CHAPTER 6

ALTERNATIVES EVALUATION

INTRODUCTION

This chapter summarizes the evaluation of alternative solutions to the deficiencies identified in Chapter 4 for the two design storm durations (24 and 72-hour) evaluated. The peak flows in the collection systems and potentially conveyed for treatment at McMinnville's Water Reclamation Facility (WRF) vary for the two storm durations. Therefore, a least cost combination of improvements were evaluated for each design storm. A series of cost curves were developed to show the relationship between alternative solutions including rain dependant infiltration and inflow (RDI/I) reduction, conveyance improvements, treatment capacity increases, and storage of peak flows. The cost impacts of peak flow associated with several alternatives assumes flow blending at the WRF. The options are presented with a discussion of the risks associated with the least cost solution for each of the storm durations. The recommended solution is described in Chapter 7 for the design storm duration and peak flow condition based on regulatory compliance, risk of collection system overflows and cost impacts.

APPROACH

As part of the planning process, a collection system model using EPA Storm Water Management Model (SWMM) Version 5 was developed to simulate the flow conditions experienced within the service area. The model was refined and calibrated to simulate the existing collection system and to reflect recent sewer rehabilitation efforts, flow monitoring, and historic pump station and treatment facility flow data. This calibrated model was used to estimate the 5-year, peak day, and 5-year peak hour wet weather regulatory design flow rates for the existing condition.

The future conditions model is based on buildout land use and was developed to incorporate additional areas within the planned service area boundary that are currently undeveloped.

Based on initial peak flow and cost results it was determined that flow blending at the WRF as well as the amount of antecedent rainfall prior to the 24-hour, 5-year design event should be incorporated into the evaluation. Therefore, results from three rainfall conditions are presented. Each meet the DEQ written regulatory criteria for a 5-year, 24-hour winter event. The conditions are as follows:

- *72-hour storm duration.* This condition includes 48-hours of rainfall prior to the start of the 5-year, 24-hour regulatory event. The amount of rainfall during this period is consistent with a 5-year frequency 72-hour event, including the 24-hour regulatory design event, and is the most conservative of the conditions modeled.
- *24-hour storm duration.* This condition assumes no prior (antecedent) rainfall to the 24-hour regulatory event. This condition meets the DEQ written regulatory criteria but since it assumes no antecedent conditions, is the least conservative of the conditions modeled.

- *1998 Wet Weather Overflow Management Plan (WWOMP storm).* This condition matches the rainfall used in the 1998 WWOMP. This event included antecedent rainfall (approximately 0.8 inches) but not nearly as much as the 72-hour event (2.8 inches). This condition is modeled for consistency in approach with the 1998 WWOMP. The rainfall condition falls between the 72- and 24-hour design events in terms of rainfall volume.

The three storms, and for comparison purposes a recent, large event from December 2005/January 2006, are shown on Figure 6-1. It is important to note that the 5-year, 24-hour design storm distribution used for the 1998 WWOMP had some periods for the shorter durations (up to approximately 6 hours) when the depth produced a frequency that was greater than the 5-year event (the green circles on the figure above the line in Figure 6-1). So while the depth for 24-hour duration is consistent for all the storms analyzed, and matches the 5-year frequency, the 1998 rainfall distribution produces short duration high peak flows.

Figure 6-1. Design Storm Comparisons

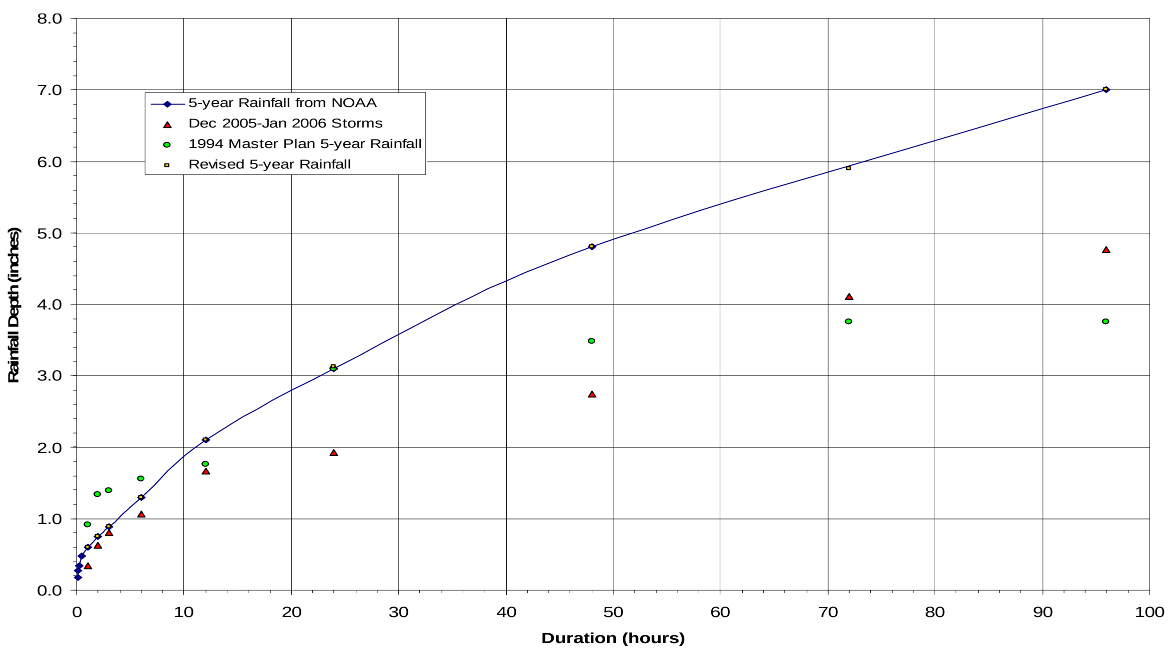


Table 6-1 presents the peak wet weather flows anticipated in the collection system during current and buildout conditions for the three rainfall conditions based on the modeling efforts and assuming that no collection system rehabilitation is performed.

Table 6-1. Model Results of the Peak Wet Weather Flows

72-Hour Duration (48 hours of antecedent rainfall prior to the 24-hour regulatory event)	Existing (mgd)	Buildout (mgd)
Peak Hour Dry Weather Sanitary Flow and Base Infiltration	5.4	6.8
Peak Hour RDI/I	46.6	55.2
Maximum Day Wet Weather Flow	47.6	54.5
Peak Hour Flow	52	62
24-Hour Duration (no antecedent rainfall)		
Peak Hour Dry Weather Sanitary Flow and Base Infiltration	5.4	6.8
Peak Hour RDI/I	37.9	42.1
Maximum Day Wet Weather Flow	35.1	45.5
Peak Hour Flow	43.3	48.9
1998 WWOMP		
Peak Hour Dry Weather Sanitary Flow and Base Infiltration	5.4	6.8
Peak Hour RDI/I	46.4	47.8
Maximum Day Wet Weather Flow	36.9	39.9
Peak Hour Flow	51.8	54.6

The analysis assumes existing capacities of 24 mgd secondary treatment at the WRF and 32 mgd at the headworks as these are the rated hydraulic capacities of these facilities at the WRF. Four types of improvements were analyzed in several combinations to identify a least cost solution.

The improvement elements are listed below with a brief description of how they were applied.

Conveyance. Selected pipelines are replaced with larger diameter pipelines to convey peak flows with adequate freeboard between the hydraulic grade line and ground surface. The freeboard criterion is 2 feet, so at all manhole locations where the water surface is predicted to be less than 2 feet from the ground, a pipeline replacement project was identified. This element also includes pump station improvements where the peak flow exceeds the rated firm capacity of the station (largest pump out of service as required by DEQ). The estimated unit costs for pipe replacement are shown in Table 6-2. Rehab costs are summarized in Table 6-3. Pump station capacity improvement costs are shown in Figure 6-2.

Capital Cost Estimates

All cost estimates are order-of-magnitude estimates as defined by the American Association of Cost Engineers (AACE). An order of magnitude estimate is one that is made without detailed engineering data and uses techniques such as cost curves and scaling factors applied to estimates developed for similar projects. The overall expected level of accuracy of the cost estimates presented is -30 percent to +50 percent. This means that bids can be expected to fall within a range of 30 percent under to 50 percent over the estimate for each project. This is consistent with the guidelines established by the AACE for planning level studies.

The economic evaluation was based on capital cost estimates. The capital cost estimates were prepared using the current 20-Cities Engineering News Record (ENR) Construction Cost Index average of 8089. The estimates reflect a professional opinion of costs at this time and are subject to change as the design of each project component develops.

Table 6-2. Pipe Replacement Unit Cost (ENR 8089)

Diameter (inches)	8	10	12	15	18	21	24	27	30	36	42	48
Cost Per Foot[1]	$321	$343	$362	$392	$431	$464	$490	$521	$551	$609	$712	$822

[1] Assumes 8 foot depth

Figure 6-2. City of McMinnville Wastewater Pump Station Costs

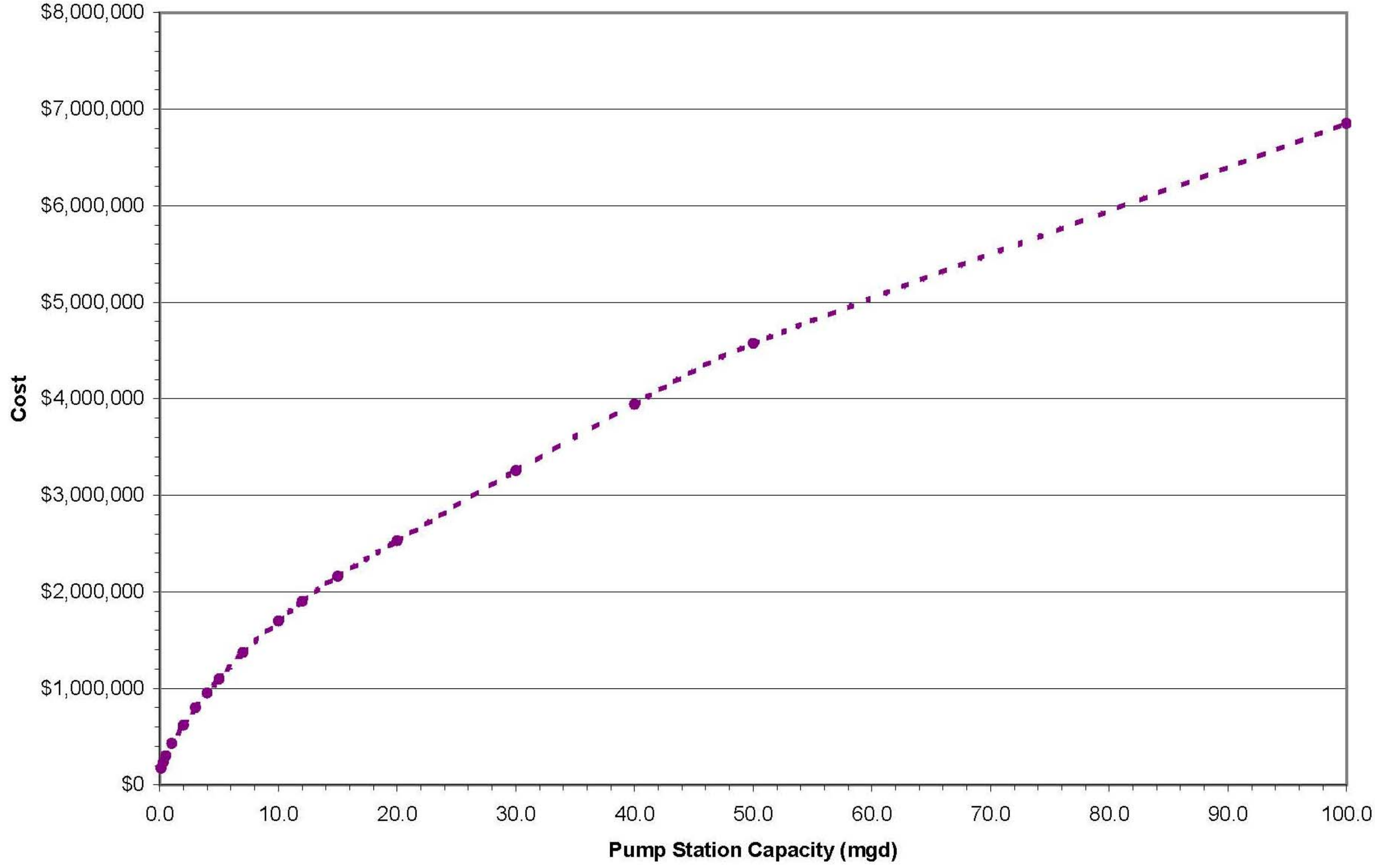


Table 6-3. Estimated Rehabilitation Costs and RDI/I Reduction For Targeted Basins

Monitor Basin	Existing RDI/I Rate From Monitor Data (gpad)	Total Length of Pipes in Basin (feet)	RDI/I Reduction Target = 27% (10% Pipe Rehabilitation)		RDI/I Reduction Target = 40% (20% Pipe Rehabilitation)		RDI/I Reduction Target = 47% (30% Pipe Rehabilitation)		RDI/I Reduction Target = 53% (40% Pipe Rehabilitation)		RDI/I Reduction Target = 57% (50% Pipe Rehabilitation)		RDI/I Reduction Target = 61% (60% Pipe Rehabilitation)		RDI/I Reduction Target = 63% (70% Pipe Rehabilitation)	
			Length (ft)	Cost ($)[1]	Length (ft)	Cost ($)[1]	Length (ft)	Cost ($)[1]	Length (ft)	Cost ($)[1]	Length (ft)	Cost ($)[1]	Length (ft)	Cost ($)[1]	Length (ft)	Cost ($)[1]
2b	24,800	65,836	6,584	1,705,000	13,167	3,410,000	19,751	5,116,000	26,334	6,821,000	32,918	8,526,000	39,502	10,231,000	46,085	11,936,000
4a	31,200	33,853	3,385	877,000	6,771	1,754,000	10,156	2,630,000	13,541	3,507,000	16,927	4,384,000	20,312	5,261,000	23,697	6,138,000
4b	8,500	12,168	1,217	315,000	2,434	630,000	3,650	945,000	4,867	1,261,000	6,084	1,576,000	7,301	1,891,000	8,518	2,206,000
5	39,700	24,699	2,470	640,000	4,940	1,279,000	7,410	1,919,000	9,880	2,559,000	12,350	3,199,000	14,819	3,838,000	17,289	4,478,000
6b	18,200	28,436	2,844	737,000	5,687	1,473,000	8,531	2,210,000	11,374	2,946,000	14,218	3,682,000	17,062	4,419,000	19,905	5,155,000
7a	8,800	46,037	4,604	1,192,000	9,207	2,385,000	13,811	3,577,000	18,415	4,769,000	23,019	5,962,000	27,622	7,154,000	32,226	8,347,000
7b	23,000	22,023	2,202	570,000	4,405	1,141,000	6,607	1,711,000	8,809	2,282,000	11,012	2,852,000	13,214	3,422,000	15,416	3,993,000
Totals		233,052	23,306	6,036,000	46,611	12,072,000	69,916	18,108,000	93,220	24,145,000	116,528	30,181,000	139,832	36,216,000	163,136	42,253,000

[1] Pipe rehabilitation cost is $259/foot based on historical rehabilitation project costs.

Rainfall dependent infiltration and inflow (RDI/I) reduction. Small diameter, existing pipelines including private service laterals are replaced or lined. The selected locations are within basins that exhibited the highest RDI/I rates (see Figure 6-3). RDII rates are based on the 5-year, 24-hour peak flow estimate and the existing developed area for each monitor basin (rather than gross monitor basin area). The result of these improvements is the reduction of RDI/I, and therefore, peak flows in the system. In order to estimate the amount of RDI/I reduction that results from pipeline rehabilitation, detailed flow monitoring data representing pre- and post-rehabilitation conditions are required. Because these data are not available for McMinnville's system, a replacement versus reduction relationship was applied from work performed for the Metropolitan Wastewater Management Commission (MWMC) that serves Eugene and Springfield. The MWMC relationship was derived from the results achieved by multiple agencies in and outside of Oregon, and is shown in Figure 6-4. Due to the successful application of the private lateral ordinance in McMinnville, the reduction values reflect the greater reduction achieved compared to rehabilitation of only the public system.

Storage. Offline storage at the old wastewater treatment plant site temporarily stores excess flows until capacity is available in the system. The storage concept and costs were developed by West Yost in the *Master Plan for Diversion Structure Modifications and Peak Flow Storage Facilities (1999).* The "Pressure Flow" solution from this analysis was selected based on a lower unit cost. This approach requires pumping to and back out of the storage facility to the RSPS. The storage cost curve used in the analysis of alternatives is given in Figure 6-5.

Treatment. Additional wet weather treatment capacity is required at the existing WRF and may include capacity increases for the RSPS, raw sewage force mains, headworks, Orbals, secondary clarifiers, disinfection and site piping. The third Orbal/clarifier (secondary treatment) train required for dry weather treatment is necessary for one option to increase wet weather treatment capacity to 36 mgd. Peak flows in excess of 36 mgd will be blended. The costs for varying levels of treatment are shown in Figure 6-6.

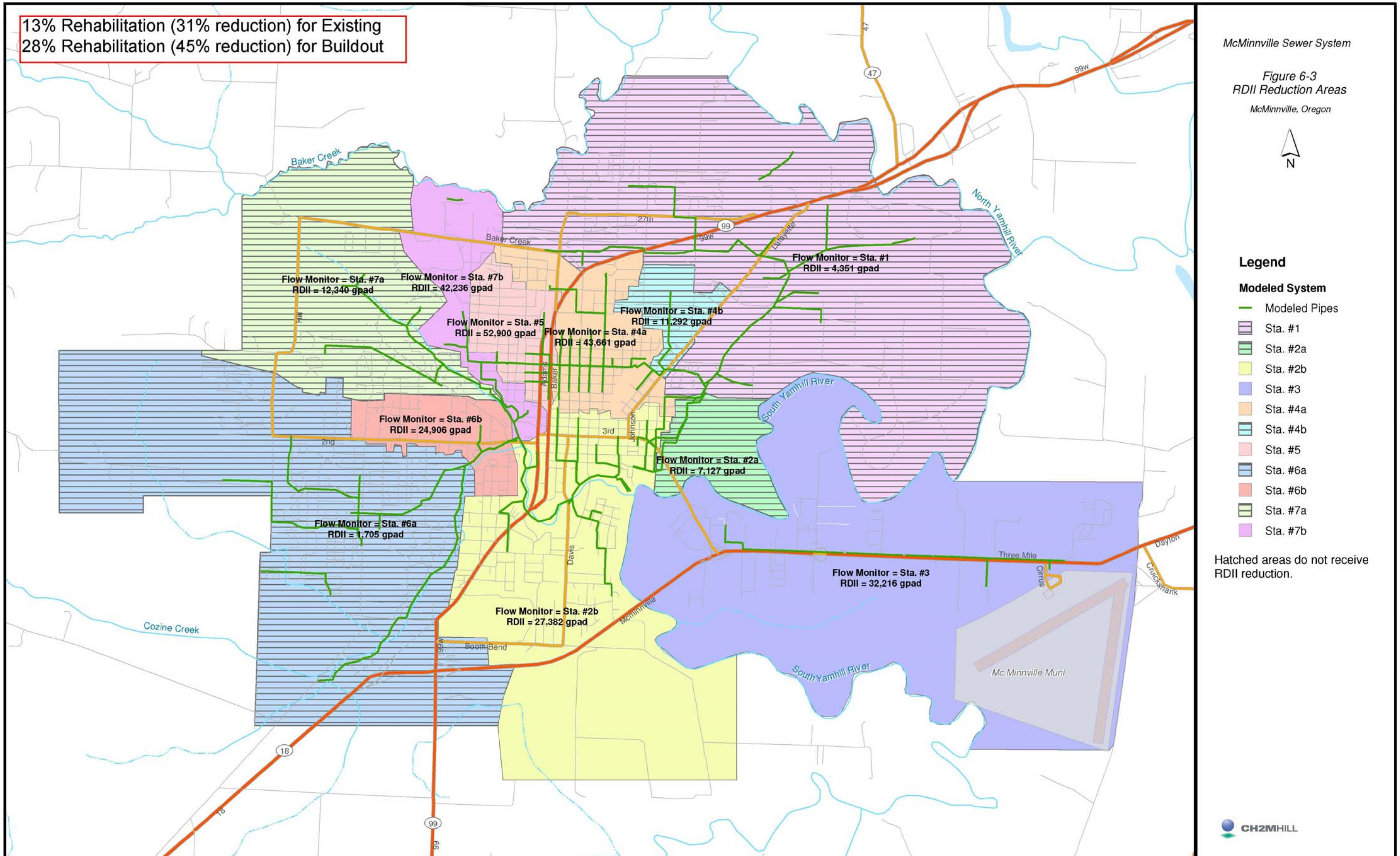
IMPROVEMENT COMBINATIONS

For both existing and future development conditions, two distinct combinations of improvements were analyzed and are identified as convey and treat (CT) or storage (S):

- CT: Conveyance, RDI/I reduction, and treatment plant capacity increases
- S: Conveyance, RDI/I reduction, offline storage, and treatment capacity increases (storage sizing is based on the peak flow reduction necessary to achieve 32 mgd peak flow capacity of the WRF).

COST ANALYSIS

Figure 6-7 and 6-8 show the individual and combined costs of the improvements relative to the amount of RDI/I reduction performed and the projected peak flow rate at the WRF for the 72-hour duration storm. Figures 6-9 and 6-10 show this same information for the 24-hour duration storm (no antecedent rain). Since the WWOMP rainfall volume falls between the 24- and 72-hour storms, costs were assumed to fall between those developed for those storms and were not specifically developed.



13% Rehabilitation (31% reduction) for Existing
28% Rehabilitation (45% reduction) for Buildout
McMinnville Sewer System
Figure 6-3
RDII Reduction Areas
McMinnville, Oregon
N
Legend
Modeled System
Modeled Pipes
Sta. #1
Sta. #2a
Sta. #2b
Sta. #3
Sta. #4a
Sta. #4b
Sta. #5
Sta. #6a
Sta. #6b
Sta. #7a
Sta. #7b
Hatched areas do not receive RDII reduction.
Flow Monitor = Sta. #1
RDII = 4,351 gpad
Flow Monitor = Sta. #7a
RDII = 12,340 gpad
Flow Monitor = Sta. #7b
RDII = 42,236 gpad
Flow Monitor = Sta. #5
RDII = 52,900 gpad
Flow Monitor = Sta. #4a
RDII = 43,661 gpad
Flow Monitor = Sta. #4b
RDII = 11,292 gpad
Flow Monitor = Sta. #6b
RDII = 24,906 gpad
Flow Monitor = Sta. #2a
RDII = 7,127 gpad
Flow Monitor = Sta. #6a
RDII = 1,705 gpad
Flow Monitor = Sta. #3
RDII = 32,216 gpad
Flow Monitor = Sta. #2b
RDII = 27,382 gpad
Baker Creek
Cozine Creek
North Yamhill River
South Yamhill River
Mc Minnville Muni
27th
3rd
2nd
Three Mile
Booth Bend
Dayton
Cruickshank
Lafayette
Johnson
Adams
Baker
Davis
Hill
Cirrus
McMinnville
99w
47
99
18
CH2MHILL

Figure 6-4. Collection System Rehabilitation Versus Estimated RDII Reduction

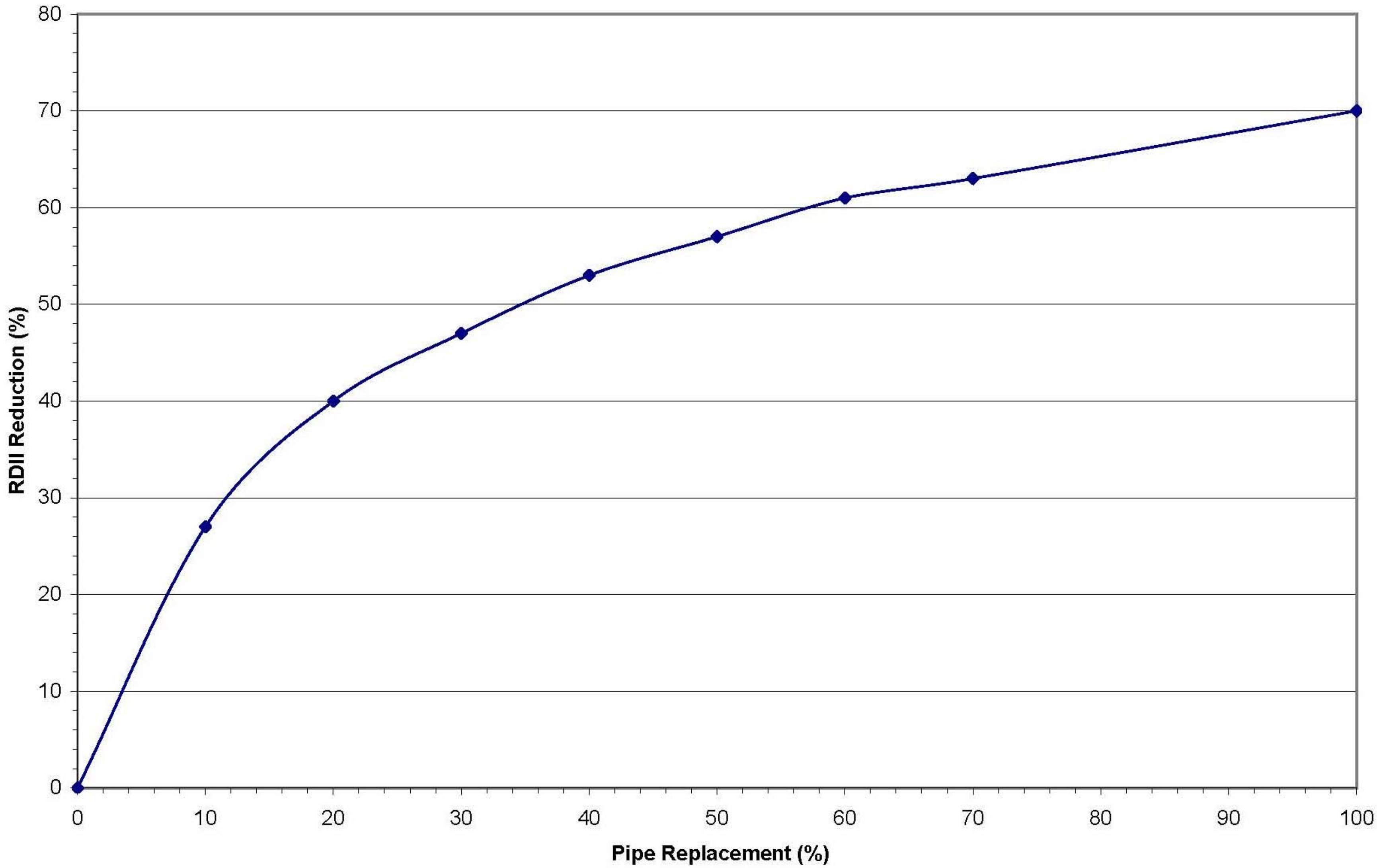


Figure 6-5. City of McMinnville Wastewater Storage Costs

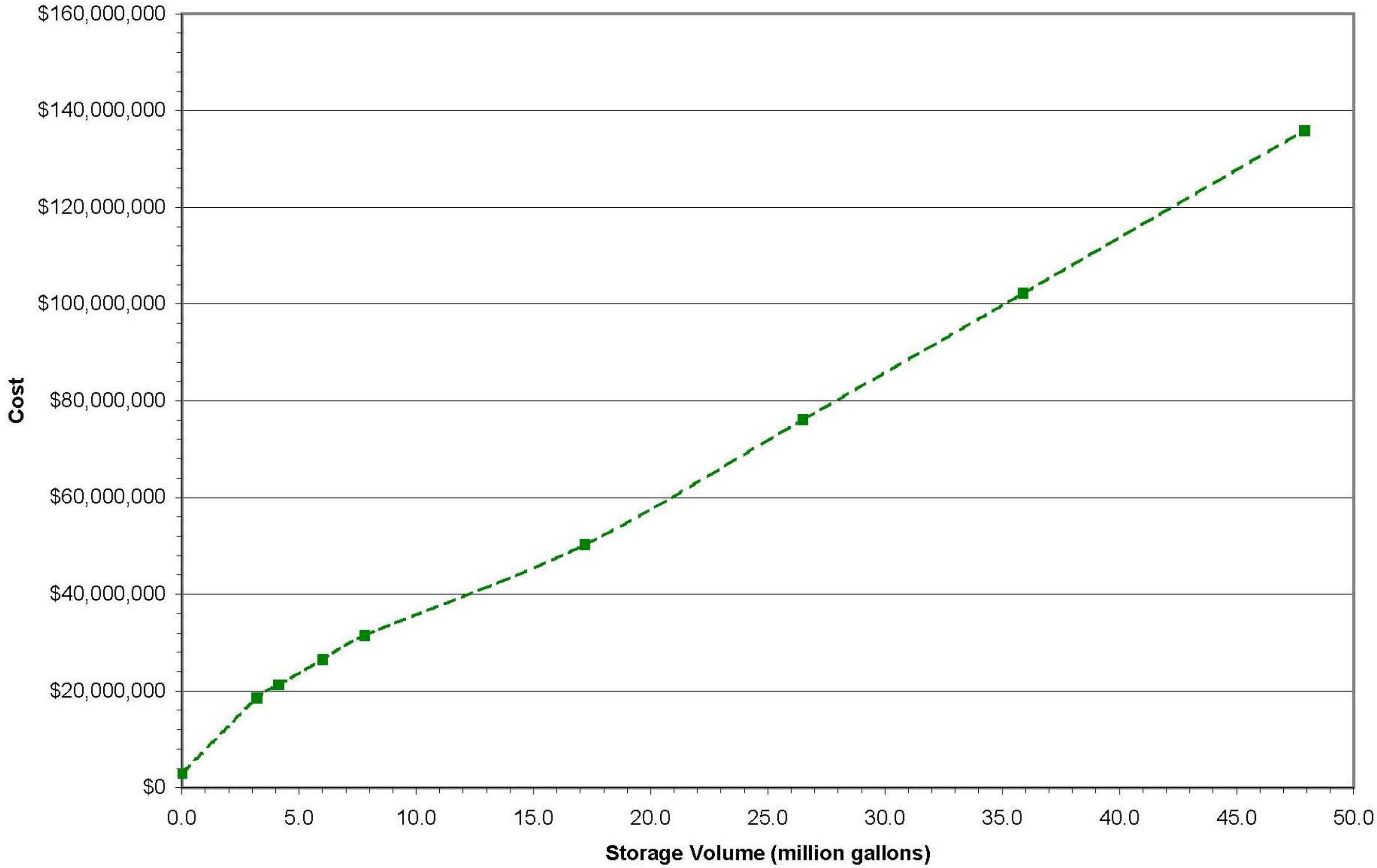
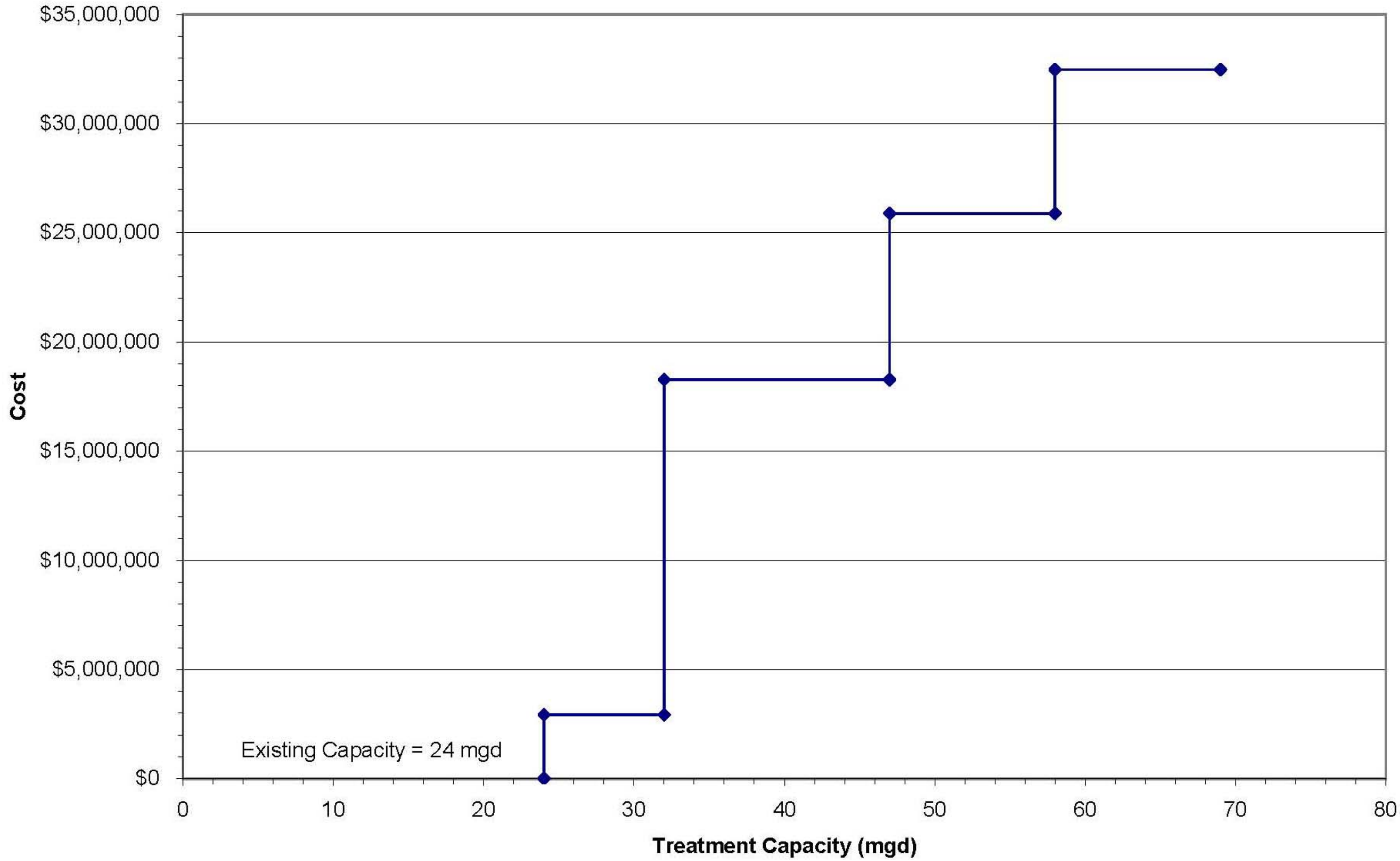


Figure 6-6. City of McMinnville Wastewater Treatment Facility Improvement Costs



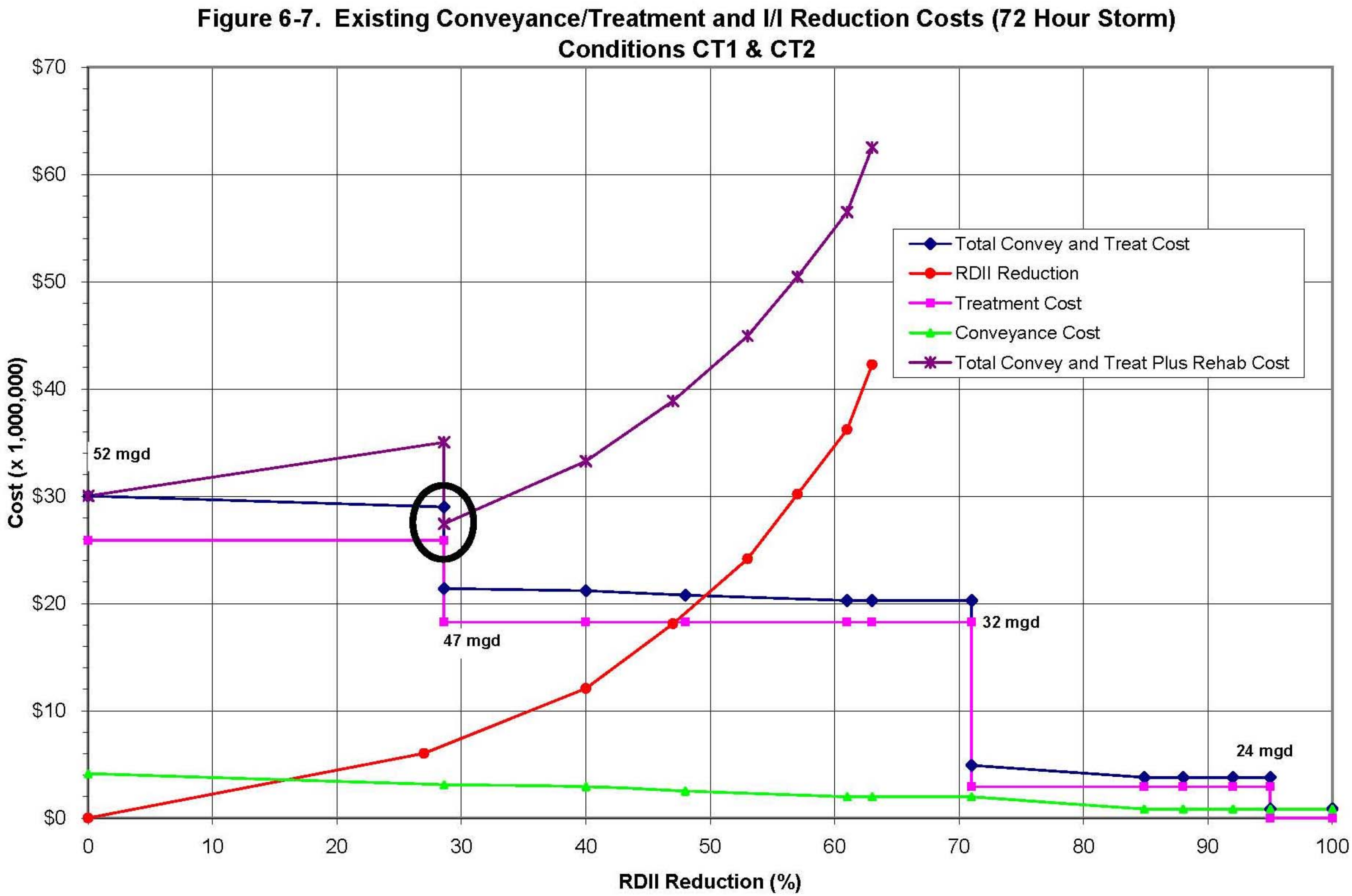


Figure 6-7. Existing Conveyance/Treatment and I/I Reduction Costs (72 Hour Storm)
Conditions CT1 & CT2
$70
$60
$50
$40
$30
$20
$10
$0
Cost (x 1,000,000)
0
10
20
30
40
50
60
70
80
90
100
RDII Reduction (%)
Total Convey and Treat Cost
RDII Reduction
Treatment Cost
Conveyance Cost
Total Convey and Treat Plus Rehab Cost
52 mgd
47 mgd
32 mgd
24 mgd

Figure 6-8. Future Conveyance/Treatment and I/I Reduction Costs (72 Hour Storm) Conditions CT3 & CT4

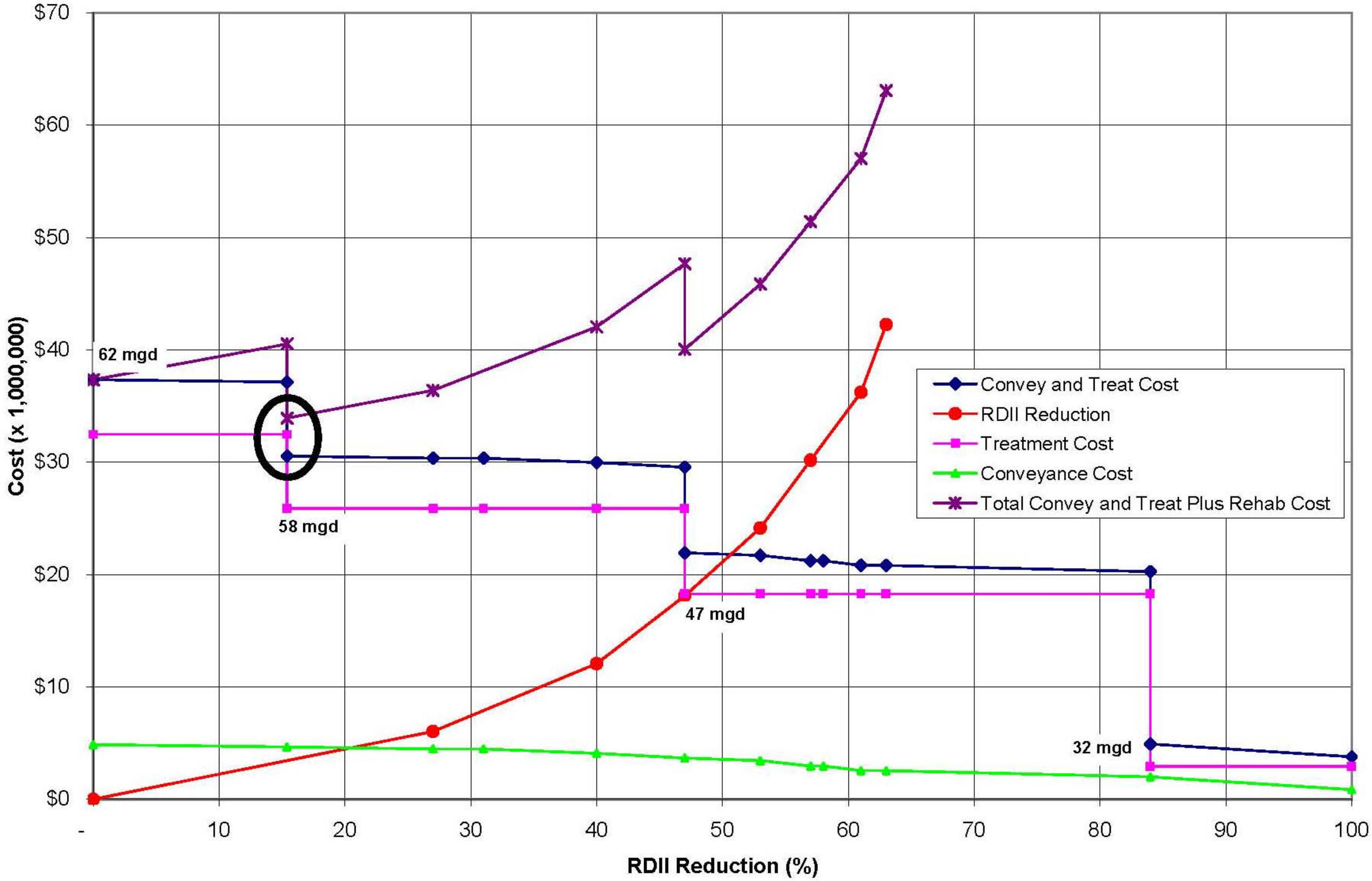
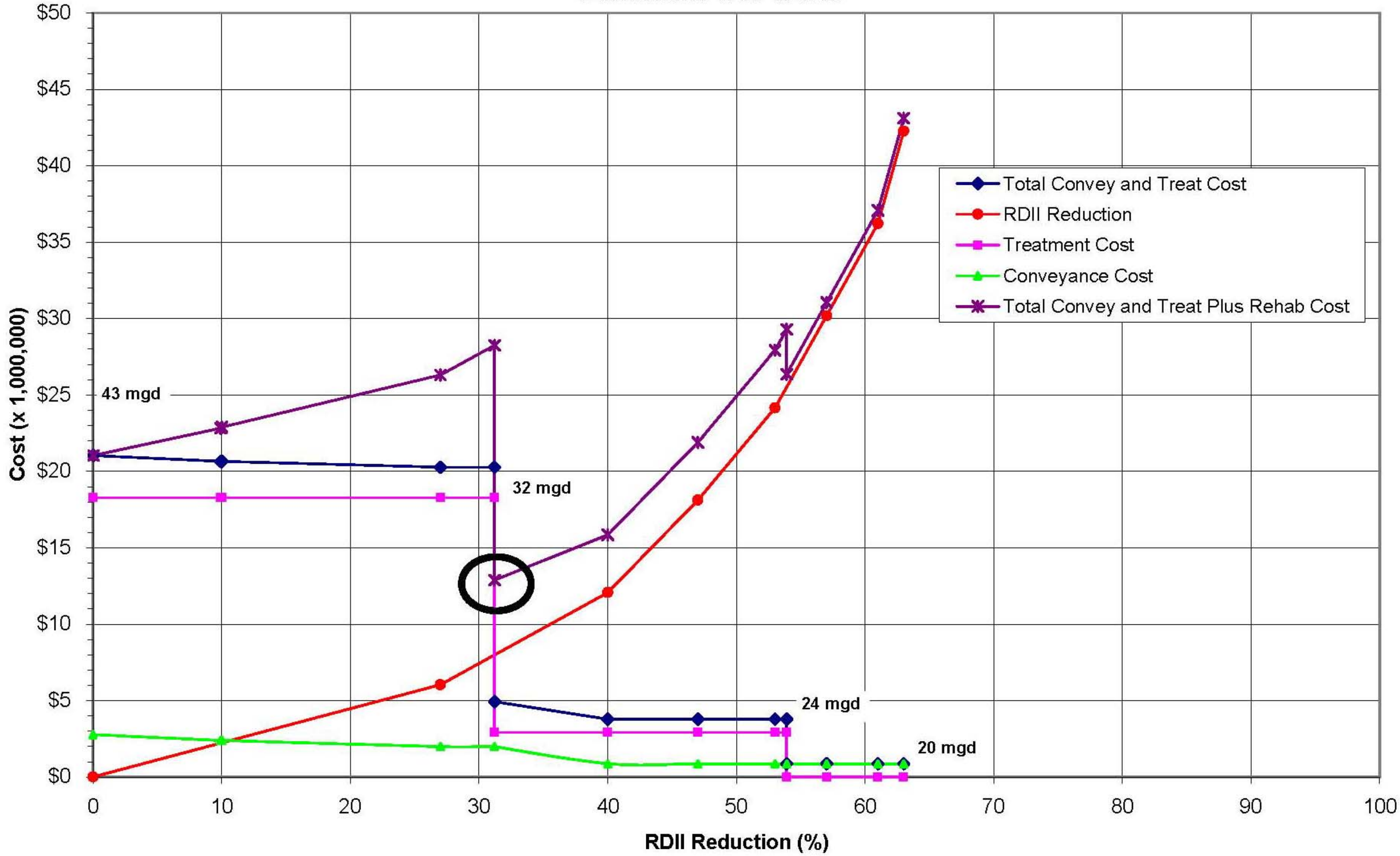


Figure 6-9. Existing Conveyance/Treatment and I/I Reduction Costs (24 Hour Storm) Conditions CT5 & CT6



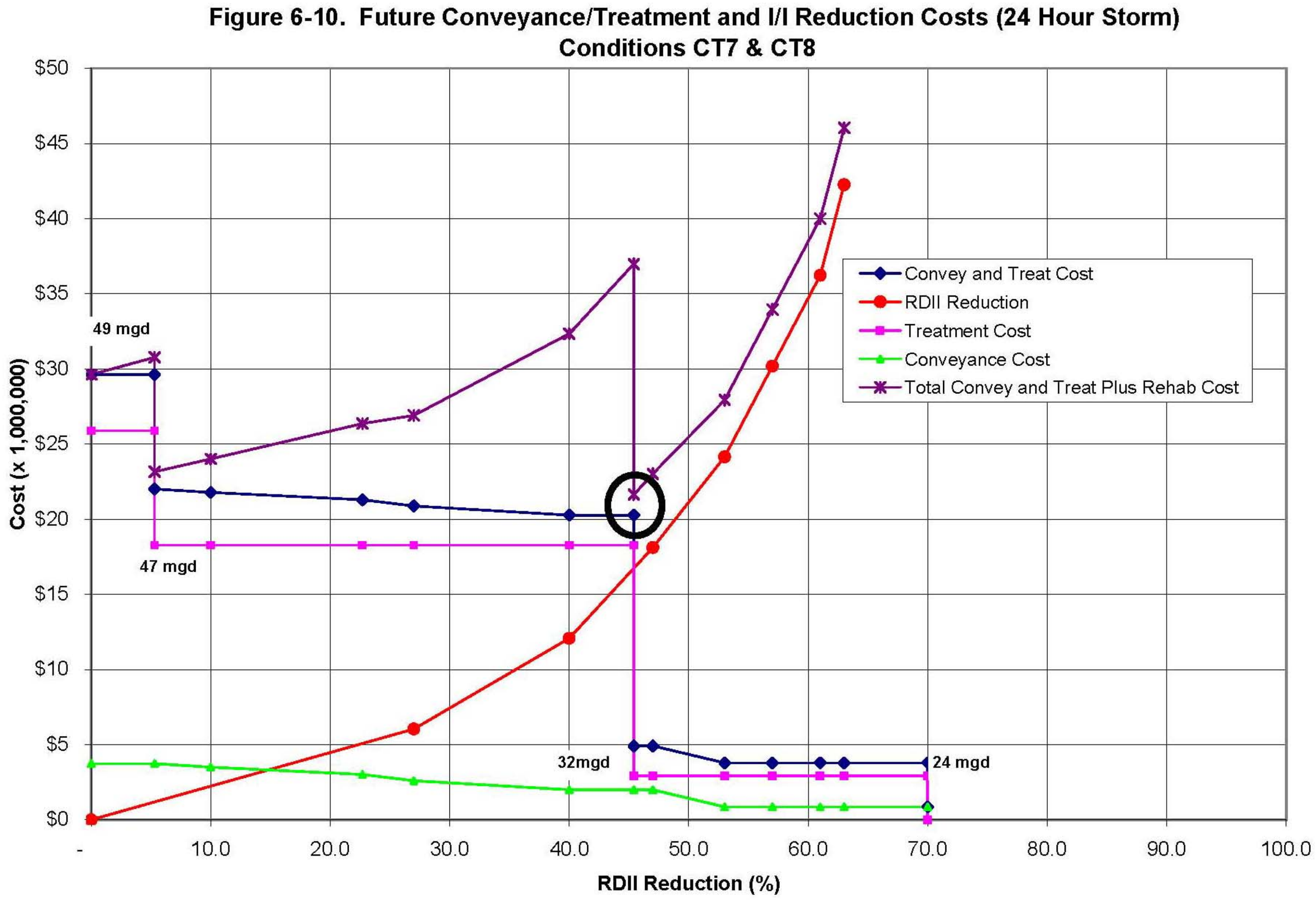


Figure 6-10. Future Conveyance/Treatment and I/I Reduction Costs (24 Hour Storm)
Conditions CT7 & CT8
$50
$45
$40
$35
$30
$25
$20
$15
$10
$5
$0
Cost (x 1,000,000)
49 mgd
47 mgd
32mgd
24 mgd
Convey and Treat Cost
RDII Reduction
Treatment Cost
Conveyance Cost
Total Convey and Treat Plus Rehab Cost
-
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
RDII Reduction (%)

Each figure provides cost on the vertical axis and the percent reduction of RDI/I on the horizontal axis. For the CT conditions at zero RDI/I reduction, the expansion of the WRF is required for flows greater than 24 mgd. In addition to the treatment improvements, conveyance improvements are also required.

The costs assuming zero RDI/I reduction are shown on the far left hand side of the figures.

The following should be noted regarding the cost data:

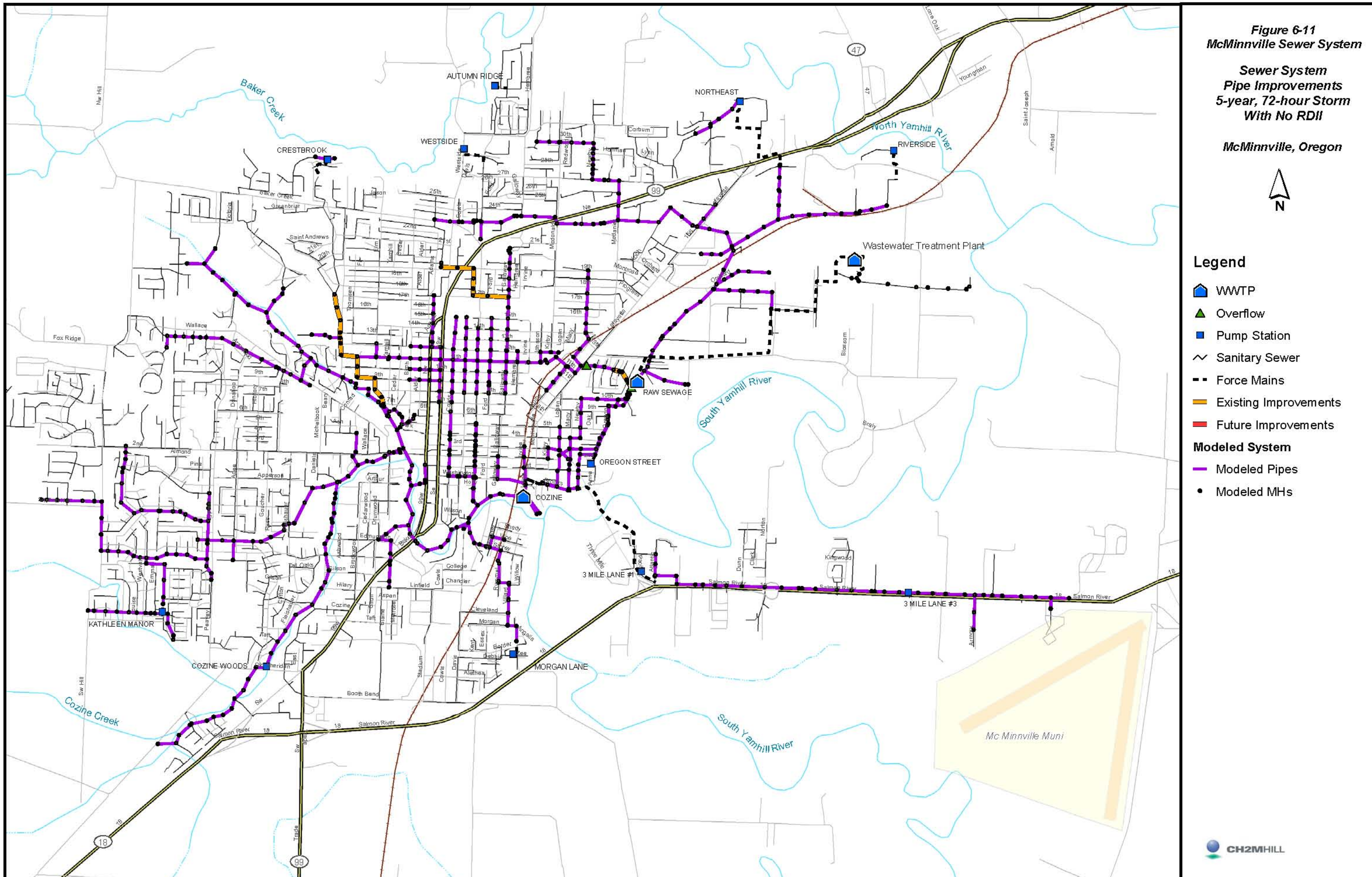
1) Treatment costs do not include a third Orbal reactor or third secondary clarifier as these are considered to be costs associated with needed expansions for dry weather.
2) The 5-year, 24-hour storm is specified in the City's permit. There is no permit language or available DEQ guidance that addresses antecedent rainfall requirements or amounts.
3) This analysis includes a condition of antecedent rainfall totaling 2.8 inches in 48 hours followed by the 5-year, 24-hour event of 3.1 inches. This total rainfall of 6 inches in 72-hr hours also has a 5-year frequency of occurrence.
4) Conveyance improvements require additional review to determine if local conditions (e.g. pipes not in the public right-of-way) require adjustments to cost assumptions.

Conditions CT 1-4 (72-hour storm duration):

Conveyance system improvements coupled with treatment facility expansion. The first step in the analysis is to identify the improvements required with no rehabilitation and RDI/I reduction that allows the peak flow to be conveyed to and treated at the plant. The conveyance improvements are detailed in Tables 6-4, 6-5, 6-6 and 6-7 for pipelines and pump stations for existing and buildout land use conditions. The improvements are shown on Figure 6-11. Figures 6-7 and 6-8 show the relationship between the cost of rehabilitation and the percent reduction of RDI/I with private lateral replacement included as part of the rehabilitation projects for existing and buildout land use conditions.

The maximum RDI/I reduction possible based on the data sources used for this analysis is 70% if 100% of the pipelines in the basin were rehabilitated or replaced. Because of the significant cost of this replacement, the maximum shown on the figures is 63% reduction based on 70% replacement.

Table 6-8 shows the specific cost elements for the least cost combination of improvements for the alternatives. For existing conditions the lowest total cost occurs at 29% reduction which corresponds with a 47 mgd peak flow rate at the WRF. For future conditions the lowest cost occurs at 15% reduction with a 58 mgd peak flow at the WRF.



PDX \\ROSA\PROJ\WESTYOSTASSOCIATES\340411MCMINNVILLE\GIS\MXDS\FIG6-11_FUTUREPIPE72HR.MXD 8/14/2008 08:16:51

Table 6-4. Required Conveyance System Improvements For Existing Conditions, 5-year, 72-hour Storm Event With No Rehabilitation

Location	Pipe ID	Existing Diameter (inches)	Required Diameter (inches)	Length (feet)	Cost
	C_H-6-5	10	12	327	$ 118,205
	C_H-6-6	10	12	328	$ 118,516
	C_H-6-7	10	15	301	$ 117,754
	C_H-6-8	10	15	128	$ 50,317
	C_H-7-4	10	15	131	$ 51,402
	C_H-7-5	10	15	291	$ 114,000
	C_H-7-6	10	15	393	$ 153,866
	C_H-7-7	10	18	237	$ 101,932
	C_H-7-8	10	18	17	$ 7,349
	C_H-7-9	10	18	253	$ 109,117
	C_H-7-10	10	18	442	$ 190,579
	C_H-7-11	10	18	282	$ 121,407
	C_H-7-12	10	18	249	$ 107,131
	C_H-7-13	10	18	175	$ 75,388
	C_I-6-2	10	15	403	$ 158,012
	C_I-6-3	12	15	400	$ 156,801
	C_I-6-4	12	15	255	$ 99,725
	C_I-6-5	12	15	245	$ 95,814
	C_I-6-6	12	15	167	$ 65,383
	C_I-6-7	12	15	362	$ 141,927
	C_I-6-8	12	15	515	$ 201,691
	C_J-7-106T	21	24	143	$ 70,002
	C_J-7-80T	21	24	68	$ 33,504
	C_J-7-62	21	24	138	$ 67,616
	C_J-7-59	21	24	317	$ 155,321
	C_J-7-50	42	48	183	$ 150,132
	C_J-7-65	42	48	170	$ 139,681
Total					$2,972,572

Table 6-5. Required Pump Station Improvements For Existing Conditions, 5-year, 72-hour Storm Event With No Rehabilitation

Pump Station	Firm Capacity (mgd)	Existing Flow (mgd)	Required Capacity Improvement (mgd)	Cost
RSPS	38.0	52.0	14.0	$--[1]
Cozine	11.5	16.9	5.4	$1,150,979

[1] Included in Treatment Costs

Table 6-6. Required Collection System Improvements For Buildout Conditions, 5-year, 72-hour Storm Event With No Rehabilitation

Location	Pipe ID	Existing Diameter (inches)	Required Diameter (inches)	Length (feet)	Cost
	C_H-6-5	10	15	327	$ 128,341
	C_H-6-6	10	15	328	$ 128,004
	C_H-6-7	10	15	301	$ 117,754
	C_H-6-8	10	15	128	$ 50,317
	C_H-7-4	10	15	131	$ 51,402
	C_H-7-5	10	15	291	$ 114,000
	C_H-7-6	10	15	393	$ 153,866
	C_H-7-7	10	18	237	$ 101,932
	C_H-7-8	10	18	17	$ 7,349
	C_H-7-9	10	18	253	$ 109,117
	C_H-7-10	10	18	442	$ 190,579
	C_H-7-11	10	18	282	$ 121,407
	C_H-7-12	10	18	249	$ 107,131
	C_H-7-13	10	18	175	$ 75,388
	C_I-6-2	10	15	403	$ 158,012
	C_I-6-3	12	15	400	$ 156,801
	C_I-6-4	12	15	255	$ 99,725
	C_I-6-5	12	15	245	$ 95,814
	C_I-6-6	12	15	167	$ 65,383
	C_I-6-7	12	15	362	$ 141,927
	C_I-6-8	12	15	515	$ 201,691
	C_J-7-106T	21	24	143	$ 70,002
	C_J-7-80T	21	24	68	$ 33,504
	C_J-7-62	21	24	138	$ 67,616
	C_J-7-59	21	24	317	$ 155,321
	C_J-7-50	42	48	183	$ 150,132
	C_J-7-65	42	48	170	$ 139,681
Total					$2,992,196

Table 6-7. Required Pump Station Improvements For Buildout Conditions, 5-year, 72-hour Storm Event With No Rehabilitation

Pump Station	Firm Capacity (mgd)	Existing Flow (mgd)	Required Capacity Improvement (mgd)	Cost
RSPS	38.0	62.0	24.0	$--[1]
Cozine	11.5	23.2	11.7	$1,870,340

[1] Included in Treatment Costs

Table 6-8. Wet Weather Flow Cost Effectiveness Analysis (72 hour storm)

Analysis Condition (2)(3)	Land Use	Storage		Rehabilitation[1]			Conveyance	Treatment		Total Cost	Comments
		Volume (MG)	Cost $M	% of Basin	Flow Reduction (%)	Cost $M	Cost $M	Peak Q at WRF (mgd)	Cost $M	$M	
CT1	Existing	0	$	0%	0%	$	$ 4.1	52	$25.9	$ 30.0	
CT2	Existing	0	$	10%	27%	$6.0	$ 3.1	47	$18.3	$ 27.4	
CT3	Future	0	$	0%	0%	$	$ 4.9	62	$32.5	$ 37.4	
CT4	Future	0	$	6%	15%	$3.4	$ 4.7	58	$25.9	$ 34.0	
S1	Existing	2.9	14.9	40	53%	$24.1	$ 2.1	32	$ 2.9	$ 41.2	Storage based on reducing flow to 32 mgd at the RSPS
S2	Future	7.8	$ 31.5	40%	53%	$ 24.1	$ 3.1	32	$ 2.9	$ 58.7	Storage based on reducing flow to 32 mgd at the RSPS

(1) Rehabilitation quantity based on a percentage of unmodeled (smaller diameter) pipe inventory in targeted basins.

(2) CT1/CT2 and CT3/CT4 represent two different points on the total cost curve for existing and future land use respectively.

(3) The values shown in the table include the least cost combination for the alternative.

Conditions S 1-2 (72-hour storm duration):

Collection system improvements coupled with treatment facility expansion and storage. Figures 6-12 and 6-13 add offline storage to the analysis and limits treatment cost to the increment between 24 and 32 mgd for both existing and future land use conditions.

For existing conditions the lowest total cost occurs at 61 % reduction with no storage. For future conditions the lowest cost is at 53 % reduction and a storage volume of 7.8 million gallons (MG).

Conditions CT 5-8 (24-hour storm duration):

Collection system improvements coupled with treatment facility expansion. Similar to the 72-hour storm, conveyance and pump station improvements are provided in Tables 6-9, 6-10, 6-11 and 6-12 for existing and buildout land use assuming no rehabilitation. The improvements are shown in Figure 6-14. For existing conditions the lowest total cost occurs at 31% reduction which corresponds with a 32 mgd peak flow rate at the WRF. For future conditions the lowest cost occurs at 45% reduction with a 32 mgd peak flow at the WRF. Figures 6-9 and 6-10 show the cost curves for existing and future conditions respectively. Table 6-13 shows the specific cost elements for the least cost combination of improvements for the alternatives.

For the 24-hour storm duration, there are no improvement alternatives that include storage. As shown for the 72-hour storm duration, the relatively high cost of the storage in comparison to the cost of current treatment, conveyance and rehabilitation solutions does not result in a low cost solution that includes storage.

OBSERVATIONS AND RISK ASSESSMENT

Observations

Based on the analysis, the following observations can be made:

1) The least cost solution requires improvements to selected pipelines to increase conveyance capacity, the WRF (assuming blending), and the collection system (to achieve RDI/I reduction). Storage is not included in the least cost solutions.
2) The 24-hour storm results in lower costs than the 72-hour storm due to lower peak flow rates.
3) The peak flow using the 1998 WWOMP storm for existing land use conditions matches the 72 hour duration results (52 mgd). For future/buildout land use conditions the flow rate is less than the 72 hour results, 54.6 vs. 62 mgd, respectively.
4) The lower flow volume associated with the 1998 WWOMP storm results in a lower cost of storage for the 1998 WWOMP storm compared to the buildout 72-hour storm.
5) The peak flow estimated in the 1998 WWOMP was 47 mgd for 1995 land use and 57 mgd for 2015. These were the values used to create the 1998 improvement plan. A buildout condition was not analyzed in 1998.

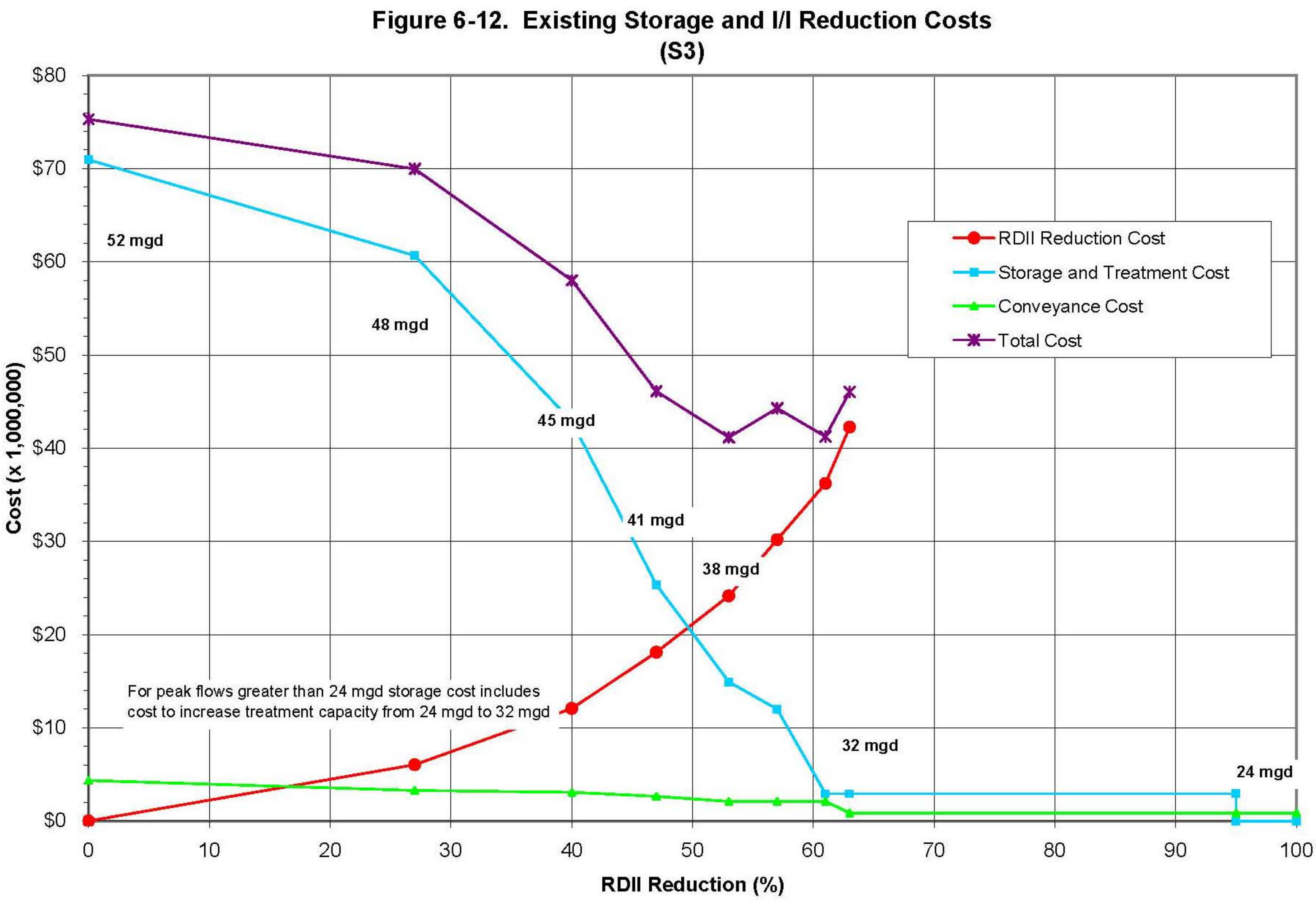


Figure 6-12. Existing Storage and I/I Reduction Costs
(S3)
$80
$70
$60
$50
$40
$30
$20
$10
$0
Cost (x 1,000,000)
0
10
20
30
40
50
60
70
80
90
100
RDII Reduction (%)
52 mgd
48 mgd
45 mgd
41 mgd
38 mgd
32 mgd
24 mgd
RDII Reduction Cost
Storage and Treatment Cost
Conveyance Cost
Total Cost
For peak flows greater than 24 mgd storage cost includes
cost to increase treatment capacity from 24 mgd to 32 mgd

Figure 6-13. Future Storage and I/I Reduction Costs (72 Hour Storm)
Condition S2

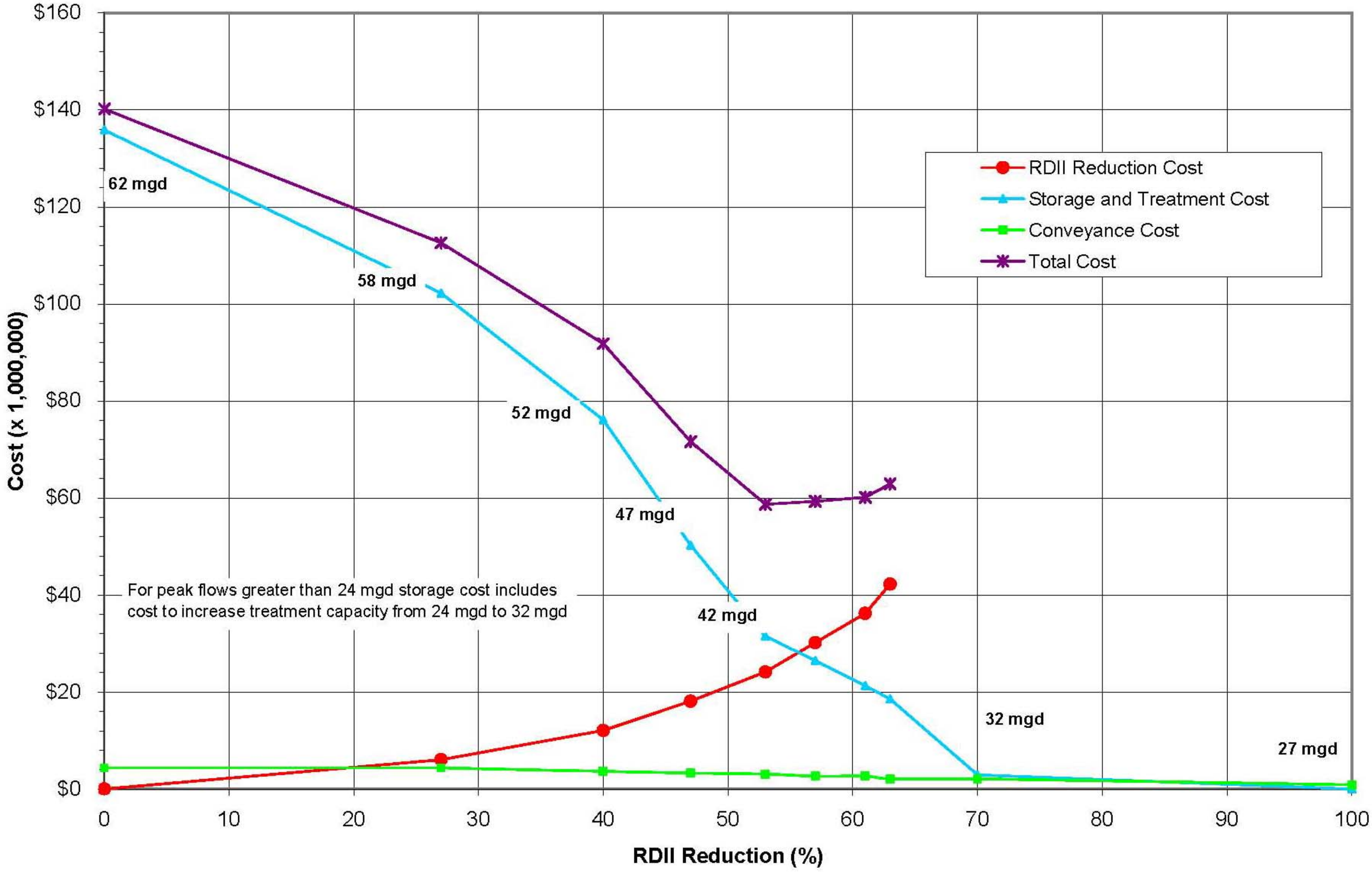


Table 6-9. Required Collection System Improvements For Buildout Conditions, 5-year, 24-hour Storm Event With No Rehabilitation

Pipe ID	Existing Diameter (inches)	Required Diameter (inches)	Length (feet)	Cost
C_H-6-5	10	12	327	$128,004
C_H-6-6	10	12	328	$118,516
C_H-6-7	10	12	301	$108,739
C_H-6-8	10	12	128	$ 46,465
C_H-7-4	10	12	131	$ 47,467
C_H-7-5	10	12	291	$105,273
C_H-7-6	10	12	393	$153,866
C_H-7-7	10	12	237	$ 92,723
C_H-7-8	10	12	17	$ 6,685
C_H-7-9	10	15	253	$ 99,259
C_H-7-10	10	15	442	$160,089
C_H-7-11	10	15	282	$101,983
C_H-7-12	10	15	249	$ 89,992
C_H-7-13	10	15	175	$ 63,327
C_I-6-3	10	12	400	$144,797
C_I-6-6	12	15	167	$ 65,383
C_I-6-7	12	15	362	$141,927
C_I-6-8	12	15	515	$201,691
C_J-7-50	42	48	183	$150,132
C_J-7-65	42	48	170	$139,681
Total				$2,165,999

Table 6-10. Required Pump Station Improvements For Buildout Conditions, 5-year, 24-hour Storm Event With No Rehabilitation

Pump Station	Firm Capacity (mgd)	Existing Flow (mgd)	Required Capacity Improvement (mgd)	Cost
RSPS	38.0	48.9	10.9	$--[1]
Cozine	11.5	20.3	8.8	$1,565,468

[1] Included in Treatment Costs

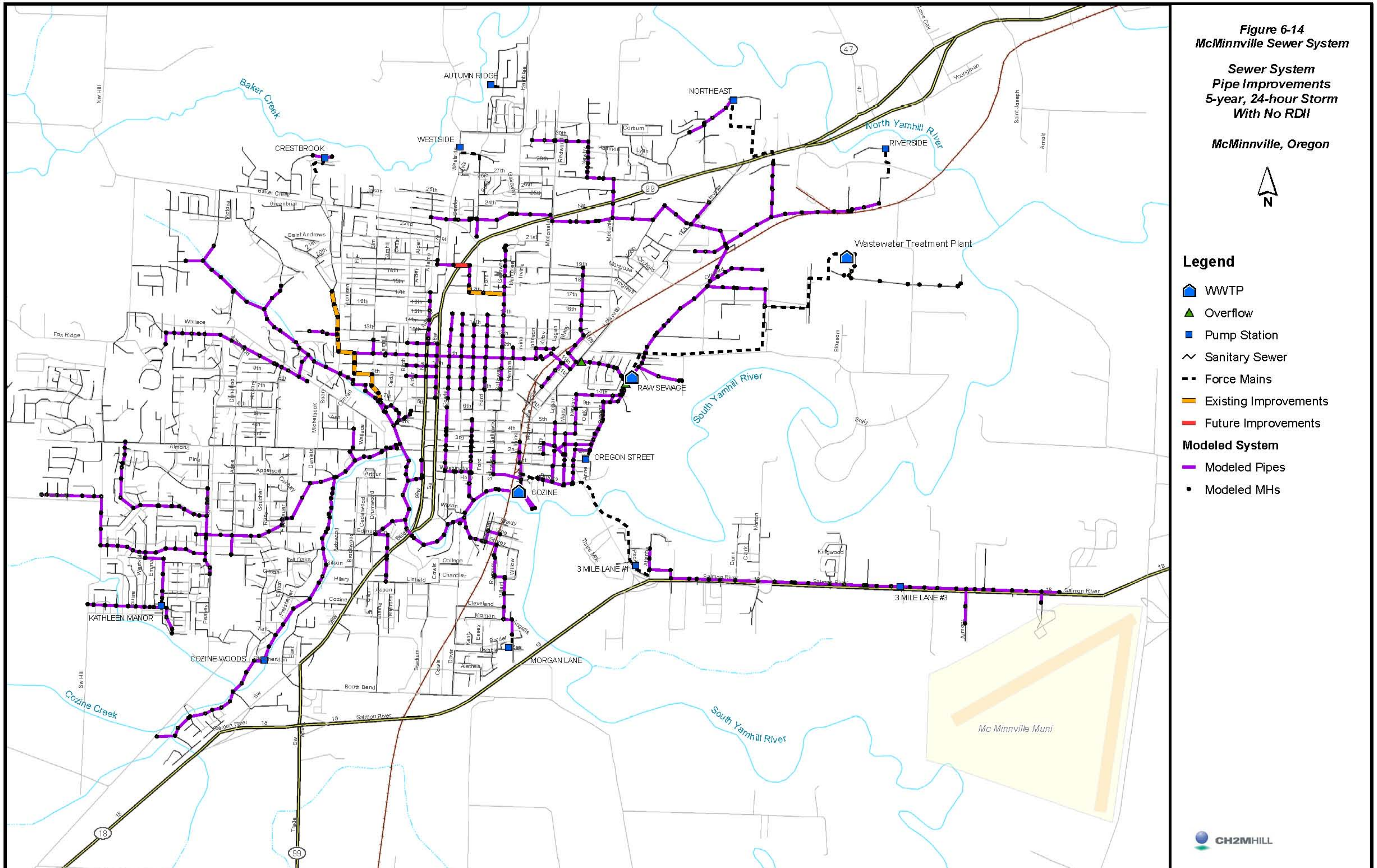
Table 6-11. Required Collection System Improvements For Existing Conditions, 5-year, 24-hour Storm Event With No Rehabilitation

Pipe ID	Existing Diameter (inches)	Required Diameter (inches)	Length (feet)	Cost
C_H-6-5	10	12	327	$128,004
C_H-6-6	10	12	328	$118,516
C_H-6-7	10	12	301	$108,739
C_H-6-8	10	12	128	$ 46,465
C_H-7-4	10	12	131	$ 47,467
C_H-7-5	10	12	291	$105,273
C_H-7-6	10	12	393	$153,866
C_H-7-7	10	12	237	$ 92,723
C_H-7-8	10	12	17	$ 6,685
C_H-7-9	10	15	253	$ 99,259
C_H-7-10	10	15	442	$160,089
C_H-7-11	10	15	282	$101,983
C_H-7-12	10	15	249	$ 89,992
C_H-7-13	10	15	175	$ 63,327
C_I-6-6	12	15	167	$ 65,383
C_I-6-7	12	15	362	$141,927
C_I-6-8	12	15	515	$201,691
C_J-7-50	42	48	183	$150,132
C_J-7-65	42	48	170	$139,681
Total				$2,021,202

Table 6-12. Required Pump Station Improvements For Existing Conditions, 5-year, 24-hour Storm Event With No Rehabilitation

Pump Station	Firm Capacity (mgd)	Existing Flow (mgd)	Required Capacity Improvement (mgd)	Cost
RSPS	38.0	43.3	15.3	$--[1]
Cozine	11.5	14.2	2.7	$742,484

[1] Included in Treatment Costs



PDX \\ROSA\PROJ\WESTYOSTASSOCIATES\340411MCMINNVILLE\GIS\MXDS\FIG6-14_FUTUREPIPE24HR.MXD 8/14/2008 07:47:25

Table 6-13. Wet Weather Flow Cost Effectiveness Analysis (24 hour storm)

Analysis Condition (2)(3)	Land Use	Rehabilitation(1)			Conveyance	Treatment		Total Cost
		% of Basin	Flow Reduction (%)	Cost $M	Cost $M	Peak Q at WRF (mgd)	Cost $M	$M
CT5	Existing	0%	0%	$ -	$ 2.8	43	$ 18.3	$ 21.0
CT6	Existing	13%	31%	$8.0	$ 2.0	32	$ 2.9	$ 12.9
CT7	Future	0%	0%	$ -	$ 3.7	49	$ 25.9	$ 30.0
CT8	Future	28%	45%	$16.7	$ 2.0	32	$ 2.9	$ 21.6

(1) Rehabilitation quantity based on a percentage of unmodeled (smaller diameter) pipe inventory in targeted basins.
(2) CT1/CT2 and CT3/CT4 represent two different points on the total cost curve for existing and future land use respectively.
(3) The values shown in the table include the least cost combination for the alternative.

6) There are several notable differences between the analysis performed in 1998 and the current work. The current work includes a new (more refined) model, more recent flow monitoring data resulting in new regression equations that relate rainfall and I/I, and revisions to land use data for existing and future conditions.
7) The likelihood of overflow is greater if improvements are based on the 24-hour versus either of the 72-hour events.

Risk Assessment

As described in Appendix D of the CMOM evaluation, risk is based on a combination of the likelihood and consequence of an event. The event in this case is a sanitary sewer overflow.

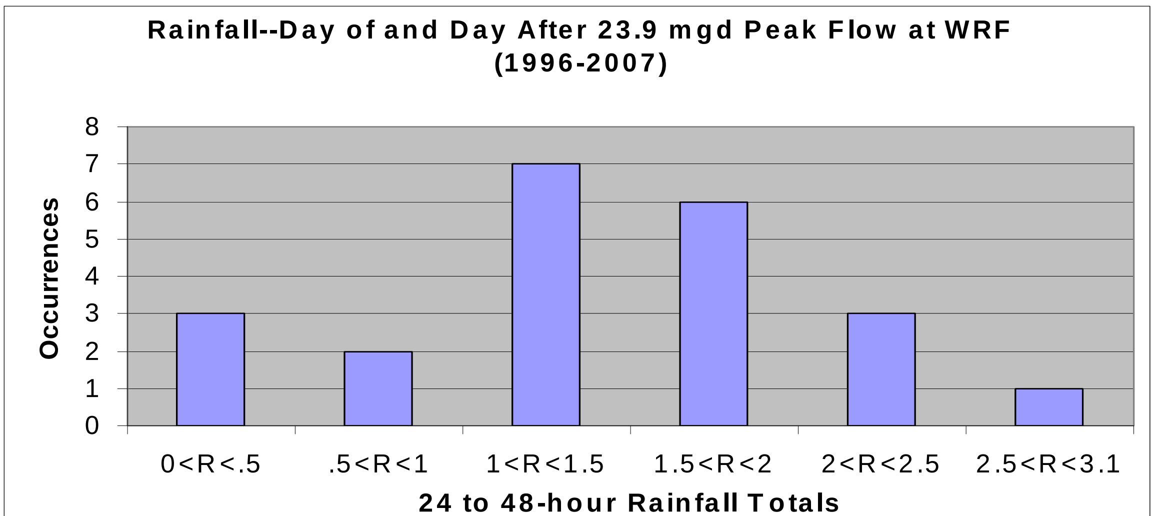
Likelihood. Two sets of least cost solutions (for existing and future land uses) were developed based on the 24-hour 5-year regulatory storm event. The two sets differ in their assumptions regarding antecedent conditions, and therefore, their likelihood of an overflow. The 24-hour event assumes no rain preceding the regulatory event and assumes the capacity of the collection system is available for conveyance of the rain associated with the storm. The likelihood of an overflow under these conditions is low.

As described previously, the 72-hour event assumes 48-hours of rainfall preceding the regulatory 24-hour storm. The 48-hours of additional rainfall significantly increases the flow rate in the system at the beginning of the 24-hour event. For existing land use conditions the flow at the RSPS at the beginning of the 24-hour design event is 5.8 mgd, while for the 72-hour event it is 23.9 mgd. Therefore, the 48 hours of antecedent rainfall creates a flow rate (23.9 mgd) that matches the existing secondary treatment capacity at the WRF. Therefore, this rainfall event diminishes the available capacity of the conveyance system and the treatment plant is already operating at capacity when the 24-hour storm occurs. The likelihood of an overflow under these conditions is higher.

Because only the total depth of rainfall defines the 5-year, 72-hour storm, the *distribution* of the rainfall over the 72-hour period also contributes to the likelihood of occurrence of 23.9 mgd occurring at the plant prior to a 24-hour 5-year storm event. Therefore an analysis of the likelihood of this event was performed. The analysis reviewed the period between February 1996 and September 2007. There were 22 days when the recorded peak flow at the WRF reached 23.9 mgd, or on average approximately twice per year. This is an indication of the likelihood of the flow conditions that match those produced from the 48-hour antecedent rain used in the 72-hour storm event.

To expand on this analysis, the rainfall for the 24-hour period following the day the peak flow reached 23.9 mgd was evaluated. As shown in Figure 6-15, during the period from 1996 to 2007, there were no 24-hour duration rainfall occurrences that met or exceeded 3.1 inches (the 5 year, 24-hour frequency) and only one where the rainfall was over 2.5 inches. This demonstrates for the period reviewed that no combination of flows at the plant and rainfall were observed that match or exceed those for the 72-hour storm modeled. Therefore, the likelihood of the plant being at capacity prior to a 24-hour 5 year storm event and that of a subsequent overflow is low based on 12 years of data.

Figure 6-15. Rainfall Following 23.9 MGD at the WRF



Notes:
1) R = rainfall total in inches
2) 5-yr storm event = 3.1 inches in 24 hours
3) Limited hourly rainfall totals are available, therefore, daily totals were used. To ensure that the rainfall amount included the 24 hours after reaching the 23.9 mgd peak flow, 48-hour totals were used and are conservative.
4) There were 3 occurrences when the 48-hour total exceeded 3.1 inches. Additional hourly rainfall data was obtained for those periods and 24 hour totals were calculated to be all less than 3.1 inches.
5) There were 3 occurrences when the total rainfall for a day was 3.1 inches or greater when the flow did not reach 23.9 mgd.

Consequences. The consequences for overflows for each of the durations considered could include permit violations, associated fines, environmental impacts to the river and third party lawsuits. However, these consequences are likely similar for each of the design storm conditions evaluated given that the system has locations for controlled overflows with little potential for human contact at the time when these rainfall events would occur.

CONCLUSION

The least cost combination of solutions occurs for the 24-hour duration storm. This is a direct result of the lower peak flows and volumes associated with this shorter duration event.

The total cost for the existing land use condition is $13.0M as shown in Table 6-13 and Figure 6-9 and includes pipeline rehabilitation and associated reduction to reduce flows to the RSPS and WRF. When flows exceed 32 mgd at the RSPS, the treatment costs exceed the corresponding costs to reduce the peak flow.

Similar to the existing land use condition the least cost combination for future land use ($21.7M) occurs for the 24-hour storm duration shown in Table 6-13 and Figure 6-10 and includes rehabilitation to limit flows to 32 mgd at the RSPS and WRF. The only difference in cost between the two land use conditions is due to increased rehabilitation from 13 to 28% in the targeted basins.