roadways and sidewalks could be tendered in a single contract.

Figure 20 – Diamond Grinding and Thin-Bituminous-Surface

The following tables list the specific sidewalk segments targeted for bonded overlay and grinding & thin-bituminous-surface treatments in the five-year horizon. Included is the condition state for the existing and modelled condition for each of the major distresses. The condition rating score is as follows:

- 1 – very good
- 2 – good
- 3 – fair
- 4 – poor
- 5 – very poor

The following table lists the recommended bonded overlay sections. The triggering condition distress is spalliing. However on application of the treatment, cracked areas would also be mitigated. The intent is to apply over the more moderate to major distress areas in spot locations. The sidewalks triggered for this treatment are in the fair condition state “3” for spalling.

Table 12 – Five-Year (2017-2021) Sidewalk Bonded Overlay Segment Listing

ITEM	SEGMENT_ID	AGE	LENGTH (m)	YEAR	TREATMENT	COST	Cracking	Spalling
SIDEWALK	326D	1974	208	4	BONDED OLAY	$ 1,297	1	2
SIDEWALK	326D	1974	208	3	BONDED OLAY	$ 6,196	2	3
SIDEWALK	327F	1974	180	3	BONDED OLAY	$ 4,485	1	3
SIDEWALK	3284	1975	220	4	BONDED OLAY	$ 1,118	1	2
SIDEWALK	328E	1975	132	2	BONDED OLAY	$ 5,218	1	3
SIDEWALK	32AB	1977	342	1	BONDED OLAY	$ 966	1	3
SIDEWALK	32DF	1980	70	3	BONDED OLAY	$ 4,114	1	3
SIDEWALK	32E2	1980	135	2	BONDED OLAY	$ 5,311	2	3
SIDEWALK	333B	1991	30	5	BONDED OLAY	$ 1,772	1	3
SIDEWALK	3355	1994	72	3	BONDED OLAY	$ 1,665	2	3
SIDEWALK	3358	1994	158	5	BONDED OLAY	$ 3,785	1	3
SIDEWALK	3365	1994	74	3	BONDED OLAY	$ 3,640	1	3
SIDEWALK	17N16		90	3	BONDED OLAY	$ 5,889	1	3
SIDEWALK	17N32		55	5	BONDED OLAY	$ 884	1	3
SIDEWALK	17N46		100	4	BONDED OLAY	$ 4,020	1	3
SIDEWALK	17N55		58	4	BONDED OLAY	$ 2,323	2	3

The following table lists the recommended diamond grinding & thin-bituminous-surface sections. The triggering condition distress is spalliing. However on application of the treatment, cracked areas would also be mitigated through the continuous application of the treatment over the entire length of sidewalk. It would be a complete renewal. The sidewalks triggered for this treatment are in the very poor condition state "5" for spalling.

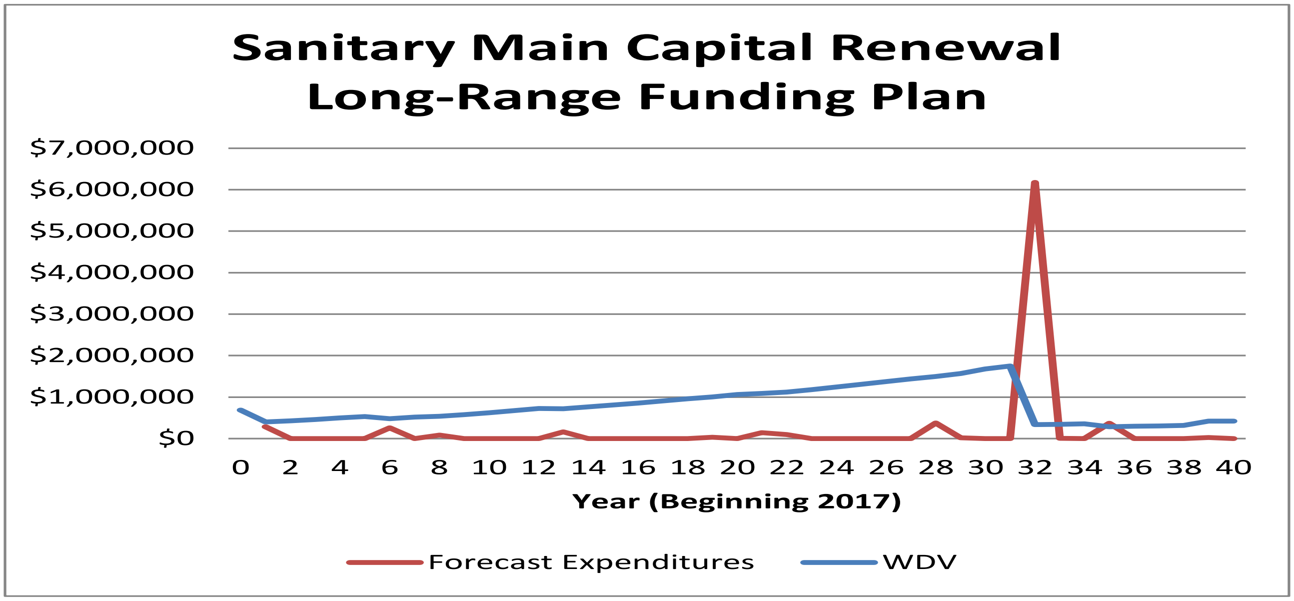
Table 13 – Five-Year (2017-2021) Sidewalk Diamond Grinding and Thin-Bituminous-Surface Segment Listing

ITEM	SEGMENT_ID	AGE	LENGTH (m)	YEAR	TREATMENT	COST	Cracking	Spalling
SIDEWALK	326A	1974	85	1	GRIND TBS	$ 10,710	1	5
SIDEWALK	327C	1974	75	1	GRIND TBS	$ 9,450	2	5
SIDEWALK	3281	1974	130	1	GRIND TBS	$ 16,380	1	5
SIDEWALK	328A	1975	87	1	GRIND TBS	$ 10,990	1	5
SIDEWALK	3311	1991	33	1	GRIND TBS	$ 4,130	1	5
SIDEWALK	3326	1991	30	1	GRIND TBS	$ 3,780	2	5
SIDEWALK	3329	1991	70	1	GRIND TBS	$ 8,820	1	5
SIDEWALK	3334	1991	47	1	GRIND TBS	$ 5,950	2	5
SIDEWALK	3336	1991	47	1	GRIND TBS	$ 5,950	2	5
SIDEWALK	335D	1994	190	1	GRIND TBS	$ 23,940	1	5
SIDEWALK	3371	1994	94	1	GRIND TBS	$ 11,830	1	5
SIDEWALK	17N12		39	1	GRIND TBS	$ 5,460	1	5
SIDEWALK	17N15		32	1	GRIND TBS	$ 4,480	1	5
SIDEWALK	17N22		31	1	GRIND TBS	$ 2,590	1	5
SIDEWALK	17N31		115	1	GRIND TBS	$ 9,660	1	5
SIDEWALK	17N39		323	1	GRIND TBS	$ 27,160	1	5
SIDEWALK	17N43		208	1	GRIND TBS	$ 26,180	1	5
SIDEWALK	17N44		130	1	GRIND TBS	$ 16,380	1	5
SIDEWALK	17N45		54	4	GRIND TBS	$ 6,790	1	5
SIDEWALK	17N47		90	1	GRIND TBS	$ 11,340	1	5
SIDEWALK	17N48		70	1	GRIND TBS	$ 8,820	2	5
SIDEWALK	17N50		285	1	GRIND TBS	$ 35,910	1	5
SIDEWALK	17N51		50	1	GRIND TBS	$ 6,300	1	5
SIDEWALK	17N52		130	1	GRIND TBS	$ 16,380	1	5
SIDEWALK	17N53		58	1	GRIND TBS	$ 7,280	2	5
SIDEWALK	17N57		145	1	GRIND TBS	$ 18,270	2	5

4.3 Wastewater Collection (Sanitary, Storm, Manholes and Catch Basins)

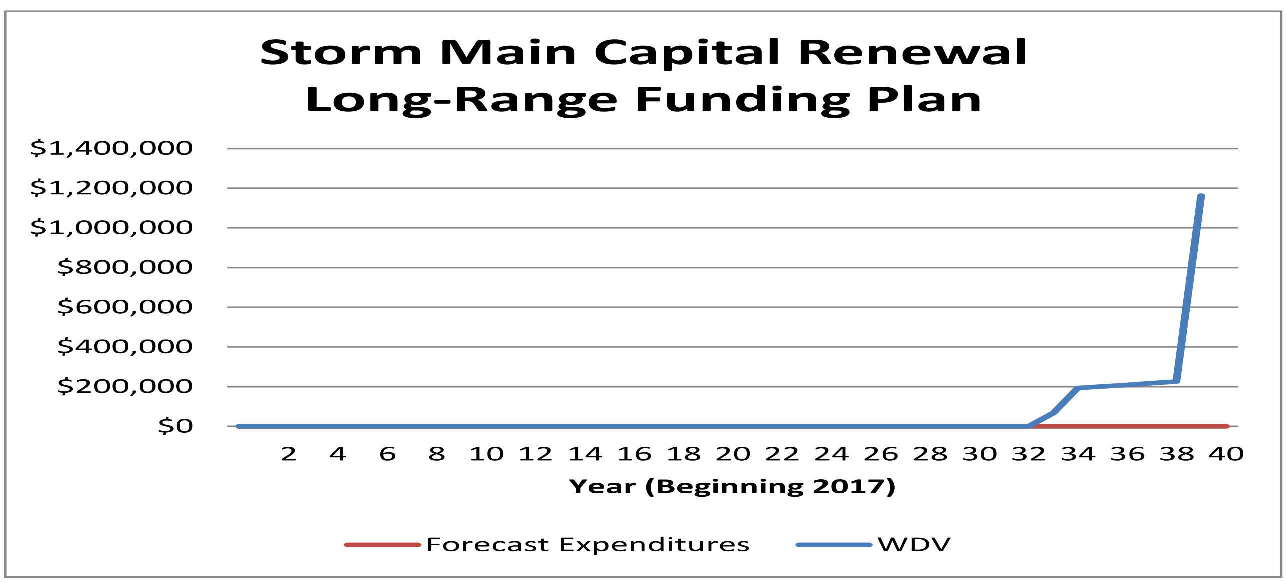
Even though the sanitary sewer system is in fairly good condition, there are some pipes subject to renewal needs in the short term. There are also some pipes in need of maintenance due to root build up. However, the greater renewal expenditure needs are forecasted for thirty years from today (i.e. 2047). The following figure illustrates the Sanitary Mains long-range expenditure forecast.

Figure 21 – Sanitary Mains Long-Range Funding Projection



Alternatively, the storm sewer system is currently in very good condition and forecasted to remain in fairly good condition for the long-range horizon. As shown in the following figure, the condition starts showing noticeable deterioration in approximately 30 years from today (i.e. 2047); with expenditure needs likely to follow in approximately 40 years from today (i.e. 2057).

Figure 22 – Storm Mains Long-Range Funding Projection



The projection is similar for the sanitary and storm manholes and catch basins, with negligible capital renewal expenditure needs within the long-range (40 year) horizon. The wastewater system capital renewal program will be predominately the sanitary mains infrastructure group.

In addition to the above noted costs, the cost projections include repair of sanitary service connection deficiencies identified by Municipal Operations personnel. It is estimated that there is a deficiency to approximately 50 sanitary service connections causing sewer back-up. This may be remedied by cured in place pipe (CIPP) lining of the service connection pipes conducted during a time when other CIPP works are being completed.

The following table measures the effectiveness of the proposed spending in the short-term (i.e. 6-year) and long-term (40-year) horizons for the sanitary mains. A six-year assessment was used instead of five, due to some expenditure needs determined for year 6 that we wanted to capture. Based on the treatment scheduling, the results are indicating a 3-6%/yr short-term and 1-2% long-term improvement to the condition of the sanitary sewer mains. This was measured by the physical condition index along with the monetary WDV. Both are relatively consistent. The ROII, which indicates the asset improvement above sustainability level, is modest but positive.

Table 14 – Sanitary Sewer Mains Performance Summary

Sanitary Mains	Optimization 6-year	Optimization 40-year
Program Expenditures		
- Total Period Expenditure (M$)	$0.636	$8.027
- Annualized Expenditure (M$/yr)	$0.106	$0.201
Monetary Performance		
- WDV (initial)	$0.685	$0.685
- WDV (Final)	$0.476	$0.417
Improved Perf (+)	$0.209	$0.268
Annual Perf Change ($/yr)	$0.035	$0.007
	5%	1%
Condition State/Index		
- Index (initial)	6	6
- Index (Final)	5	2
Improved Condition (+)	1	4
Annual Condition Change (/yr)	0.2	0.1
Annual Condition Change (%/yr)	3%	2%
ROII - Annualized (%/yr)	133%	103%
- (100% = Stabilization Level)		

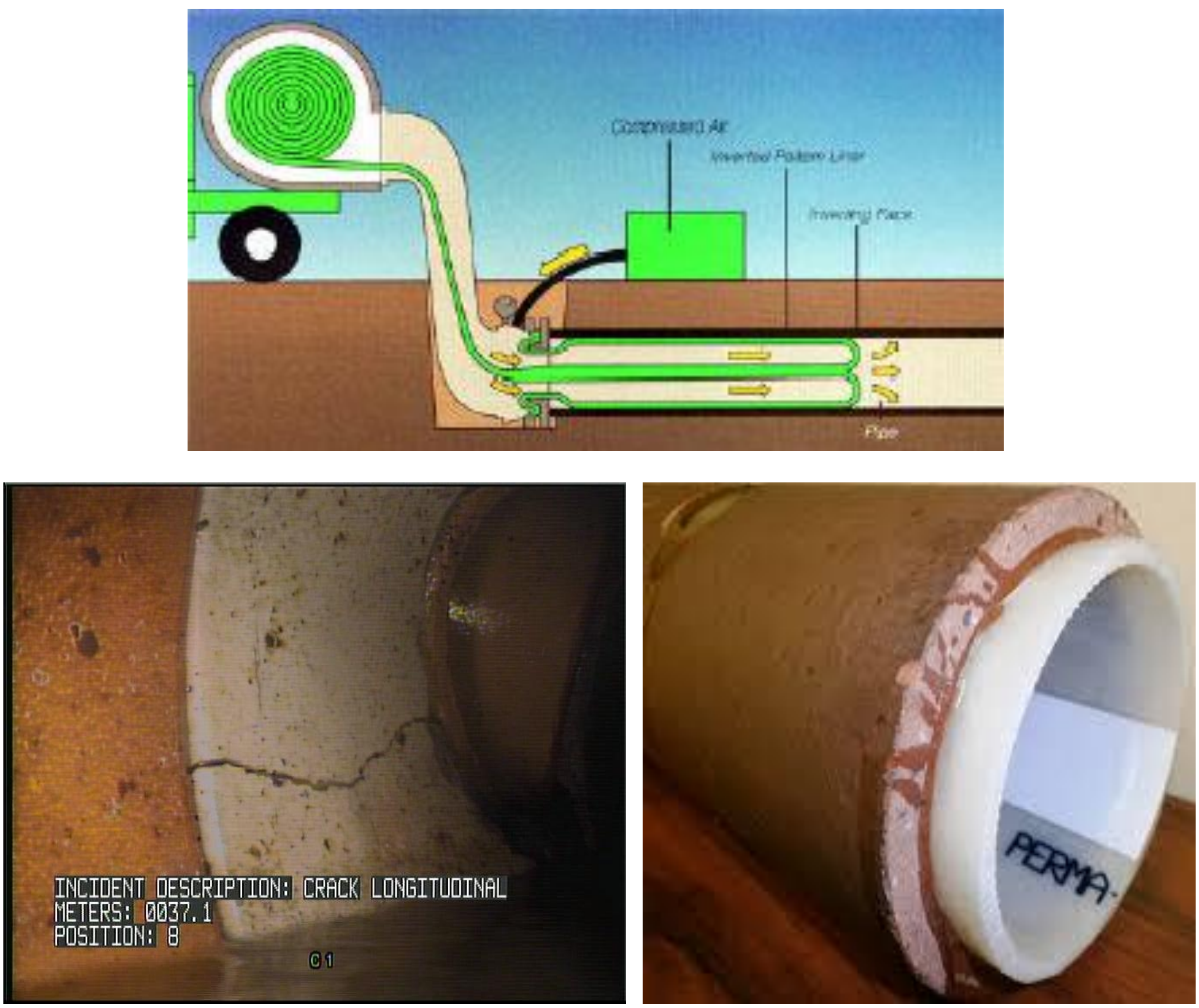
Within the six-year horizon, the following table summarizes the annualized cost broken out by maintenance (i.e. rooting & jetting), cured in place lining and pipe bursting. Cured in place lining is lower unit cost than pipe bursting. However, if the pipe is too far deteriorated, or undersized, the pipe may have to be replaced. The unit price differences between pipe bursting and open cut excavation are relatively negligible. For the purpose of this report, we assume pipe bursting over open cut excavation due to less surface disruption to the community. The following table includes also the costs for lining of one manhole identified in for renewal in the six-year horizon.

Table 15 – Sanitary Sewer Six-Year (2017-2022) Maintenance and Renewal Summary

Treatment Activity	Length (m)	Cost ($/yr)
Rooting & Jetting	399	$2,000
Repair of SC Deficiencies (CIPP)	50	$15,000
Cured in Place Pipe (CIPP) Liners	582	$58,000
Pipe Bursting	200	$31,000
Average Annual Cost		**$106,000**
Total Cost Over 6 Years		**$636,000**

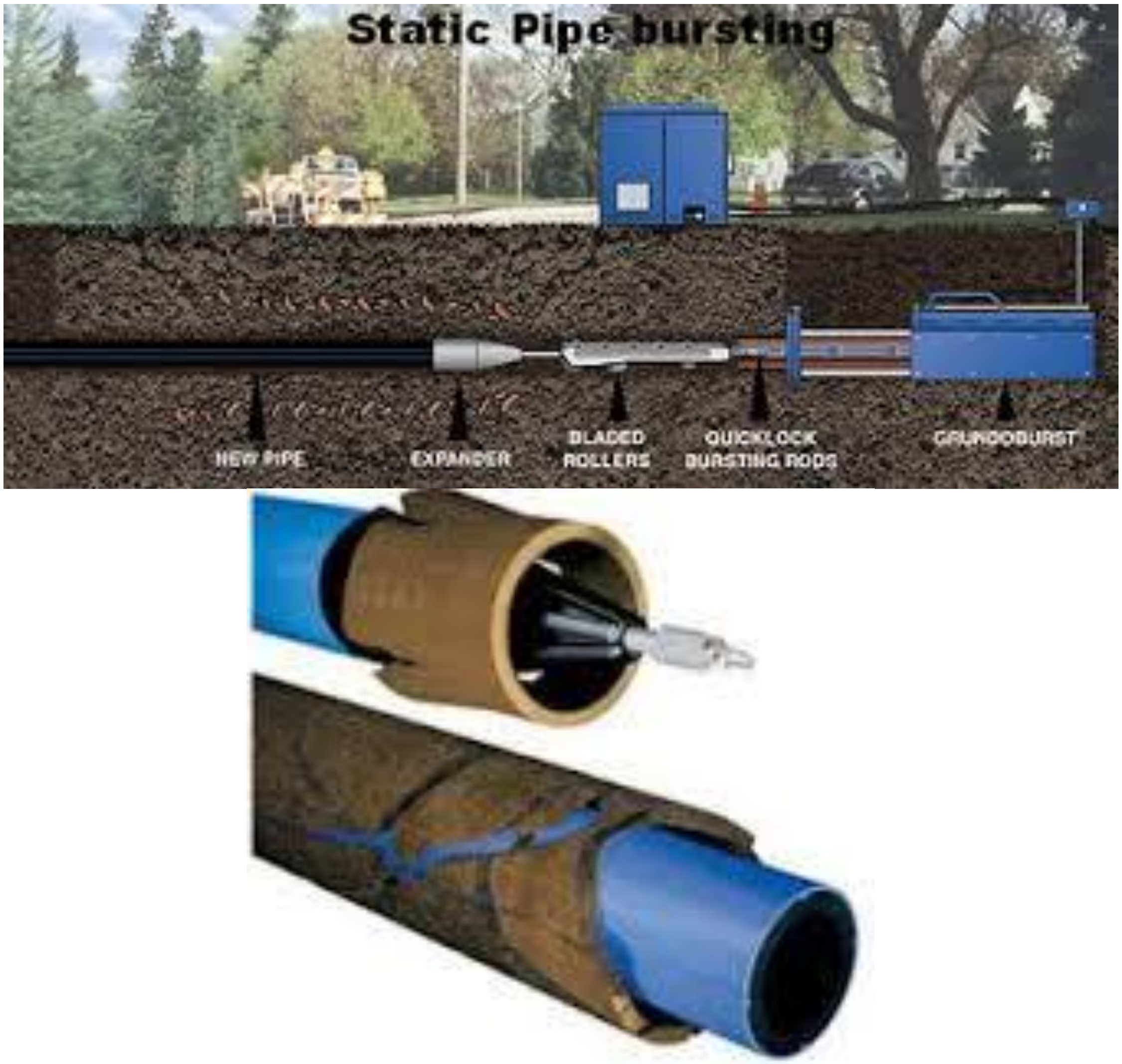
The following figure provides illustrations of cured in place pipe (CIPP) lining technique. It is a trenchless technology designed to minimize disruption to the surface during application. Note the top picture describes the process of inserting the fibreglass material. Then the fibreglass sock is expanded in the pipe with the injection water or hot air. The photo underneath illustrate a moderate level crack within pipe segment JSD011 and the result of what the completed CIPP liner would look like within the pipe.

Figure 23 – Cured In-Place Liners



The following figure provides illustrations of pipe-bursting technique. It too is a trenchless technology designed to minimize disruption to the surface during application. It works by pulling through a flexible HDPE pipe while busting the existing pipe as the new pipe is being pulled through. The top picture illustrates the process, while the bottom picture illustrates what the new pipe looks like relative to the old.

Figure 24 – Pipe Bursting



The following tables list the specific sanitary pipe segments targeted for Operations & Maintenance (i.e. rooting and jetting) and major works (i.e. lining and replacement). Included is the condition state for the existing and modelled condition for each of the major distresses. The condition rating score is as follows:

- 1 – very good
- 2 – good
- 3 – fair
- 4 – poor
- 5 – very poor

Each of the tables also includes a "TESTED" column. A "TRUE" indicates the pipe was physically inspected. As it was unfeasible to provide physical inspections of all the pipes, those not inspected, the condition assessment was correlated based on age and material type in comparison to pipes inspected of similar nature.

The following table lists the recommended O&M sections. Tree root infiltration through the pipe joints was the major issue on these pipes. The following figure illustrates CCTV footage of pipe segment JSD039, indicating the rooting issue that requires maintenance works to address.

Figure 25 - O&M Trigger for Sanitary Pipe #JSD039

Table 16 – Six-Year (2017-2022) Operation and Maintenance Segment Listing

ITEM	SEGMENT	LOCATION	AGE	LENGTH	DIA	MATERIAL	TESTED	YEAR	TREATMENT	COST	Structural	O&M	Capacity
SANITRY MAIN	JSD009	Pyramid Lk Rd between Elm & Py	1973	83	203	VCT	TRUE	1	ROOT_JET	$ 2,311	1	5	3
SANITRY MAIN	JSD038	Between Activity Center and Sc	1973	31	203	VCT	TRUE	1	ROOT_JET	$ 1,100	1	5	1
SANITRY MAIN	JSD039	Cedar Ave	1972	46	203	CONCRETE	TRUE	1	ROOT_JET	$ 1,595	1	5	1
SANITRY MAIN	JSD040	Geikie Street between Pyramid	1973	35	203	VCT	TRUE	1	ROOT_JET	$ 1,210	1	5	1
SANITRY MAIN	NE007	Juniper Street	1955	85	203	VCT	TRUE	1	ROOT_JET	$ 2,311	1	5	3
SANITRY MAIN	RW005	Alley between Connaught & Patr	1955	119	203	VCT	TRUE	1	ROOT_JET	$ 3,143	2	5	1

The following table lists the recommended major works sections based on the structural condition. Where the pipe is not broken, liners are a viable alternative. Where the pipe has undergone further deterioration and the pipe is no longer structurally intact, the treatment alternative moves to pipe replacement. In this case, we are showing pipe replacement by pipe bursting. It could be completed by open cut excavation as well. The costs are comparable. It is possible that significantly deteriorated pipes could undergo a lining treatment, even late in its remaining service life. However, that would require excavation and repair of the broken sections prior to initiating the trenchless liner technique. In this case our recommended liner is referred to as cured in place pipe (CIPP). The following figure illustrates CCTV footage of pipe segment JSD012, indicating the structural conditions triggering treatment through lining. Note the two types of cracking (longitudinal and spiral). The pipe is functional today. However, through its lifecycle if the deficiency is deferred too long, the cost to replace the pipe is approximately four-times the cost of lining.

Figure 26 - Structural Condition Trigger for CIPP on Sanitary Pipe #JSD012

The following figure illustrates CCTV footage of pipe segment JSD023 indicating the structural conditions triggering replacing the pipe through pipe bursting. In this case the circumference cracking is accelerating (left) in places to which the pipe is beginning to fail (right) in places. As a result, the pipe needs to be replaced. Lining is only an option on excavation and repair of the broken sections, which has been calculated in the model to be less cost effective than pipe replacement.

Figure 27 - Structural Condition Trigger for Pipe Bursting (Replacement) on Sanitary Pipe #JSD023

It should be noted that the structural condition triggering pipe lining through CIPP techniques is in the range of fair “3” to poor “4”. The structural condition triggering pipe replacement through bursting techniques is very poor”5”.

The following table shows one manhole. The treatment generated is a spin-cast lining technique. However, if other pipes are being lined through CIPP methods, the CIPP lining technique would too be appropriate for the manhole.

Table 17 – Six-Year (2017-2022) Major Treatment Segment Listing

ITEM	SEGMENT	LOCATION	AGE	LENGTH	DIA	MATERIAL	TESTED	YEAR	TREATMENT	COST	Structural	O&M	Capacity
SANITRY MAIN	JSD001	Pyramid Lk Rd near Maligne Ave	1973	80	254	VCT	TRUE	1	CIPP 2	$ 32,000	3	1	1
SANITRY MAIN	JSD011	Pyramid Lk Rd between Elm & Py	1973	79	254	VCT	TRUE	6	CIPP 2	$ 96,756	4	1	1
SANITRY MAIN	JSD012	Pyramid Ave between Pyramid Lk	1972	53	254	CONCRETE	TRUE	1	CIPP 2	$ 21,000	3	1	1
SANITRY MAIN	JSD022	Pyramid Ave between Colin and	1973	66	203	VCT	TRUE	1	CIPP 2	$ 21,000	4	1	1
SANITRY MAIN	JSD023	Pyramid Ave between Colin and	1973	65	203	VCT	TRUE	1	PIPE BURST 2	$ 50,400	5	1	1
SANITRY MAIN	JSD041	Geikie Street and Pyramid Ave	1973	26	203	VCT	TRUE	1	CIPP 2	$ 8,513	3	1	1
SANITRY MAIN	NE012	Patricia Circle South End	1966	50	203	VCT	TRUE	6	CIPP 2	$ 66,916	4	1	1
SANITRY MAIN	NE014	Patricia Circle North End	1966	13	203	VCT	TRUE	1	CIPP 2	$ 4,000	4	1	1
SANITRY MAIN	NE018	Patricia Circle North End	1966	27	203	VCT	TRUE	1	PIPE BURST 2	$ 20,400	5	1	1
SANITRY MAIN	RW003	Alley between Connaught & Pat	1955	95	203	VCT	FALSE	6	CIPP 2	$ 42,236	3	3	1
SANITRY MAIN	RW004	Alley Between Connaught & Patr	1955	109	203	VCT	FALSE	6	CIPP 2	$ 48,467	3	3	1
SANITRY MAIN	RW010	Alley between Connaught and Pa	1955	78	305	VCT	TRUE	1	PIPE BURST 2	$ 90,000	5	1	1
SANITRY MAIN	RW011	Hazel Ave between Connaught &	1955	9	305	CONCRETE	FALSE	6	CIPP 2	$ 6,231	3	3	1
SANITRY MAIN	SH032	Alley Between Willow and Pine	1955	30	203	VCT	TRUE	1	PIPE BURST 2	$ 22,800	5	1	3
SANITARY MH	36B4	895 Pyramid Lake Road	1973	2	1200	UNKNOWN	TRUE	5	SPIN CAST	$ 4,001	4	1	1

With respect to <u>storm water</u> pipes, manholes, and catch basins, there were no major works generated for any of these infrastructure groups. Overall, the storm water collection system is in a better condition state than the sanitary collection system.

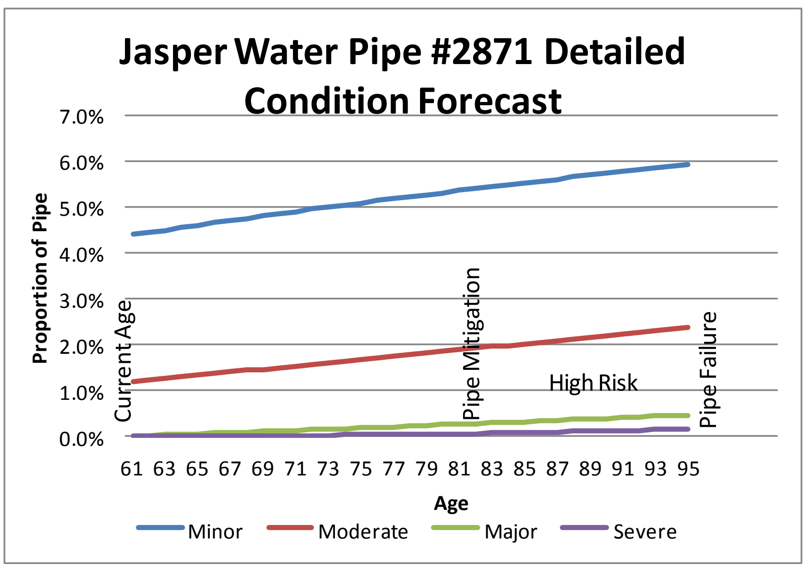
4.4 Water Distribution (Pipes and Valves)

The water distribution comprises of two main components. One is the pipe. The other is associated valves, including isolation valves, hydrants, and service connection taps.

Collecting the condition assessment on the water distribution system is difficult due to access availability to the inside of a pressure pipe. The condition assessment procedure used electromagnetic technology for determining the severity and extent of pipe remaining wall thickness. The only pipe the condition assessment contractor was able to access was water main #2871 located in Patricia Circle. It is a 61 year old cast-iron 150 mm (6") pressure pipe water main. Overall, the pipe is in relatively good condition. It has approximately 5-6% of the surface area pitted. The majority is in the minor severity grouping (i.e. 50-80% remaining wall thickness). There is no major (5-20% remaining wall thickness) or sever (0-5% remaining wall thickness) pitting (failure). Based on the age, material type, and condition measurements attained, this pipe was used to correlate a condition assessment for the remainder of the water main piping network.

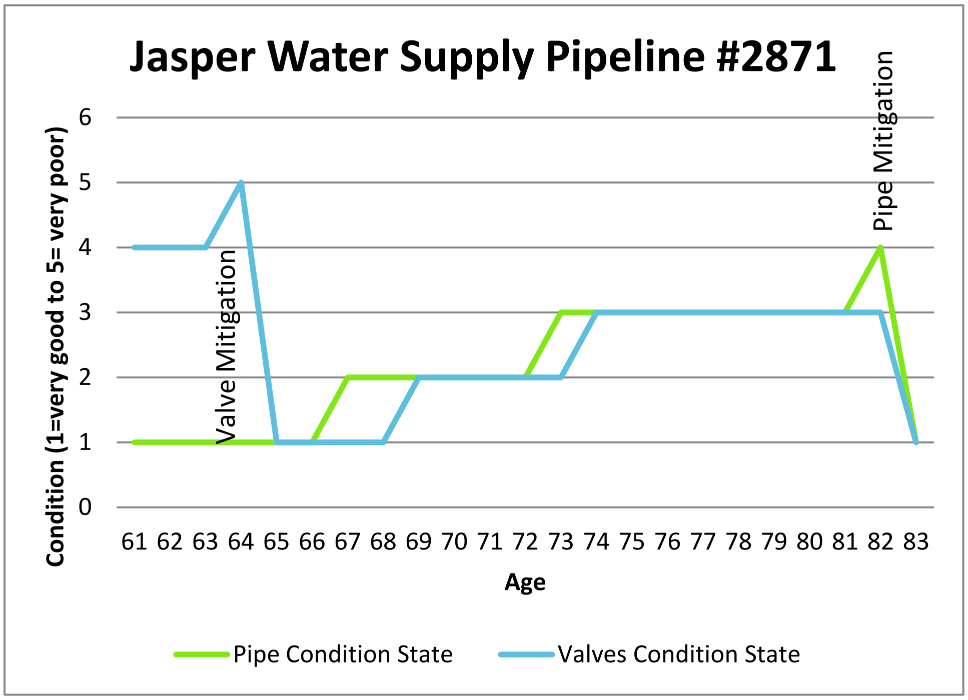
Based on the piping assessment, it was observed that the valves were deteriorating at a different rate than the pipe. As example, with pipe #2871, the following figures shows the modelled deterioration estimating a remaining service life of 20-30 years, while know valve failures associated in this are now reaching the end of their service life.

Figure 28 – Water Main #2871



The following figure shows the expectation of renewal needs between pipe and valve. In the prediction model, we include a probabilistic allowance for valve failure and associated valve repair within the pipe lifecycle. Then when the pipe is eventually replaced, renewal occurs for all components associated with the pipe (i.e. pipe, isolation valves, hydrants, and service connection).

Figure 29– Condition State Performance Prediction - Water Main #2871



The following figure shows a valve repair that was occurring concurrent with the data collection within pipe segment #2871 in Patricia Circle.

Figure 30– Patricia Circle Water Main Pipe #2871 Valve Assembly Replacement (Year 2016)

The following figures work together in illustrating the expenditure needs versus performance of the water distribution infrastructure assets. The performance prediction models are indicating that the overall state of the water pipelines will remain in a very good “1” condition state for the next 14 years. At this time, there is expected to be approximately $9 Million in pipeline renewal activity required. The associated valves are currently in a fair “3” condition state with on-going repair/replacement needed over the next 22 year. In year-22, it is expected the system will sustain a good “2” condition state until year 38, when the next surge of pipeline renewal is expected again.

Figure 31– Water Mains Long-Range Performance Prediction Projection

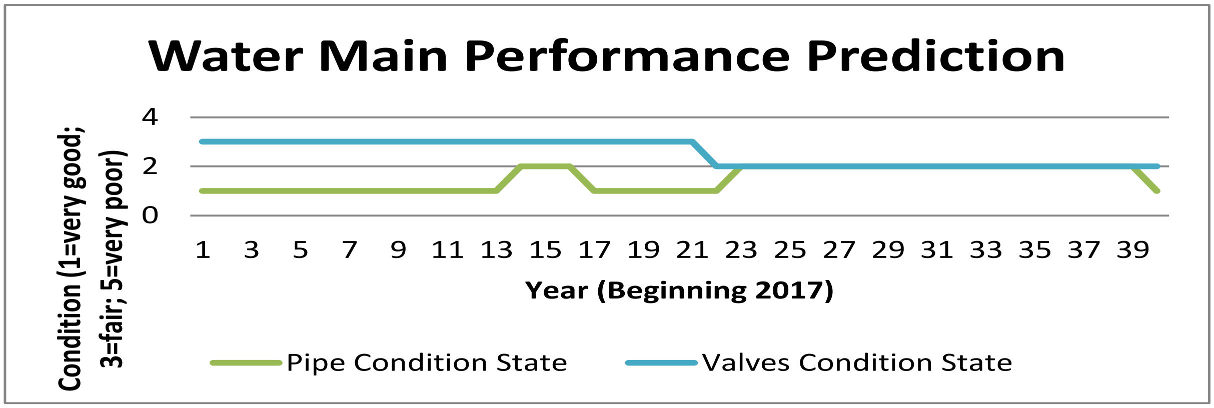
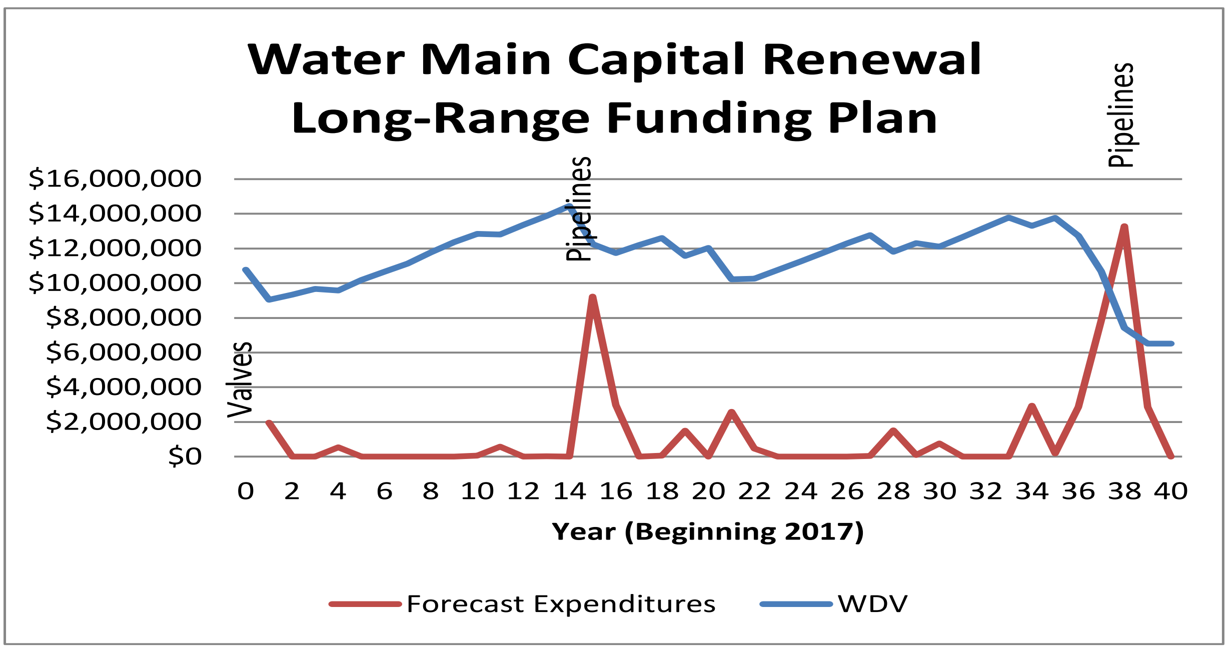


Figure 32– Water Mains Long-Range Funding Projection



As the deterioration cycles appear to be different, between the pipes and its associated valves, the short-term (i.e. 5-year) expenditure needs do not include any pipe replacement. The short-term allocation needs are entirely associated with the probability of valve failure and associated emergency repairs.

The following table measures the effectiveness of the proposed spending in the short-term (i.e. 5-year) and long-term (40-year) horizons for the sanitary mains. The results are indicating a 1%/yr short-term and 2%/yr long-term improvement to the condition of the water mains. This was measured by the physical condition index along with the monetary WDV. Both are relatively consistent. The ROII, which indicates the asset improvement above sustainability level, is modest but positive. The short-term is specific to valve repair. The long-term related to pipeline renewal, including replacement of valves and pipes together.

Table 18: **– Water Mains Performance Summary**

Water Mains	**Optimization 5-Year**	**Optimization 40-Year**
Program Expenditures		
- Total Period Expenditure (M$)	$2.500	$52.375
- Annualized Expenditure (M$/yr)	$0.500	$1.309
Monetary Performance		
- WDV (initial)	$9.912	$9.912
- WDV (Final)	$9.328	$2.538
Improved Perf (+)	$0.584	$7.374
Annual Perf Change (M$/yr)	$0.117	$0.184
	1%	2%
Condition State/Index		
- Index (initial)	17	17
- Index (Final)	16	4
Improved Condition (+)	1	13
Annual Condition Change (/yr)	0.2	0.3
Annual Condition Change (%/yr)	1%	2%
ROII - Annualized (%/yr)	123%	114%
- (100% = Stabilization Level)		

The following summarizes where the expected short-term expenditures may be allocated. We are not showing an immediate need for water main capital renewal. However, we are showing a relatively significant allocation to associated valve repair needs required to sustain the pipeline until the pipeline renewal period begins in approximately 14 years from now.

Table 19– Water Mains Five-Year (2017-2021) Maintenance and Renewal Summary

Treatment Activity	Length (m)	Cost ($/yr)
Valve Repair (inc. other pipe repair)		$500,000
Pipe Bursting (i.e. pipe replacement)		$0
Average Annual Cost		**$500,000**
Total Cost Over 5 Years		**$2,500,000**

The following tables list the locations of the high risk areas that may expect valve failure in the short-term horizon. The Municipality may be pragmatic in anticipating failures within these locations and others. If failures are observed to repeat within the pipe segment, the Municipality may wish to consider scheduled valve replacement of the remaining valves and connections along these pipe segments. These tables also list the projected time of pipe replacement. The time gap between valve failure and full line replacement is approximately 14 years. It may be desirable to bridge the time gap by monitoring and repairing unless a significant amount of repairs are noted on any pipe segment as logged within the Municipality's maintenance management system.

Table 20 – Five-Year (2017-2021) High Risk Valve Failure Locations

ITEM	SEGMENT	AGE	LENGTH	DIA	MATERIAL	Year Valve	TREATMENT	COST	Pipe	Valve	Capacity	Year Pipe
WATER MAIN	1DA7	1950	17	150	CAST IRON	1	VALVE FAIL	$ 6,720	2	5	1	15
WATER MAIN	1DA9	1950	16	150	CAST IRON	1	VALVE FAIL	$ 6,300	2	5	1	15
WATER MAIN	1DAB	1950	21	50	CAST IRON	1	VALVE FAIL	$ 2,940	2	5	4	15
WATER MAIN	1DAC	1950	5	50	CAST IRON	1	VALVE FAIL	$ 840	2	5	4	15
WATER MAIN	1DB0	1955	6	50	CAST IRON	4	VALVE FAIL	$ 794	2	5	4	17
WATER MAIN	273E	1950	7	150	CAST IRON	1	VALVE FAIL	$ 2,940	2	5	1	15
WATER MAIN	27E7	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	27FF	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	2853	1950	109	250	CAST IRON	1	VALVE FAIL	$ 71,820	2	5	1	15
WATER MAIN	2854	1950	15	50	CAST IRON	1	VALVE FAIL	$ 2,100	2	5	4	15
WATER MAIN	2856	1950	7	150	CAST IRON	1	VALVE FAIL	$ 2,940	2	5	1	15
WATER MAIN	2859	1950	5	150	CAST IRON	1	VALVE FAIL	$ 2,100	2	5	1	15
WATER MAIN	285A	1950	10	150	CAST IRON	1	VALVE FAIL	$ 3,780	2	5	1	15
WATER MAIN	285B	1950	32	150	CAST IRON	1	VALVE FAIL	$ 12,600	2	5	1	15
WATER MAIN	285E	1955	46	150	CAST IRON	4	VALVE FAIL	$ 17,073	2	5	1	17
WATER MAIN	285F	1955	19	150	CAST IRON	4	VALVE FAIL	$ 7,147	2	5	1	17
WATER MAIN	2860	1955	15	150	CAST IRON	4	VALVE FAIL	$ 5,559	2	5	1	17
WATER MAIN	2861	1955	8	150	CAST IRON	4	VALVE FAIL	$ 3,176	2	5	1	17
WATER MAIN	2862	1955	24	150	CAST IRON	4	VALVE FAIL	$ 9,132	2	5	1	17
WATER MAIN	2863	1955	12	150	CAST IRON	4	VALVE FAIL	$ 4,368	2	5	1	17
WATER MAIN	2864	1955	34	150	CAST IRON	4	VALVE FAIL	$ 12,706	2	5	1	17
WATER MAIN	2869	1955	22	250	CAST IRON	4	VALVE FAIL	$ 13,897	2	5	1	17
WATER MAIN	286A	1955	118	150	CAST IRON	4	VALVE FAIL	$ 44,073	2	5	1	17
WATER MAIN	286B	1955	6	150	CAST IRON	4	VALVE FAIL	$ 2,382	2	5	1	17
WATER MAIN	286C	1955	11	150	CAST IRON	4	VALVE FAIL	$ 3,971	2	5	1	17
WATER MAIN	286F	1955	11	150	CAST IRON	4	VALVE FAIL	$ 3,971	2	5	1	17
WATER MAIN	2871	1955	115	150	CAST IRON	4	VALVE FAIL	$ 42,882	1	5	1	22
WATER MAIN	2872	1955	13	150	CAST IRON	4	VALVE FAIL	$ 4,765	2	5	1	17
WATER MAIN	2874	1955	37	150	CAST IRON	4	VALVE FAIL	$ 13,897	2	5	1	17
WATER MAIN	2875	1955	21	150	CAST IRON	4	VALVE FAIL	$ 7,941	2	5	1	17
WATER MAIN	2879	1950	181	150	CAST IRON	1	VALVE FAIL	$ 71,400	2	5	1	15
WATER MAIN	287A	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	287B	1950	45	200	CAST IRON	1	VALVE FAIL	$ 23,940	2	5	1	15
WATER MAIN	287E	1950	37	200	CAST IRON	1	VALVE FAIL	$ 19,740	2	5	1	15
WATER MAIN	2882	1950	9	150	CAST IRON	1	VALVE FAIL	$ 3,360	2	5	1	15
WATER MAIN	2883	1950	174	250	CAST IRON	1	VALVE FAIL	$114,660	2	5	1	15
WATER MAIN	2884	1950	19	50	CAST IRON	1	VALVE FAIL	$ 2,520	2	5	4	15
WATER MAIN	2886	1950	47	50	CAST IRON	1	VALVE FAIL	$ 6,300	2	5	4	15

Table 21 – Five-Year (2017-2021) High Risk Valve Failure Locations

ITEM	SEGMENT	AGE	LENGTH	DIA	MATERIAL	Year Valve	TREATMENT	COST	Pipe	Valve	Capacity	Year Pipe
WATER MAIN	2887	1950	3	50	CAST IRON	1	VALVE FAIL	$ 420	2	5	4	15
WATER MAIN	2888	1950	16	50	CAST IRON	1	VALVE FAIL	$ 2,100	2	5	4	15
WATER MAIN	288C	1950	142	150	PVC	1	VALVE FAIL	$ 55,860	2	5	1	
WATER MAIN	288D	1950	23	150	CAST IRON	1	VALVE FAIL	$ 9,240	2	5	1	15
WATER MAIN	288E	1950	17	150	ASBES CEMENT	1	VALVE FAIL	$ 6,720	2	5	1	7
WATER MAIN	2891	1950	60	150	CAST IRON	1	VALVE FAIL	$ 23,520	2	5	1	15
WATER MAIN	2893	1950	8	50	CAST IRON	1	VALVE FAIL	$ 840	2	5	4	15
WATER MAIN	2894	1950	11	50	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	4	15
WATER MAIN	2897	1950	15	50	CAST IRON	1	VALVE FAIL	$ 2,100	2	5	4	15
WATER MAIN	2898	1950	39	50	CAST IRON	1	VALVE FAIL	$ 5,040	2	5	4	15
WATER MAIN	289C	1950	142	150	CAST IRON	1	VALVE FAIL	$ 55,860	2	5	1	15
WATER MAIN	289D	1950	20	150	CAST IRON	1	VALVE FAIL	$ 7,980	2	5	1	15
WATER MAIN	289E	1950	50	150	CAST IRON	1	VALVE FAIL	$ 19,740	2	5	1	15
WATER MAIN	28A1	1950	169	150	CAST IRON	1	VALVE FAIL	$ 66,780	2	5	1	15
WATER MAIN	28A3	1950	41	150	CAST IRON	1	VALVE FAIL	$ 16,380	2	5	1	15
WATER MAIN	28A4	1950	40	150	CAST IRON	1	VALVE FAIL	$ 15,960	2	5	1	15
WATER MAIN	28BD	1950	193	150	CAST IRON	1	VALVE FAIL	$ 76,020	2	5	1	15
WATER MAIN	28BE	1950	3	150	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	1	15
WATER MAIN	28C0	1950	46	150	CAST IRON	1	VALVE FAIL	$ 18,060	2	5	1	15
WATER MAIN	28C2	1950	3	150	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	1	15
WATER MAIN	28C3	1950	9	50	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	4	15
WATER MAIN	28C4	1950	33	100	CAST IRON	1	VALVE FAIL	$ 8,820	2	5	4	15
WATER MAIN	28C8	1950	45	100	CAST IRON	1	VALVE FAIL	$ 11,760	2	5	4	15
WATER MAIN	28CB	1950	95	150	CAST IRON	1	VALVE FAIL	$ 37,380	2	5	1	15
WATER MAIN	28CC	1950	72	150	CAST IRON	1	VALVE FAIL	$ 28,560	2	5	1	15
WATER MAIN	28CD	1950	3	100	CAST IRON	1	VALVE FAIL	$ 840	2	5	4	15
WATER MAIN	28CE	1950	18	150	CAST IRON	1	VALVE FAIL	$ 7,140	2	5	1	15
WATER MAIN	28CF	1950	59	150	CAST IRON	1	VALVE FAIL	$ 23,100	2	5	1	15
WATER MAIN	28D0	1950	40	150	CAST IRON	1	VALVE FAIL	$ 15,960	2	5	1	15
WATER MAIN	28D2	1950	65	100	CAST IRON	1	VALVE FAIL	$ 17,220	2	5	4	15
WATER MAIN	293A	1950	31	150	CAST IRON	1	VALVE FAIL	$ 12,180	2	5	1	15
WATER MAIN	293B	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	293C	1950	31	150	CAST IRON	1	VALVE FAIL	$ 12,180	2	5	1	15
WATER MAIN	2940	1950	61	200	CAST IRON	1	VALVE FAIL	$ 32,340	2	5	1	15
WATER MAIN	2941	1950	99	150	CAST IRON	1	VALVE FAIL	$ 39,060	2	5	1	15
WATER MAIN	2947	1950	3	200	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	294C	1950	48	250	CAST IRON	1	VALVE FAIL	$ 31,500	2	5	1	15
WATER MAIN	2955	1950	26	150	CAST IRON	1	VALVE FAIL	$ 10,080	2	5	1	15
WATER MAIN	2956	1950	105	150	CAST IRON	1	VALVE FAIL	$ 41,580	2	5	1	15
WATER MAIN	2957	1950	41	150	CAST IRON	1	VALVE FAIL	$ 16,380	2	5	1	15
WATER MAIN	298C	1955	206	150	CAST IRON	4	VALVE FAIL	$ 77,028	2	5	1	17
WATER MAIN	29A7	1955	189	150	CAST IRON	4	VALVE FAIL	$ 70,675	2	5	1	17
WATER MAIN	29AC	1955	204	150	CAST IRON	4	VALVE FAIL	$ 76,234	2	5	1	17
WATER MAIN	29CE	1955	18	150	CAST IRON	4	VALVE FAIL	$ 6,750	2	5	1	17
WATER MAIN	29CF	1955	87	150	CAST IRON	4	VALVE FAIL	$ 32,558	2	5	1	17
WATER MAIN	29D2	1955	61	150	CAST IRON	4	VALVE FAIL	$ 22,632	2	5	1	17
WATER MAIN	2B14	1955	4	150	CAST IRON	4	VALVE FAIL	$ 1,588	2	5	1	17

Table 22 – Five-Year (2017-2021) High Risk Valve Failure Locations

ITEM	SEGMENT	AGE	LENGTH	DIA	MATERIAL	Year Valve	TREATMENT	COST	Pipe	Valve	Capacity	Year Pipe
WATER MAIN	2C54	1950	9	150	CAST IRON	1	VALVE FAIL	$ 3,360	2	5	1	15
WATER MAIN	2C55	1950	166	150	CAST IRON	1	VALVE FAIL	$ 65,520	2	5	1	15
WATER MAIN	2C60	1955	35	150	CAST IRON	4	VALVE FAIL	$ 13,103	2	5	1	17
WATER MAIN	2C61	1955	59	150	CAST IRON	4	VALVE FAIL	$ 21,838	2	5	1	17
WATER MAIN	2C62	1955	34	150	CAST IRON	4	VALVE FAIL	$ 12,706	2	5	1	17
WATER MAIN	2C63	1950	13	150	CAST IRON	1	VALVE FAIL	$ 5,040	2	5	1	15
WATER MAIN	2C64	1950	156	150	CAST IRON	1	VALVE FAIL	$ 61,740	2	5	1	15
WATER MAIN	2C66	1950	31	100	CAST IRON	1	VALVE FAIL	$ 8,400	2	5	4	15
WATER MAIN	2C67	1950	4	100	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	4	15
WATER MAIN	2C69	1950	54	100	CAST IRON	1	VALVE FAIL	$ 14,280	2	5	4	15
WATER MAIN	2C6A	1950	71	100	CAST IRON	1	VALVE FAIL	$ 18,900	2	5	4	15
WATER MAIN	2C6B	1950	59	100	CAST IRON	1	VALVE FAIL	$ 15,540	2	5	4	15
WATER MAIN	2C6C	1950	30	50	CAST IRON	1	VALVE FAIL	$ 3,780	2	5	4	15
WATER MAIN	2C6D	1950	62	50	CAST IRON	1	VALVE FAIL	$ 7,980	2	5	4	15
WATER MAIN	2C6E	1950	5	50	CAST IRON	1	VALVE FAIL	$ 840	2	5	4	15
WATER MAIN	2C6F	1950	69	100	CAST IRON	1	VALVE FAIL	$ 18,060	2	5	4	15
WATER MAIN	2C70	1950	47	100	CAST IRON	1	VALVE FAIL	$ 12,600	2	5	4	15
WATER MAIN	2C71	1950	50	100	CAST IRON	1	VALVE FAIL	$ 13,440	2	5	4	15
WATER MAIN	2C74	1950	51	200	CAST IRON	1	VALVE FAIL	$ 26,880	2	5	1	15
WATER MAIN	2C75	1950	8	200	CAST IRON	1	VALVE FAIL	$ 4,200	2	5	1	15
WATER MAIN	2C87	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	2C8E	1950	3	150	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	1	15
WATER MAIN	2C8F	1950	25	150	CAST IRON	1	VALVE FAIL	$ 10,080	2	5	1	15
WATER MAIN	2C90	1950	58	200	CAST IRON	1	VALVE FAIL	$ 30,660	2	5	1	15
WATER MAIN	2C92	1950	3	200	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	2C94	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	2C95	1950	3	150	CAST IRON	1	VALVE FAIL	$ 1,260	2	5	1	15
WATER MAIN	2C96	1950	4	150	CAST IRON	1	VALVE FAIL	$ 1,680	2	5	1	15
WATER MAIN	2CBD	1950	5	150	PVC	1	VALVE FAIL	$ 2,100	2	5	1	
WATER MAIN	2CBE	1950	5	150	PVC	1	VALVE FAIL	$ 2,100	2	5	1	
WATER MAIN	2CC2	1950	11	150	PVC	1	VALVE FAIL	$ 4,200	2	5	1	
WATER MAIN	2CC3	1950	26	150	PVC	1	VALVE FAIL	$ 10,080	2	5	1	
WATER MAIN	2CC4	1950	7	150	CAST IRON	1	VALVE FAIL	$ 2,940	2	5	1	15
WATER MAIN	3EE1	1950	53	100	CAST IRON	1	VALVE FAIL	$ 13,860	2	5	4	15
WATER MAIN	3EF6	1950	235	150	CAST IRON	1	VALVE FAIL	$ 92,820	2	5	1	15
WATER MAIN	3EF8	1950	316	100	CAST IRON	1	VALVE FAIL	$ 83,580	2	5	4	15
WATER MAIN	3EF9	1950	182	150	CAST IRON	1	VALVE FAIL	$ 71,820	2	5	1	15
WATER MAIN	42EF	1950	110	150	CAST IRON	1	VALVE FAIL	$ 43,260	2	5	1	15
WATER MAIN	42F0	1950	44	150	CAST IRON	1	VALVE FAIL	$ 17,220	2	5	1	15
WATER MAIN	42F1	1950	30	250	CAST IRON	1	VALVE FAIL	$ 19,740	2	5	1	15
WATER MAIN	42F2	1950	6	150	CAST IRON	1	VALVE FAIL	$ 2,520	2	5	1	15
WATER MAIN	44AA	1950	23	50	PVC	1	VALVE FAIL	$ 2,940	2	5	4	
WATER MAIN	44C6	1950	199	250	CAST IRON	1	VALVE FAIL	$ 131,040	2	5	1	15
WATER MAIN	44E0	1950	6	200	CAST IRON	1	VALVE FAIL	$ 3,360	2	5	1	15
WATER MAIN	4517	1950	11	150	CAST IRON	1	VALVE FAIL	$ 4,200	2	5	1	15
WATER MAIN	4568	1950	72	150	CAST IRON	1	VALVE FAIL	$ 28,560	2	5	1	15

5. Program Summary

The following table summarizes the short-term (5-year) and long-term infrastructure renewal needs. The summary from the tactical level is compiled from above and deemed to be the most accurate due to the field level of condition rating assessments and associated analysis for each infrastructure segment in the network. This is compared to the strategic level long-range funding plan completed in December 2015.

Table 23 – Short-Range (2017-2021) and Long-Range Funding Plan Summary

	Tactical				Strategic	Historic	Difference
Asset Group	**Short-Term (5 Year) Needs Total (M$)**	**Short-Term (5 Year) Needs Annual (M$/yr)**	**Long-Term Sustainabiliity Needs Annual (M$/yr)**	**Reserve Fund Annual Accumulation (+) building; (-) drawing (M$/yr)**	**Long-Term Sustainabiliity Needs Projection (M$/yr)**	**Current Budget Allocation (M$/yr)**	**Sustainability to Budget Surplus (+); Deficit (-) (M$/yr)**
Roadways							
- Streets	$2.660	$0.532	$0.230				
- Sidewalks	$0.375	$0.075	$0.074				
Sub-Total	$3.035	$0.607	$0.304	-$0.303	$1.220	$0.710	$0.406
Wastewater							
- Collection	$0.636	$0.127	$0.201				
- Treatment	TBD	TBD	$0.415				
Sub-Total	$0.636	$0.127	$0.616	$0.489	$0.730	$0.130	-$0.486
Water							
- Distribution	$2.500	$0.500	$1.309				
- Treatment	TBD	TBD	$0.332				
Sub-Total	$2.500	$0.500	$1.641	$1.141	$0.940	$0.310	-$1.331
Total	**$6.171**	**$1.234**	**$2.561**	**$1.327**	**$2.890**	**$1.150**	**-$1.411**

In reference to the above table, tactical level assessment of the treatment facilities (incl. lift stations) for the water and wastewater asset groups was not yet completed. Such will be completed following this report. The short term-needs is not yet know for the treatment facilities. However, the strategic level report provided a reasonable understanding of the long-term expenditure needs. This was included above. There is reasonable chance the short-term capital renewal expenditure needs for treatment facilities may be slight due to the relatively new age of these facilities. The treatment facilities short-term funding needs are marked as “To Be Determined” for the interim, until that component if the infrastructure assessment is complete. However, due to the expectation of minimal expenditure needs of the treatment facilities in the short-term, the above table is relatively complete for preliminary discussions on budget allocations and capital renewal programming.

For the asset groups of Roadways, Wastewater, and Water, the short-term capital renewal expenditure needs is collectively $1.234 Million per year. This is what the Municipality should be spending over the next five years as per the details provided in this report. However, what the Municipality should be allocating in its capital programming is $2.561 Million per year to provide a sustainable funding level. The surplus of $1.327 Million per year may be allocated to a Reserve Fund for use beyond year 2021 when there will be significantly greater spikes in capital renewal expenditure needs.

6. Conclusions and Recommendations

The following summarizes key conclusions and recommendation with respect to the given Municipality of Jasper Tactical Level Asset Management Study.

6.1 Conclusions

- The roadways (streets and sidewalks) infrastructure group has the greatest need for infrastructure renewal. However, the expenditure needs are less than previously estimated due to state of the infrastructure that can still permit cost effective mitigation through "Micro-Surfacing" that can renew the roadways infrastructure at approximately ¼ the cost of conventional resurfacing or replacement methods. The five-year horizon has targeted $1.7 Million towards streets micro-surfacing. Timeliness on implementation is important. If such works are deferred, the streets will undergo further deterioration in which the renewal costs could escalate to $6.8 Million if conventional pavement resurfacing becomes required.

- The wastewater collection (sanitary and storm) infrastructure group is in a condition state where a relatively small component of the sanitary piping system is in need of renewal today. The majority of these works may be completed through a relatively cost effective cured in place pipe (CIPP) trenchless technology (i.e. approximately ¾ the cost of pipeline replacement). Overall, the long-range sustainable funding levels are close to previously anticipated. Initiating the CIPP renewal practice on a small proportion of the network today will get the practice in place later in the long-term when more renewal will be required.

- The water distribution infrastructure group has a cast iron piping network that is in better condition than previously estimated. However, this is based on analysis of one pipe that was accessible for a condition assessment. The performance prediction analysis is forecasting a significant amount pipeline replacement needs in approximately 14 years from today. When this occurs, it would be replacement of the pipeline and associate valve components (i.e. isolation valves, hydrants, and service connections). Until then, the valve related components may fail earlier and will have to be replaced on an emergency basis as the failure occurs; in which the funding allocation needs appear to be manageable. The short-range high-risk valve failure pipe segments are listed in this report. This gives the opportunity for the Municipality to develop a Maintenance Management System (MMS) and begin logging pipe or valve failures. On high risk pipe segments with repeat failures, the Municipality may consider the options to:

   i. Continue with emergency valve/pipe repair until the pipe is scheduled for replacement, or
   ii. Conduct a scheduled valve replacement as an interim measure until the pipe segment replaced, or
   iii. Accelerate the pipe replacement, including associated valves, hydrants and fittings.

- The GIS contains information gaps. During the condition assessment, sections of the Town's sidewalks were missing. The GIS inventory states that water distribution pipelines are of a cast iron material type. There is potential, the metallic pipes installed in the 1980s could be ductile iron, which has a lower service life than cast iron. Pipeline diameters measured during emergency repairs were sometimes different to what was recorded in the GIS inventory. A full infrastructure inventory (GIS) review of the roadways (streets and sidewalks), wastewater collection (storm water and sanitary sewer piping, manholes, catch basins, service connections), and water distribution (pipes, valves, hydrants, service connections) could update the GIS through combined efforts of record drawing reviews and field investigation. The field investigation completed in part to investigating the subsurface infrastructure upon completion of emergency repairs.

- The extent of physical condition inspection of the various infrastructure assets was dependent on access. The surface assets (i.e. streets and sidewalks) were easily accessed for assessment. Wastewater collection was more difficult, requiring access through manholes. Water distribution was the most difficult, requiring access through fire hydrants. For infrastructure assets not physically assets, their corresponding condition assessment was based on correlation from findings of the infrastructure assets that were assessed. The following summarizes the proportion of the infrastructure assets for which the condition assessment was based on a physical inspection or a correlation. Condition inspections need to be repeated on a regular basis (i.e. 2-4 years). However, the order of priority should be for the water distribution system followed by the wastewater collection (storm and sanitary). Access to the water distribution system may be based on opportunity. Times of planned excavation and repair to the water pipes and valves, where the pipe is opened, may be used to schedule condition assessment of the pipe segment as a whole. Continuous efforts on condition assessments and subsequent analysis will improve reliability in asset management.

Table 24 – Condition Assessment Basis

Asset Group	Physically Inspected	Correlated
Roadways (Streets)	100%	0
Roadways (Sidewalks)	100%	0
Sanitary Mains	26%	74%
Storm Water Mains	10%	90%
Water Distribution Mains	0.3%	99.7%

- Overall, the short-term capital renewal expenditure needs of $1.234 Million/year for the next five years are in line with existing budget levels of $1.150 Million/year. However, to meet the long-term sustainability needs, the current-day capital renewal budget needs are $2.561 Million per year.

- This study provides details what is the recommended treatment type, where to do the treatment and, when to do the treatment. Even though these detailed works programs are spread out over five years, practicality may combine works of a similar nature in a contract deployed in one of the five years. In all cases, a review of the infrastructures should be completed as a check before progressing to design and tender; in particular to any changes that may have occurred since the inspections.

- Even though the time-frame for this study goes decades into the future, the critical components are within the short-term (five-year) horizon. To sustain capital renewal programming reliability, a tactical level asset management plan should be repeated on 2-4 year cycles. Each analysis cycle would reproduce the 5-year capital renewal program and strategy.

- As the above works programs unfold, including maintenance and repairs, this work, including type of activity, cost, data, and location (including segment identification) be captured in the form of a suitable maintenance management system (i.e. database application); and this application contain link to the existing GIS.

6.2 Recommendations

i. That the Municipality of Jasper implements the short-term (five-year) capital renewal program as per the tactical level analysis and results attained within this report and to the following allocations; annualized at $1.234 Million/year.

Table 25 – Short-Range (5-year) Capital Renewal Recommended Funding Allocations

Asset Group	Short-Term (5 Year) Needs Total (M$)
Roadways	
- Streets	$2.660
- Sidewalks	$0.375
Sub-Total	$3.035
Wastewater	
- Collection	$0.636
- Treatment	TBD
Sub-Total	$0.636
Water	
- Distribution	$2.500
- Treatment	TBD
Sub-Total	$2.500
Total	**$6.171**

ii. That the Municipality recognize the long term sustainability funding level of $2.561 Million per year for the roadways, water, and wastewater (storm water and sanitary) infrastructure groups.

iii. That the sustainable funding level is used in applying for external funding grants and consideration in tax and utility rates moving forward.

iv. That the Municipality implements an infrastructure inventory (GIS) review to update infrastructure records.

v. That the Municipality develops a Maintenance Management System (MMS) to track maintenance and renewal works; and that this is a database application with link to the existing GIS.

vi. That the Municipality repeat this tactical level asset management analysis and study on 2-4 year cycles; with a focus on assessing more water distribution pipes where opportune to do so.

Appendix A

Condition Assessment Criteria

Municipality of Jasper

Asset Management Condition Rating Criteria

- Final

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Project Number:

Phase 2

Date:

2017-03-10

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1. Introduction

The Municipality of Jasper Condition Rating Criteria is designed to provide consistency and structure in periodic condition assessments of the various asset groups. This document will be used as the basis for field condition rating assessments beginning the summer of 2016.

The criterion for each asset group is unique. However, the common element for all condition assessments is the “Severity” and “Extent” format. Severity measures the extremity of the condition rating. This would typically be None, Minor, Moderate, Major, and Severe. Extent measures the proportion of the asset segment within each of these severity categories.

The Severity-Extent condition data format is the foundation of the lifecycle optimization model. The model uses this information in both performance predictions over time as well as infrastructure renewal and treatment selection.

It is expected the assessment criteria may evolve over time. However, there is advantage in maintaining consistency of the given condition rating framework. The first year of two using the given condition rating criteria may establish an infrastructure performance benchmark. Delivery of the recommended program into the future may be used later to compare the state of the infrastructure at that time to the 2016 condition assessment benchmark.

2. Roadways – Pavements

The roadways condition assessment is based on the following four distresses (i.e. rutting, lineal cracking, fatigue cracking, and surface condition) and one geometric condition (i.e. grade). An experienced rater will be able to complete the assessment based on a visual review if each segment. A less experienced rater would be expected to conduct measurements of sample areas within the roadway segment.

2.1 Rutting

Definition

Rutting is the longitudinal surface depression developing in the wheel paths due to repeated load applications. One wheel path depression may have single or double ruts.

Severity

- None - Rut depths less than 5 mm
- Minor (slight) - Rut depths of 5 -10 mm
- Moderate - Rut depths of 11 to 15 mm
- Major (Extreme) - Rut depths greater than 15 mm

Extent

The extent will be determined as the percentage of visual measurements in each severity category. The extent will be of the proportion of rutted area as a ratio of the entire road surface.

2.2 Lineal Cracking

Definition

Lineal Cracks are single line cracks that have not formed into blocks, either transverse or longitudinal.

A nominal width of 0.1 metres is assigned to that crack. A nominal area can then be calculated (0.1m X length of crack). Any adjacent crack less than 1 m apart should be included together and considered under Fatigue Cracking.

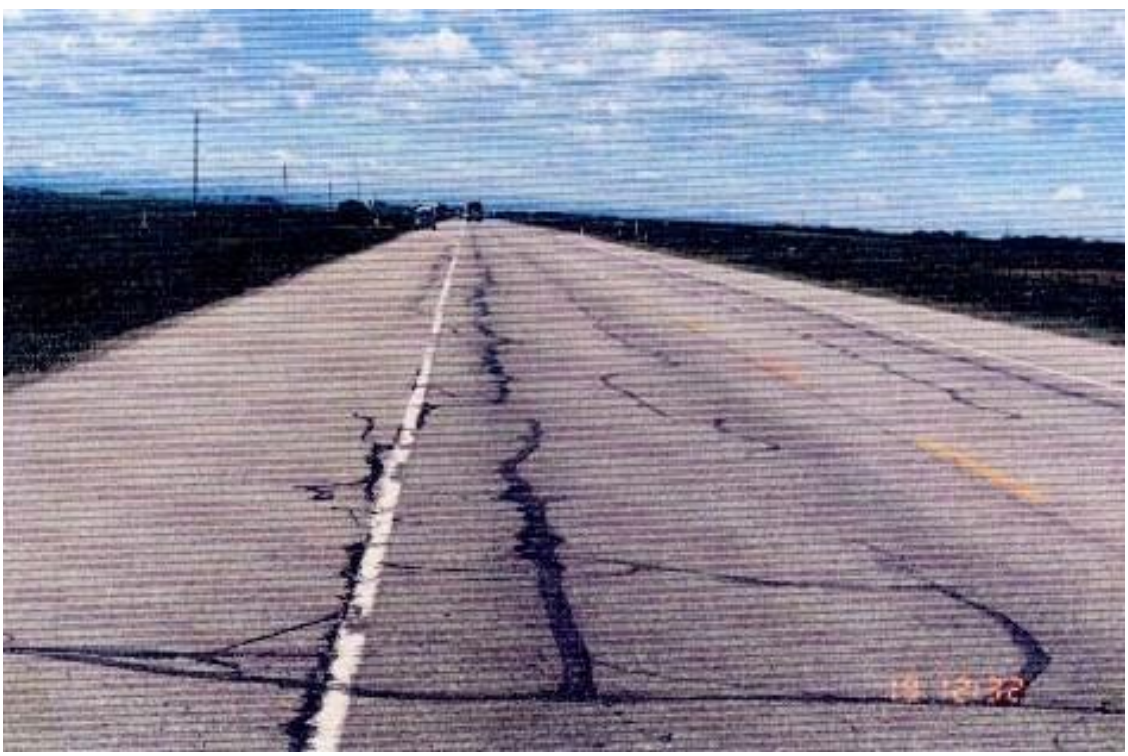
Severity

- None – No cracking area
- Minor - Crack width < 12.5mm
- Moderate - crack width between 12.5mm and 25mm
- Major - crack width > 25 mm

Extent

The extent is the percentage of each severity area to the road surface area.

Repaired areas will be assessed only on cracking that has reflected through the repair.



2.3 Fatigue Cracking

Definition

Cracks that form a block, or adjacent cracks that are less than 1 m apart.

The area of a fatigue block is the length multiplied by the width.

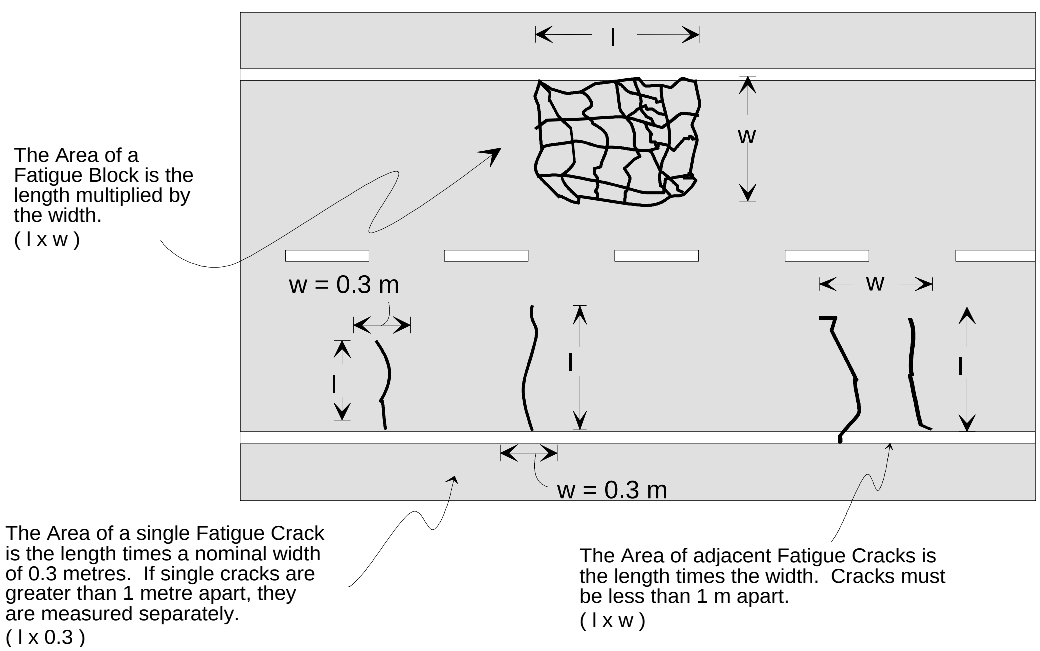
Severity

- None – No cracking area
- Minor (slight) - Short side of block having a length between 0.4 m and 1.0 m
- Moderate - Short side of block having a length less than 0.4 m
- Major (extreme) - Short side of block being less than 0.4 m and block area loose or picking out

NOTE: Any side of a block is not to exceed 1.0 metres. If a block exceeds 1.0 metres, each crack compromising the block is reported as a lineal crack (i.e. length of crack x 0.1m).

Extent

The area of cracking is reported for each severity level. The extent is the percentage of each severity area to the road surface area.



2.4 Surface Condition

Definition

Surface condition is an assessment of the pavement surface with respect to raveling, segregation and loss of aggregate.

Raveling is the progressive separation of aggregate particles in a pavement from the surface. Weathering, construction techniques, construction materials and the abrasive action of traffic can all cause raveling. Usually, the fine aggregates separate first and leave little "pock marks" on the pavement surface. As the separation continues, larger and larger particles will break free leaving the pavement with a rough and jagged appearance, including potholes.

Segregation is the separation of the coarse aggregate particles from the finer particles in a new asphalt mix.

Loss of aggregate in pavements occurs when single aggregates are removed from the surface creating a "pick-out". Eventually, the pick-out will grow as the asphalt concrete mix is worn away from the hole. This defect is usually evenly distributed throughout the pavement surface. Soft or fractured aggregate and lumps of silt or clay can create a pick-out.

Severity

- None
  - No noticeable deterioration
- Minor (slight)
  - Loss of pavement matrix material
  - Pavement surface may be oxidized or grey
- Moderate
  - Having an open textured appearance
  - Significant exposed aggregate
  - Road surface beginning to become rough
  - Fairly well spaced between pock marks
  - Grey or oxidized pavement surface
- Major (extreme)
  - Disintegrated with small potholes,

Extent

The area of surface condition is reported for each severity level. The extent is the percentage of each severity area to the road surface area.

Moderate Surface Condition

2.5 Grade

Definition

The grade is a measure of the amount of curb and gutter lost due to pavement rehabilitation overlays.

Severity

- None – Pavement at or below gutter elevation
- Minor – Pavement from 0 mm to 50 mm above gutter elevation
- Moderate – Pavement from 50 mm above gutter elevation to 50 mm below top of curb
- Major – Pavement higher than 50 mm below top of curb.

Extent

The extent is the percentage of each severity area to the road surface area.

3. Sidewalks

The sidewalks condition assessment is based on the following two distresses (i.e. Cracking and Spalling).

3.1 Cracking

Definition

Cracking is defined as either lineal or blocking in nature; even though blocking is not typical for cracking. Cracking can also be reflected on trip-edge potential.

A nominal width of 0.1 metres is assigned to that crack. A nominal area can then be calculated (0.1m X length of crack).

Severity

- None – No cracking area
- Minor – Vertical differential (i.e. trip-edge) < 10mm
- Moderate - Vertical differential (i.e. trip-edge) <= 10 mm to 25 mm
- Major - Vertical differential (i.e. trip-edge) > 25mm

Extent

The extent is the percentage of each severity area to the sidewalk surface area.

3.2 Spalling

Definition

Spalling is defined as surface deterioration due to pick-outs, pop-outs, or other surface abrasion. This is often caused by salts, direct impacts (i.e. wheel hits to the curb), and quality of the concrete material during construction.

Severity

- None
  - No visible defects noted.
- Minor
  - Loss of cement binder
  - Beginning of exposed aggregate
- Moderate
  - Distinct exposed aggregate and open surface texture
  - Surface is or becoming rough
- Major
  - Disintegrated surface with potholes or breaks

Extent

The area of surface condition is reported for each severity level. The extent is the percentage of each severity area to the sidewalk surface area.

Moderate Sidewalk Spalling

4. Water Distribution

4.1 Structural

Definition

The condition assessment will apply to the water main piping network. The piping materials assessed will be "Cast Iron" pipes only. PVC pipes will not be assessed as they are assumed to be within a relatively good condition state.

The condition assessment will be completed for the pipe. The condition assessment may be applied separate for the aggregate of the valves within the section of pipe.

The assessment will be based on information available from "Remaining Wall Thickness (RWT)" analysis and/or "Break History (BH)" analysis. This information will be correlated to the remainder of the network based on pipe material and "Remaining Service Life (RSL)".

The break BH is based on the last five years of information available. If information is only available for the last two years, the BH analysis will be based on averaging the breaks over the two-year period.

The order of priority on the assessment information will be 1-RWT, 2-BH, and 3-RSL.

The direct results attained for the pipes assessed will be correlated to the remainder of the pipe network based on material type and remaining service life (RSL). The RSL was determined earlier from the Strategic Level Asset Management Analysis.

Severity

- None
  - RWT = 80% to 100%
  - BH = 0 breaks/yr/100m
  - RSL > 50 years
- Minor
  - RWT = 50% to 80%
  - BH = 0 to 0.5 breaks/yr/100m
  - RSL = 30 to 50 years
- Moderate
  - RWT = 20% to 50%
  - BH = 0.5 to 1.0 breaks/yr/100m
  - RSL = 10 to 30 years
- Major
  - RWT = 5% to 20%
  - BH = 1.0 to 2.0 breaks/yr/100m
  - RSL = 0 to 10 years
- Severe
  - RWT = 0% - 5% (incl. through hole)
  - BH > 2.0 breaks/yr/100m
  - RSL = < 0 years

Extent

The extent will be the proportion of the assessment within each of the above severity ratings. The RWT will be distributed across the severity ratings. If RWT is not available, the extent calculation using BH and RSL will be 100% to a single severity rating.

Minor Pitting (50-80 percent remaining wall thickness)

4.2 Capacity

Definition

Capacity will be based on Volume/Capacity (V/C) ratio as per information provided from water system peak period capacity modeling or other related information provided.

Severity

- None
  - V/C = 0% to 20%
- Minor
  - V/C = 20% to 50%
- Moderate
  - V/C = 50% to 80%
- Major
  - V/C = 80% to 100%
- Severe
  - V/C = >100%

Extent

The extent will be the proportion of the assessment within each of the above severity ratings. It will be typically be 100% for one of the capacity severity ratings.

5. Wastewater (Storm and Sanitary) Collection

The condition assessment will apply to gravity collection pipes and connecting manholes. The piping materials assessed will be of the “concrete” and “vitrified clay tile (VCT) material types. PVC pipes will not be assessed as they are assumed to be within a relatively good condition state.

5.1 Structural and Operations & Maintenance

Definition

The assessment will be based on a partial network assessment using CCTV sewer photography and NASSCO’s Pipeline Assessment and Certification Program (PACP). The direct results attained for the pipes assessed will be correlated to the remainder of the pipe network based on material type and remaining service life (RSL). The RSL was determined earlier from the Strategic Level Asset Management Analysis.

The condition assessments will be completed for two condition types (i.e. Structural and Operations & Maintenance (O&M)). The assessment will follow the standard 5-point grading system.

The assessment will be applied separate for the pipes and the connecting manholes and catch basins

Severity

- None (Grade 1) – Excellent condition with only minor defects detected. Near new condition state.
- Minor (Grade 2) – Good condition with defects have not begun to deteriorate. Greater than 20 years RSL.
- Moderate (Grade 3) – Fair condition with moderate defects that will continue to deteriorate. 10 to 20 years RSL expected.
- Major (Grade 4) – Severe defects that will become grade 5 defects within the foreseeable future. 5 to 10 years RSL expected.
- Severe (Grade 5) – Severe defects that require immediate action. 0 to 5 years RSL expected.

Extent

The extent is the proportion of readings within each of the above severity categories. For example, on 10 grade readings of 2-Grade 1, 3-Grade 3, 4-Grade 4, and 1 Grade 5, the following would be the extent recordings for each severity category:

- None – 20%
- Minor – 0%
- Moderate – 30%
- Major – 40%
- Severe – 10%

Moderate (Grade 3) Structural Defects

Severe (Grade 5) Structural Defects

Severe (Grade 5) O&M Defects

5.2 Capacity

Definition

Capacity will be based on Volume/Capacity (V/C) ratio as per information provided from wastewater system peak period capacity modeling or other related information provided. CCTV inspections may provide an indication of capacity based on high level water markings in the pipe.

Severity

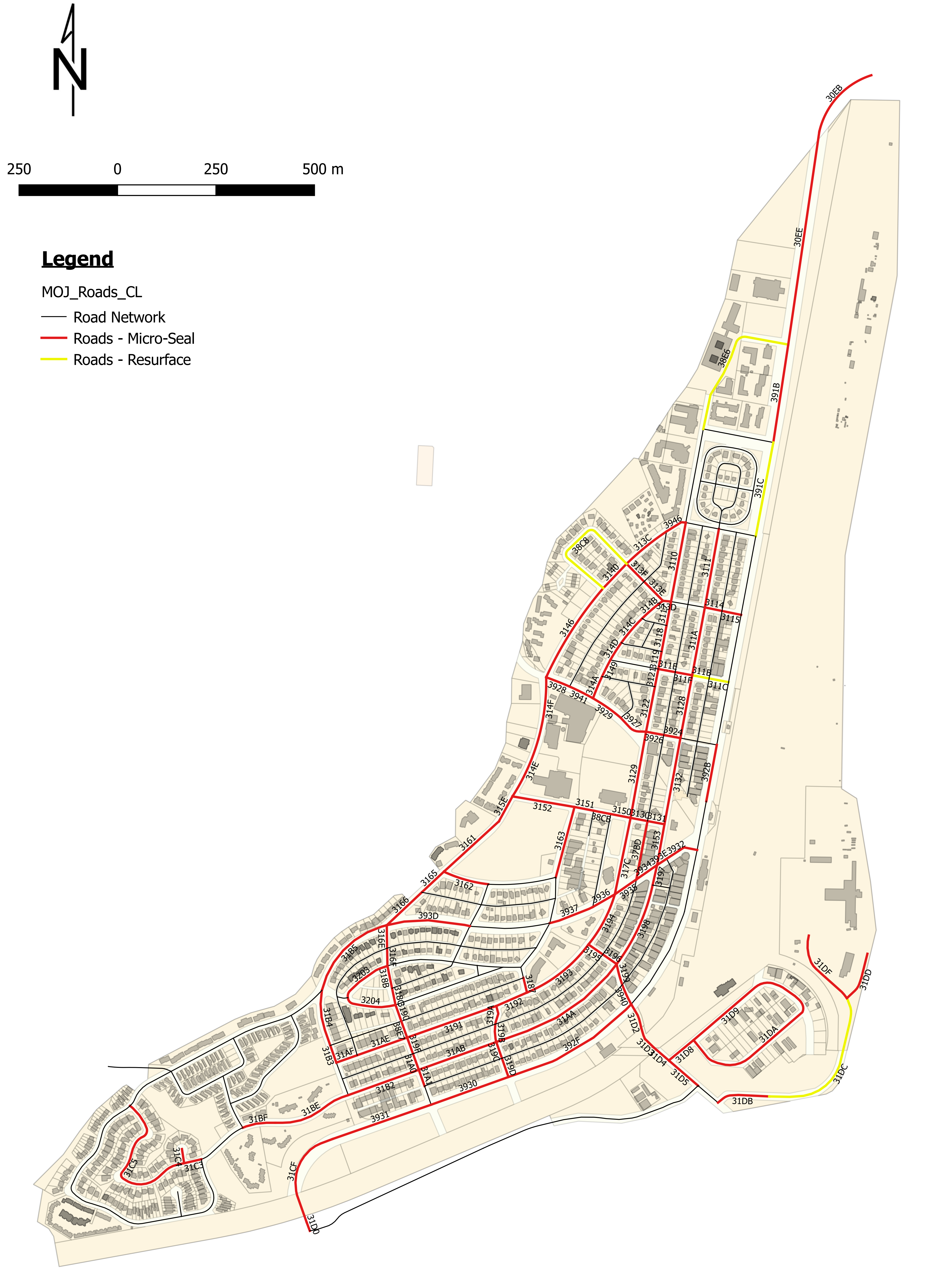
- None
  - V/C = 0% to 20%
- Minor
  - V/C = 20% to 50%
- Moderate
  - V/C = 50% to 80%
- Major
  - V/C = 80% to 100%
- Severe
  - V/C = >100%

Extent

The extent will be the proportion of the assessment within each of the above severity ratings. It will be typically be 100% for one of the capacity severity ratings.

Appendix B

Infrastructure Life-Cycle Optimisation Modelling Runs and Maps



Municipality of Jasper

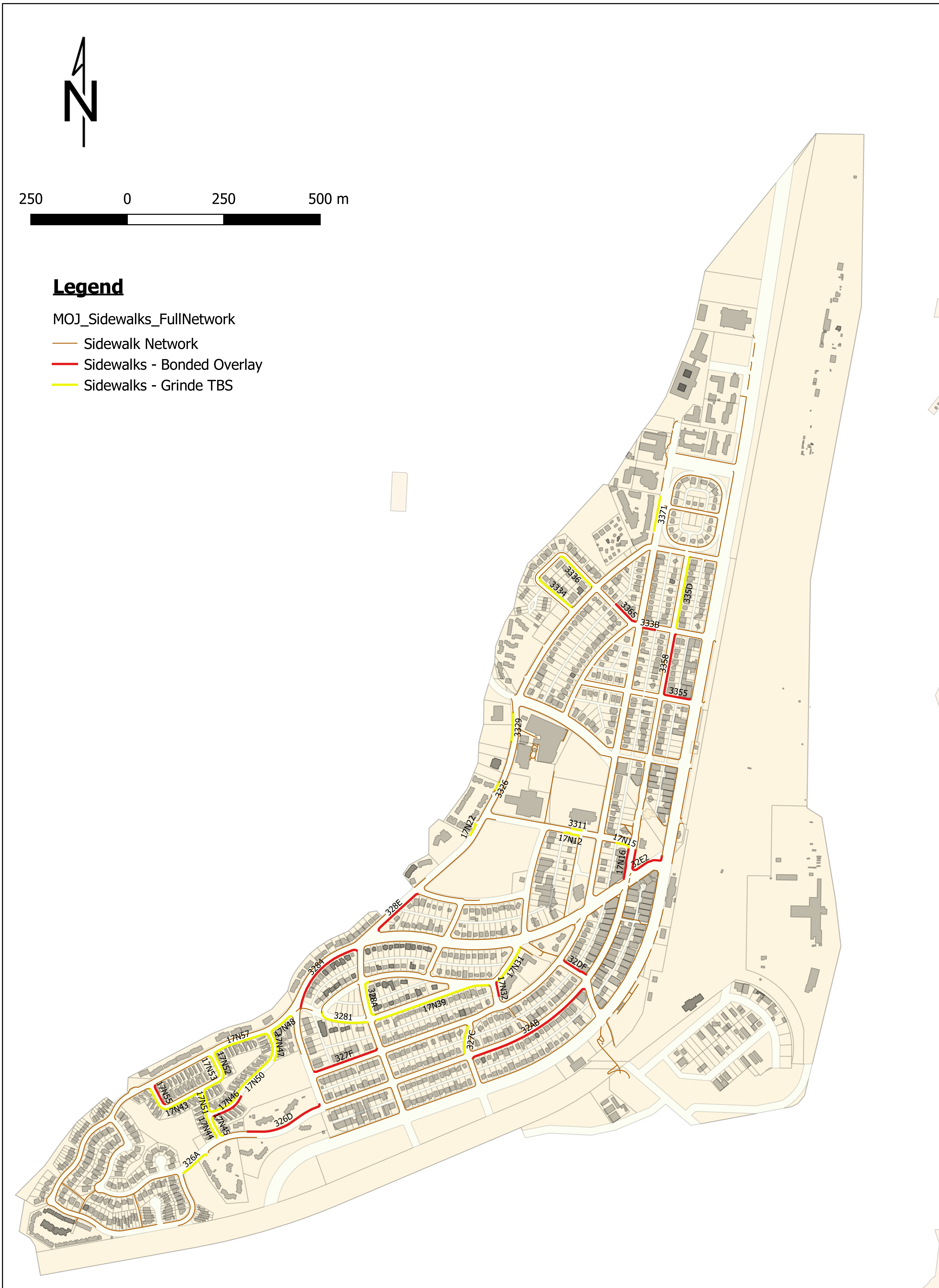
Tactical Level Asset Management Study (Phase 2)
Water Distribution, Wastewater Collection, and Roadways

2017-04-06

Pillar SYSTEMS

Map 1 - Roadway Treatments

Rev.2 - 2017-04-04



Municipality of Jasper

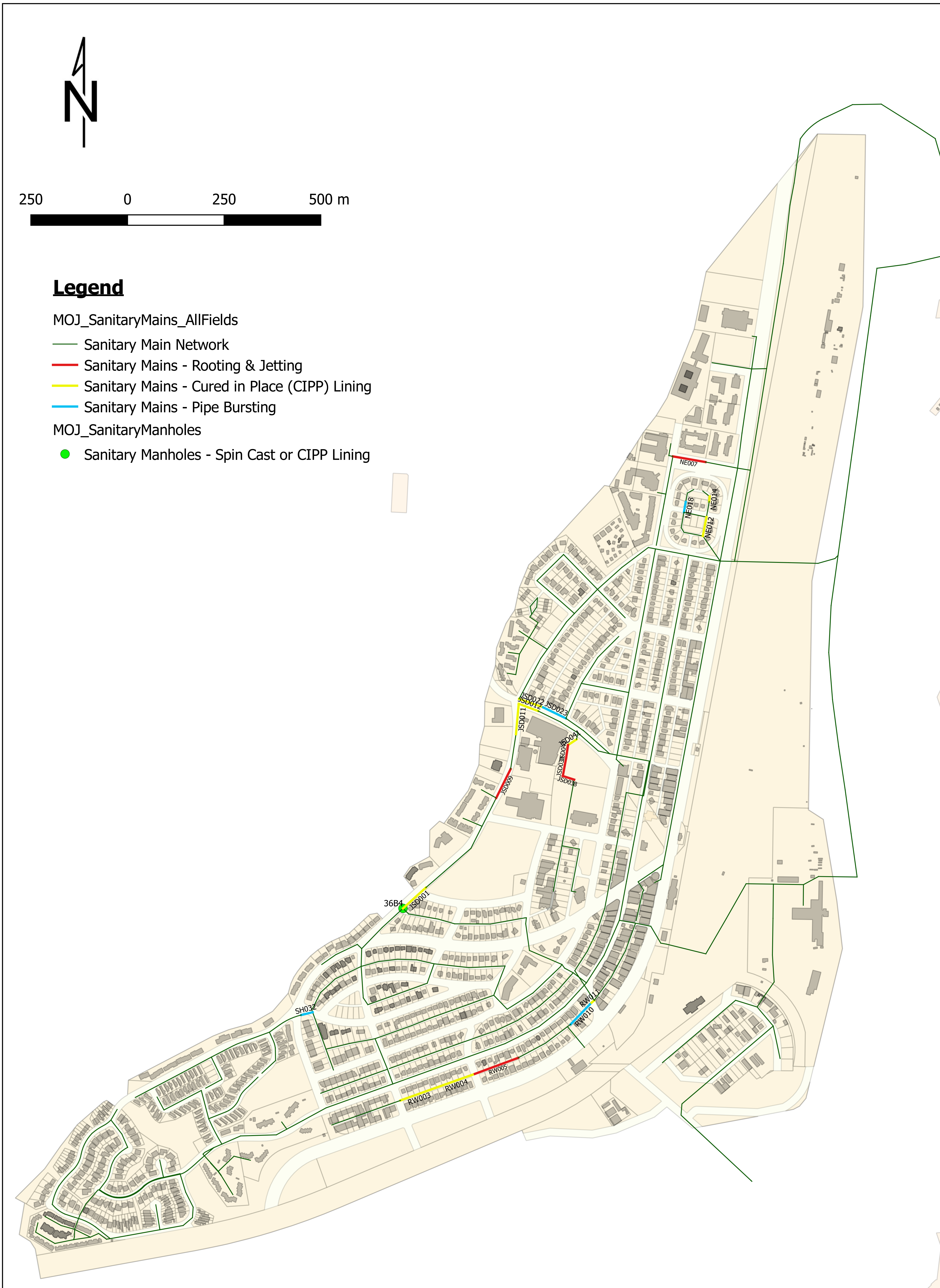
Tactical Level Asset Management Study (Phase 2)
Water Distribution, Wastewater Collection, and Roadways

2017-04-06

Pillar SYSTEMS

Map 2 - Sidewalk Treatments

Rev.2 - 2017-04-04



Municipality of Jasper

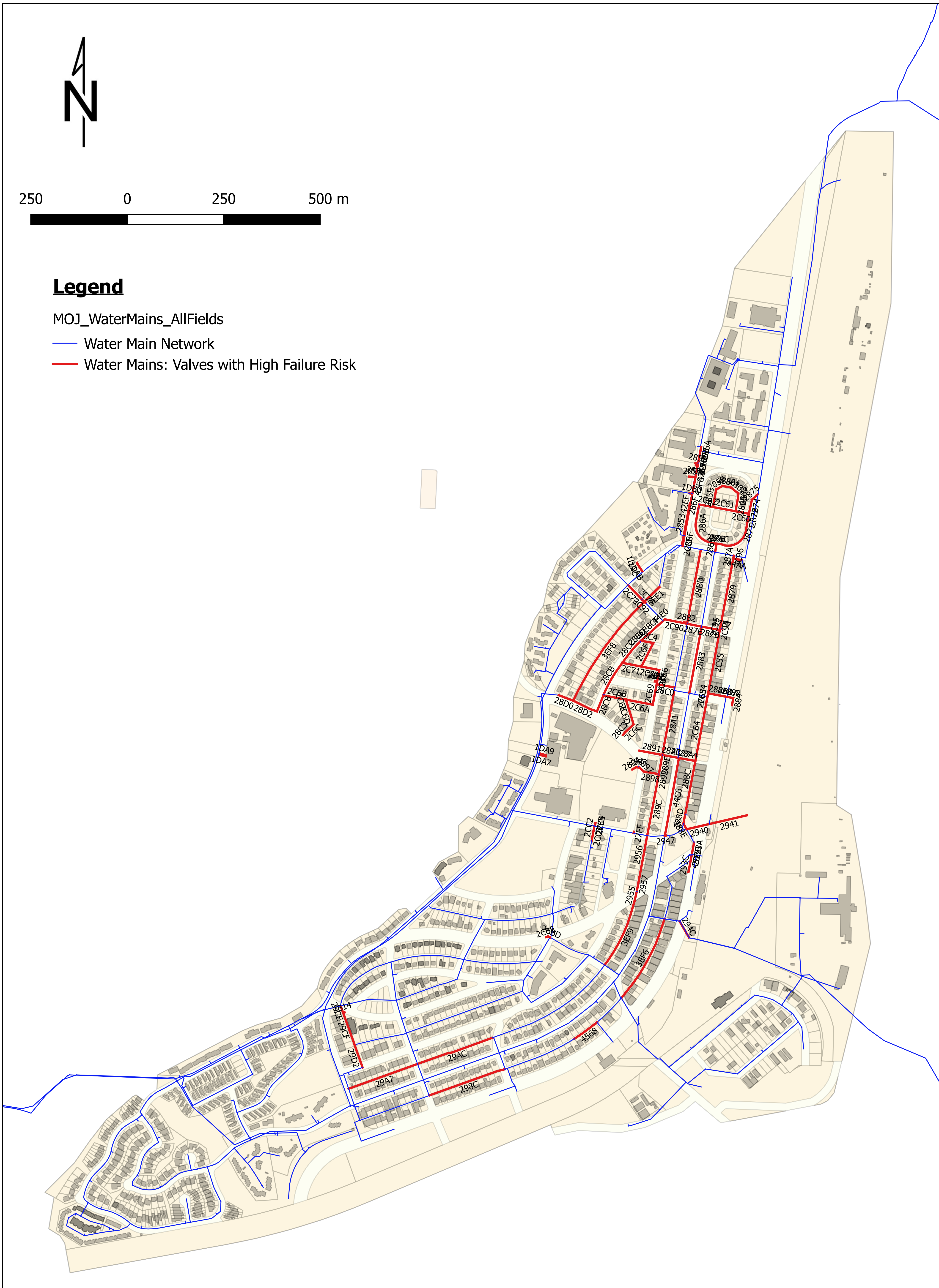
Tactical Level Asset Management Study (Phase 2)
Water Distribution, Wastewater Collection, and Roadways

2017-04-06

Map 3 - Wastewater System Treatments

Pillar SYSTEMS

Rev.2 - 2017-04-04



Municipality of Jasper

Tactical Level Asset Management Study (Phase 2)
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2017-04-06

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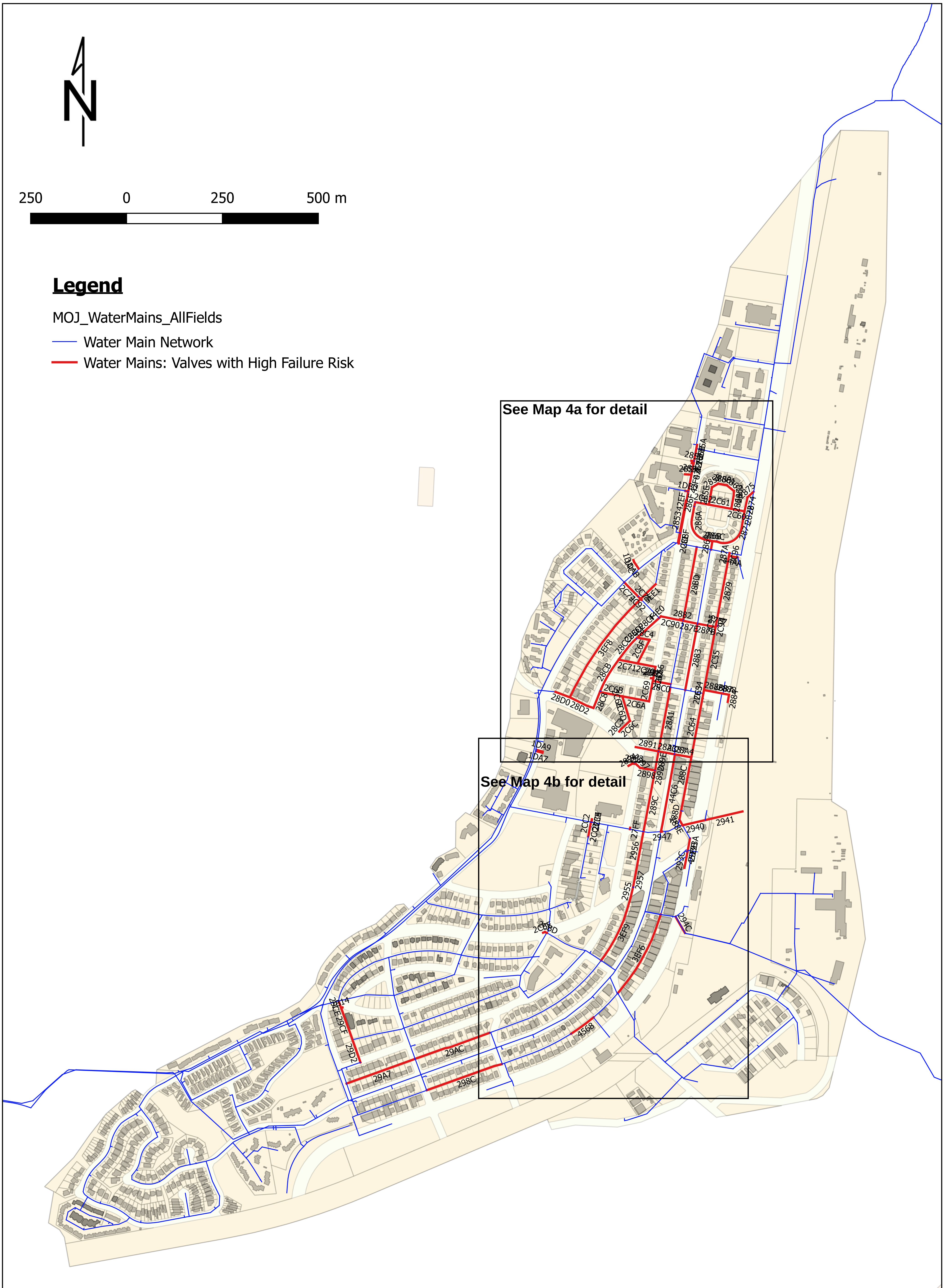
SYSTEMS

Map 4 - Water Distribution System: Valve Treatments

Rev.2 - 2017-04-04



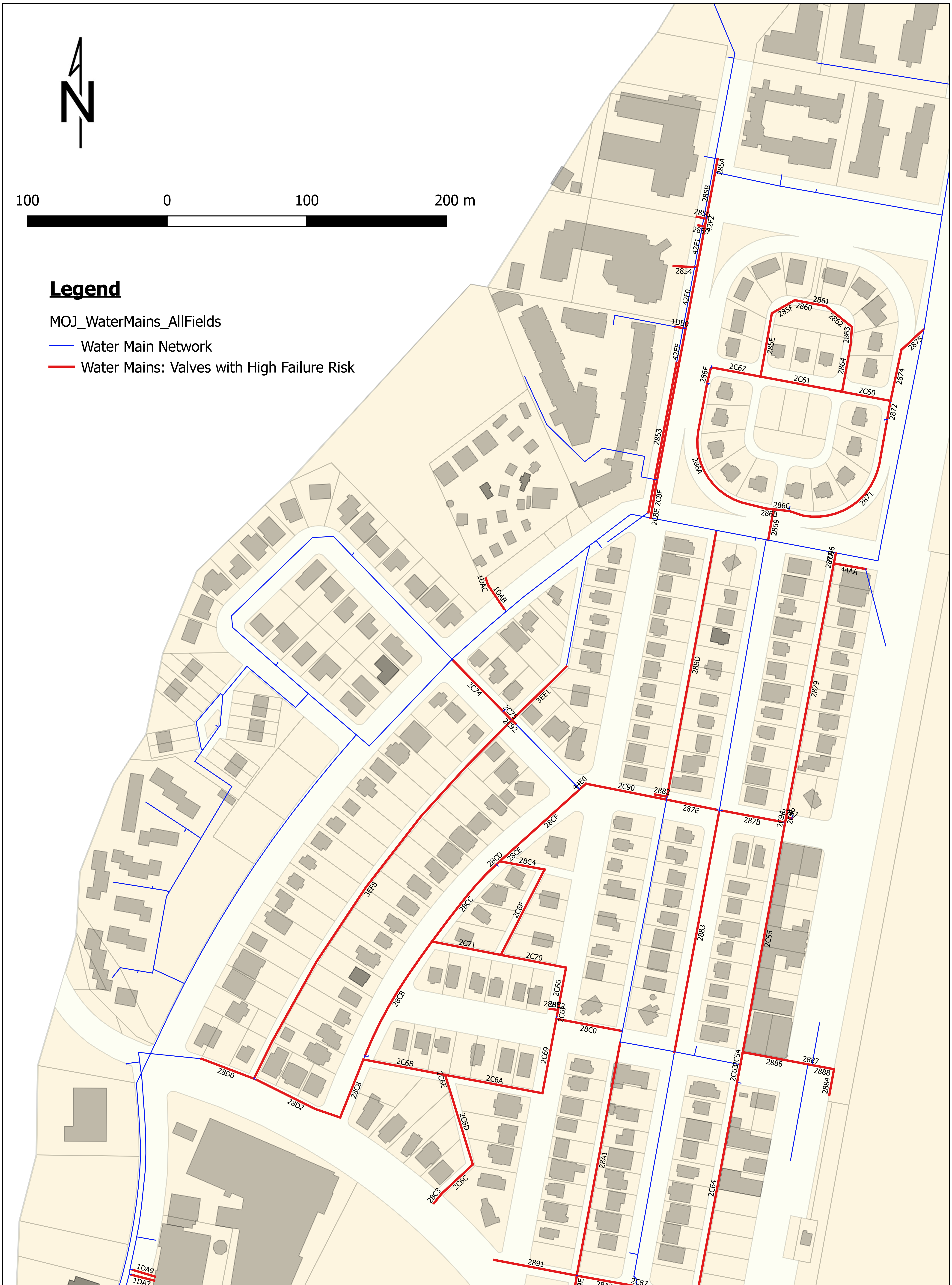
Municipality of Jasper

Tactical Level Asset Management Study (Phase 2)
Water Distribution, Wastewater Collection, and Roadways

2017-04-06

Map 4 - Water Distribution System: Valve Treatments

Rev.2 - 2017-04-04



Pillar SYSTEMS

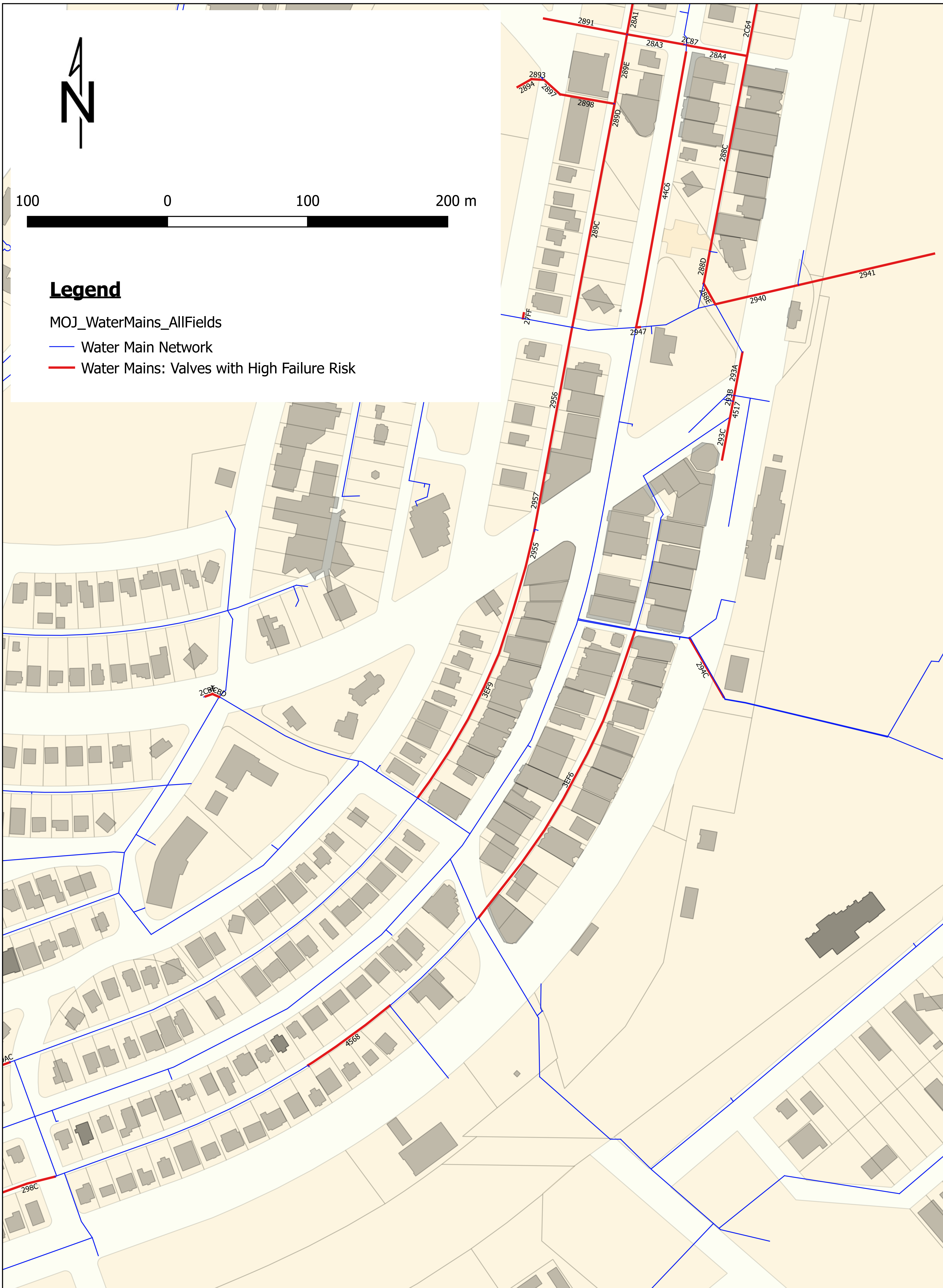
Municipality of Jasper

Tactical Level Asset Management Study (Phase 2)
Water Distribution, Wastewater Collection, and Roadways

2017-04-06

Map 4a - Water Distribution System: Valve Treatments

Rev.2 - 2017-04-04



Municipality of Jasper

Tactical Level Asset Management Study (Phase 2)
Water Distribution, Wastewater Collection, and Roadways

2017-04-06

PILLAR SYSTEMS

Map 4b - Water Distribution System: Valve Treatments

Rev.2 - 2017-04-04