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SARUP

[WHITEFISH BAY FLOOD MITIGATION REPORT]

Prepared by Zach Bentzler, Xylia Rueda, Mike Slezak, and Cal Stoffel

November 2, 2010
Katie Pritchard
Whitefish Bay, Village President
5300 N. Marlborough Drive
Whitefish Bay, WI 53217

Dear Katie Pritchard,

Thank you for the opportunity to provide this analysis and recommendation. Our analysis focused on the goal of reducing the amount of flow through both the sanitary sewer and storm sewer systems in order to decrease the amount of basement flooding during large wet weather events. We are aware that timing is of the essence as residents are unhappy without levels of property damage and some residents also contend that the village has not done enough to help them. Cooperation between the village and its residents is necessary in order to have success implementing our recommendation.

Although one alternative is recommended in this analysis, others should be considered along with our recommendation. This is a complex problem that will require many solutions to remedy. There are alternatives in this report that are not recommended, which could help the Village immensely. Looking at solutions comprehensively along with our recommendation will prove to have the best overall effect on the issue of flooding in Whitefish Bay.

We recommend a single strategy that we feel will not only help to mitigate flooding and property damage in Whitefish Bay, but reinstall community wide confidence in the Village and its leadership. Our recommended alternative is paying for the replacement of all single family residential laterals. Private lateral infiltration is a major source of clearwater in the sanitary sewer system. Replacing these on a large scale is estimated to remove roughly 40% of the clearwater entering the sanitary sewer system.

This recommendation directly relates to the storm sewer system, but does nothing about overland flows. Those flooding scenarios can more easily be remedied through grey and green infrastructure projects over the long-term, as the storm sewer has no imposed discharge limit. This approach will eliminate sanitary sewer basement backups once complete, allowing for the Village to focus on overland flooding. An educational campaign will also help residents understand that all of their laterals contribute to basement backups throughout the Village.

Sincerely,

Zach Bentzler Xylia Rueda Mike Slezak Cal Stoffel

Executive Summary:

The primary objective of the following report is to determine the most effective strategy to reduce sanitary sewer loads during wet weather events in the Village of Whitefish Bay. This will address three problems facing Whitefish Bay: sanitary sewer backups into residential basements, compliance with an MMSD directive to reduce sanitary sewer discharges, and sanitary sewer bypasses into local water bodies. These problems go back over a decade, though the recent catalyst for action was a 500-year storm that caused over 900 flooding events and $10.5 million in damages.

The Village has made significant efforts to determine and address the causes over the past 11 years. Numerous studies have attempted to identify the source of the flooding. The results have been inconclusive, but have identified a large amount of clear storm water entering the sanitary sewer as the primary cause. Following recommendations from the 2002 Bonestroo Facilities Plan, the Village has spent over $12.5 million on storm and sanitary sewer improvements since 2006. Despite the fact that the recent flooding events were caused by an unprecedented and unmanageable amount of rain, discontent in the Village is mounting as the problem still appears to be unresolved.

In developing this recommendation, we considered alternatives that had the potential to effectively mitigate flooding caused by a 100-year storm event. Alternatives included: foundation drain disconnection program, a sanitary sewer lateral replacement program, a residential stormwater management program, and a city-wide green infrastructure initiative.

Alternatives were evaluated according to four criteria: it must not impose involuntary costs to homeowners aside from property taxes, it must effectively eliminate the potential for basement backups, it must be able to achieve 20% of total efficiency in the first year, and it must have an annual average cost of less than $3 million.

The preferred alternative is private lateral replacement program. It was chosen primarily for the ability to effectively reduce sanitary sewer loading during a 100-year storm to the equivalent of a current 10-year storm. Studies suggested that private laterals are responsible for 20-60% of sanitary sewer infiltration, and the majority laterals in Whitefish Bay are over 60 year old. The implementation of this alternative would be equitable, as it does not require non-tax fee increases for residents. While two other alternatives are equitable, they do not meet both the short-term and long-term cost effectiveness criteria. Replacing private laterals results in a 100% reduction; meeting the short-term and long-term goals. Other alternatives are less effective in the long-run. Finally, at an average cost of $1.8 million per year, lateral replacement will cost less than the annual $3 million allotted by the Village. This is not the most preferred average annual cost, but unlike other options, satisfies both short-term and long-term criteria. Over a period of 10 years, the average cost is less than the capital improvement budget of the village.

Problem:

For over a decade residents of Whitefish Bay have suffered periodic episodes of sewage backing up into basements; causing both significant property damage and a strong sentiment that Village leadership has not adequately addressed the problem. The catalyst for the recent call to action was two major flooding events the Village experienced in 2010. On July 15th, the Village received 3.8 inches of rain in 10 hours, causing 102 basement backups. On July 22, the Village received 7 inches of rain in 6 hours, causing 340 basement backups and 563 over-land flooding incidents. Property damages exceeded $10.7 million between both storms.

Numerous studies have shown that clear water (storm water) is entering the sanitary sewer system, filling the sanitary sewer beyond capacity and causing backups. However, the major hurdle to eliminating basement backups is that it is not known how clear water is entering the system. Our analysis focuses on solutions with the potential to completely mitigate sanitary sewer overloading. Backups only occur during wet weather events; therefore reducing sanitary or storm sewer loadings are potentially viable solutions. This allows us to explore both green infrastructure to mitigate storm water and grey infrastructure to reduce infltration.

The Village conducted numerous studies to locate the sources of clear water, but they have been largely inconclusive. The Sanitary Sewer Evaluation Survey, conducted in 2002, made specific recommendations that the Village should undertake in order for their sewer system accommodate a 100-year storm event without flooding. Following recommendations, the Village has spent $12.5 million since 2006 on capital sewer improvements, replacing roughly 24% of the total public system.

Basement backups are not the only consideration; the Village is also concerned with complying with an MMSD directive to reduce sanitary sewer loading and avoiding sanitary sewer bypass events into the storm sewer. Bypasses allow raw sewage to enter directly into the Milwaukee River and Lake Michigan, while cleanup efforts expose residents to potentially hazardous situations. As importantly, there is a strong public perception that Village leadership has not adequately addressed the problem, as well as a fear that continued backups will compromise property values in the Village. To address these concerns, the Village must provide a comprehensive solution that can be implemented quickly.

Problem Statement: The Village of Whitefish Bay wishes to identify solutions that will reduce the amount of flow entering either the sanitary sewer or storm sewer system. Reducing instances of basement backups and overland flooding to low areas causing property damage is a priority in both the short and long term infrastructure planning efforts of the village. Solutions that incorporate both public and private investments in property, while keeping costs to a minimum are paramount.

Criteria:

Equity: The preferred alternative must not impose any involuntary costs on the homeowners, aside from property taxes.

Rationale: Although flooding affects individual homeowners, it is a community problem because all property adds water to the sewer system during a rainfall event. It may not be politically feasible to force private property owners to make improvements to their properties in order to reduce flow during rainfall events. However, numerous homeowners at Village meetings have stated that they would be willing to pay for improvements and thus, a voluntary system could still adequately reduce flow.

Long-term effectiveness: The preferred alternative must capture 71.78 million gallons of rainfall in a 100-year storm, or reduce the amount of clear water entering the sanitary sewer system in a similar storm by 4.28 million gallons before January 1, 2021.

Rationale: The Village of Whitefish Bay has indicated that it would like to be able to accommodate a 100-year flood with minimal basement backups. According to SEWRPC, a 100-year flood produces 227.98 million gallons of rain fall in Whitefish Bay in a 48 hour period. The Village's storm sewer system is currently designed to accommodate the amount of rain which falls in a 10-year flood. SEWRPC estimates that 156.2 million gallons of rain fall in Whitefish Bay in a 10-year flood over a 48 hour period. Thus, the amount of a predicted 100-year flood flow needs to be reduced by 71.78 million gallons for the the storm sewer system to reach this goal.

According to the 2002 Bonestroo Report, during a 100-year flood, 10.7 million gallons of waste water fill the sanitary sewer system in a one hour period. The Village's sanitary sewer system is currently designed to accommodate 6.33 million gallons of waste water without flooding. Thus, the amount of a predicted 100-year flood flow needs to be reduced by 4.28 million gallons for the the sanitary sewer system to reach this goal. A ten year time frame for an alternative to meet its long term effectiveness goal will allow the high costs of the project to be spread out, which will lower annual cost.

Short-term effectiveness: The preferred alternative must capture 14.36 million gallons of rainfall in a 100-year storm, or reduce the amount of clearwater entering the sanitary sewer system in a similar storm by 856,000 gallons before January 1, 2012.

Rationale: The Village of Whitefish Bay wants to accommodate a 100-year flood with minimal basement backups, but this will take time to implement. Thus, to reassure residents that appropriate action is being taken to address the problem, it is important to show improvement within one year. To have a visible impact, the preferred alternative must achieve 20 percent of the long-term goal in the first year.

Cost: The preferred alternative must not cost the Village more than an average of $3 million annually in sewer capital improvement costs for the next ten years.

Rationale: The Village has stated that it prefers to spend no more than $3 million per year on sanitary and storm sewer improvements and replacements. Thus, limiting costs to $3 million per year will ensure that the Village does not go over budget. A ten year time frame for an alternative to meet its budgeted goal will allow the high costs of the project to be spread out, which will lower annual cost.

Alternatives:

Alternative #1: Mandatory Drain Tile Testing and Disconnect During Home Sales

Water backing up into homes through drain tiles is a fundamental problem in all of extreme wet weather scenarios. The backup is caused by too much clearwater overloading the sanitary sewer system. The capacity of the sanitary sewer pipes can't be increased, due to MMSD's restrictions on the amount of flow the Village of Whitefish Bay can add into the MMSD system at any given time. One of the major sources of clearwater entering the sanitary sewer system is from drain tiles, also known as footing drains or foundation drains. In fact according to Yaggy Colby Associate's calculations roughly 75% of inflow entering the sanitary sewer system can be attributed to drain tiles and 73% of homes in Whitefish Bay have their drain tiles connected to the sanitary sewer system.

Mandatory drain tile testing and disconnect during home sales would eliminate this problem over time. This could be done by passing a village wide ordinance, which by law requires disconnection of a property's foundation drain from the sanitary sewer before ownership of the property can be transferred between parties. The inspections would be carried out by village staff upon request by the homeowner.

The average turnover rate of a home in Whitefish Bay between 2005 and 2009 was about 9.3 years. This is the time frame the village could expect most of the homes in the village to be disconnected by according to this data. According to a study undertaken by the Detroit Water and Sewerage Department roughly 5% of the water that falls onto a residential lot ends up in the drain tile. Although this may seem like a small amount of water, according to the same study inflow and infiltration make up 95% of the total flow of the sanitary sewer during a wet weather event.

Alternative #2: Replace Private Sewer Laterals

The Village of Whitefish Bay performed dye testing of storm sewers in a 2002 study and found that clear water transfers almost immediately from the storm sewers to the sanitary sewers. As a result, it was suggested that wet weather flows were attributable to inflow and infiltration sources other than foundation drains [a]. The 2010 MMSD Sanitary Sewer Facility Plan estimates that leaking private sanitary sewer laterals account for 20 to 60 percent of clear water inflow and infiltration. These results suggest that faulty laterals are the biggest source of private inflow and infiltration.

According to the 2000 Census, there are approximately 4,800 owner-occupied homes. Whitefish Bay has aging sewer infrastructure and many private laterals are clay pipes which have

deteriorated over time. Therefore, a majority of homes in the Village have laterals which are collapsed, cracked, or perforated and blocked by tree roots. These are all major sources of infiltration.

The average length of private lateral, from the foundation to the sewer drain, is approximately 30 to 50 feet in Whitefish Bay. In this alternative, lateral replacement is preferred over lateral repair, due to the poor condition of each lateral. CCTV inspection can cost $150 per lateral, resulting in approximately $693,000 for all owner-occupied properties [b]. Approximately 20 to 30 private laterals could be inspected per day. This alternative would replace aging laterals with more versatile materials, such as HDPE or MDPE. Pipe bursting has been found to be the most inexpensive and efficient method for lateral replacement. Replacement is done by independent contractors, who are then reimbursed by the Village.

Alternative #3: On-site Stormwater Management

Managing storm water at each residential site will prevent rain water from entering either the storm or sanitary sewers. As the main component of this program we are recommending rain gardens. A rain garden is a shallow depression, filled with water absorbing soil and plants, that gathers runoff generated from nearby impervious surfaces and infiltrates that runoff into the ground. Rain gardens cost between $5-10 per square foot to construct and hold approximately 1-3 gallons per square foot (though draining in 24 hours). This cost includes labor for construction and design, plants, and soil mixture [c]. This practice was chosen because it was the only one capable of holding large amounts of water without requiring large and intrusive cisterns or replacing functional impervious surfaces, which were felt to be too intrusive for local residents. The ideal size for optimal rain garden drainage is 15% of the total lot size; therefore the overall percent of residential spaces converted to rain gardens should not exceed this.

Total roof area was used to calculate the potential amount of water that could be captured. Using the SEWRPC estimate of a 100-year flood at 6.13 inches over 48 hours, the total amount that falls on residential roofs in Whitefish Bay is estimated at 45.86 million gallons. In order to absorb this quantity of water, 16% of every yard in Whitefish Bay would have to be converted to rainwater. At a cost of $10 per square foot, the total cost would be approximately $76 million dollars. The total cost per house is $15,800. However, this alternative may be most effective when combined with other storm water and soil remediation techniques. It also provides an intangible benefit of creating a sense of community action and aesthetic benefits.

Alternative #4: City-wide Green Infrastructure: **Bioretention swales**

Bioretention swales (bioswales) are a very useful distributed BMP that can be easily incorporated into the design of projects. They are landscape features adapted to treat stormwater runoff. Surface runoff is directed into shallow, landscape depressions. Since they simultaneously filter, convey and often detain runoff, not only can they provide considerable savings over conventional conveyance and detention structures, they also are effective in reducing pollutant loads [d]. Often, bioswales and filter strips are the only BMPs needed to reduce pollutant loads to acceptable levels. They are designed to maximize the time rainwater

spends in the bioswale. Average cost of a bioswale is $3-10 per cubic foot and retains about 5 gallons per cubic foot (based on a bioswale size of 32.8 ft. long, 6.6 ft. wide, and 3.3 ft. depth) [e].

Bioswales can potentially be located in the medians along Santa Monica Boulevard (from north Village limits to Hampton Road), Lexington Boulevard (from Marlborough Drive to Lake Drive), Hampton Road (from Santa Monica Boulevard to Bartlett Avenue), and Cumberland Boulevard (from Hampton Road to Oakland Avenue), and Bartlett Drive (from Hampton Road to Oakland Avenue). The total available space is 310,508.3 square feet.

Evaluation of Alternatives:

Alternative #1: Mandatory Drain Tile Testing and Disconnect During Home Sales

Equity

The alternative doesn't meet this criterion. It would force private landowners to invest their own money into disconnecting their foundation drains during the sale of their home. Another probable cost to the land owner is the installation of a sump pump or some other means to remove water from their foundation drain.

Short-term Effectiveness

The alternative doesn't meet this criterion. This alternative will remove 380,704 gallons of water during a 1 year, 100 year rain event from the sanitary sewer system within the first year of implementation. This is not sufficient as our short term criterion is 856,000 gallons removed during an event of this size within a year of implementation. This only meets 45% of our goal. These numbers were calculated from the 2002 Bonestroo Report as well as the Detroit Water and Sewer Master Plan.

Long -term Effectiveness

The alternative doesn't meet this criterion. Although this alternative will remove 3.46 million gallons of water during a 1 hour, 100 year rain event from the sanitary sewer system this criterion requires that the long term solution will remove 4.91 million gallons of water during this size of an event. This gives the alternative an 81% level of effectiveness. This data was calculated using the same methodology as the short term criterion only increased accordingly to meet the specifics of this criterion.

Cost

The alternative meets this criterion. The only cost to Whitefish Bay would be the cost of hiring someone full-time or part-time to carry out the inspections as a service to the residents. We accounted for this by assuming the person would make around $80k (full-time) a year including salary and benefits. On average over the last five years 516 houses were sold in Whitefish Bay annually. We determined that this would probably be an excessive burden to

place on existing staff. Additional equipment would probably need to be acquired. Dye testing will probably be used and is not projected to have a significant cost at this time.

Alternative #2: Replace Private Sewer Laterals

Equity

This alternative will not impose any involuntary costs on homeowners, aside from taxes, as the Village already has allocated $3 million per year to address flooding and basement backups. Therefore, this alternative satisfies the equity criterion.

Short-term Effectiveness

Leaking laterals are assumed to contribute 20 to 60% of clearwater inflow and infiltration in storms. Using 40% a midpoint and multiplying this by 10.7 million gallons results in 4.28 million gallons from leaking laterals in a 100-year, 1-hour rainfall. There are approximately 4,800 homes in the village, so this amounts to 892 gallons per lateral. After the first year, 960 laterals will be replaced, at a cost of $3.67 million. This will result in a reduction 856,320 gallons. This is a 100% reduction of the short-term goal of 856,000. Therefore, this alternative passes the short-term effectiveness criterion.

Long-term Effectiveness

A total of 960 laterals will be replaced in the first year, followed by 653 laterals per year in years 2 through 6. In the last year, 575 laterals will be replaced. Thus, after 7 years, all 4,800 laterals will be replaced, resulting in a decrease of 4,281,600 gallons (100%) over that time. Therefore, this alternative meets the long-term effectiveness requirement.

Cost

The high average bid cost for pneumatic pipe bursting in 1999 was $60 per lineal foot [f]. Inflation would bring this amount to $76.53 in today's dollars. Therefore, assuming that the average length of a lateral in Whitefish Bay is 50 feet, the cost to replace a lateral would be $3,826.50. Therefore, the Village could replace 960 laterals in the first year and spend $2.5 million, leaving $500,000 annually for inspection and unexpected costs. For example, CCTV inspection, at $150 per lateral, would amount to $97,950 per year if all 653 laterals are inspected. Ultimately, this alternative meets the cost requirement.

Alternative #3: On-site Stormwater Management

Equity

This alternative meets the equity criterion by not imposing additional costs on individual homeowners. However, it does impose a property burden by requiring a portion of homeowners property to be converted to a rain garden.

Short-term Effectiveness

This alternative can be 100% effective in the first year, though it will require converting 2.3 million square feet of lawn into rain garden.

Long-term Effectiveness

This alternative does not meet the long-term requirement, as the amount of rainwater available for collection is only equal to 64% of the total reduction needed.

Cost

This alternative fails the cost criteria. At only 64% effective, it will still cost $7.6 million per year for 10 years. To meet the short term criteria, the total cost will be $23.9 million.

Alternative #4: City-wide Green Infrastructure

Equity

This alternative will not impose any involuntary costs on homeowners, aside from taxes. The Village allocated $3 million per year to address the problem. This alternative passes the equity criterion.

Short-term Effectiveness

There is a total of 310,508.3 square feet of available median green space. An ideal bioswale depth is approximately 3.3 feet. In total, this amounts to 1,024,677.4 cubic feet of bioswale. It is estimated that 5 gallons of water is collected per cubic foot of bioswale. If all the available median space were to be converted into bioswales within the first year, this would only amount to 5.12 million gallons collected versus the goal of 14.36 million gallons. This alternative does not meet the short-term effectiveness criterion.

Long-term Effectiveness

If all available medians in the Village are converted to bioswales, the total amount of rainfall collected would amount to 5,123,387 gallons. This alternative does not meet the goal of attempting to collect rainfall in a 100-year storm.

Cost

The cost of a bioswale averages to $6.50 per cubic foot. If all the available median space were to be converted into bioswales, the total average cost will be $6,660,403. If this cost is then distributed over a ten-year period, it will amount to $666,040 annually. This alternative meets the cost criterion.

Evaluation Table Key	Most Preferred	Preferred	Least Preferred	

Criteria **Alternatives**	**Equity** ----------	**Short-term Effectiveness** ----------	**Long-term Effectiveness** ----------	**Cost** ----------
1. Mandatory Drain Tile	No	45%*	81%*	$80,000
2. Replace Private Sewer Laterals	Yes	100%*	100%*	$1.8 million
3. On-site Stormwater Management	Yes	100%*	64%*	$7.6 million
4. City-wide Green Infrastructure	Yes	36%*	7%*	$666,040

*As a percent of total goal

Recommendation:

After objectively evaluating the alternatives, it has been determined that city-wide lateral replacement for single-family owner-occupied homes is the best option for reducing flooding in the Village. The implementation of this alternative would be equitable, as it does not require non-tax fee increases for residents. While two other alternatives are equitable, they do not meet both the short-term and long-term cost effectiveness criteria. Replacing private laterals results in a 100% reduction; meeting both the short-term and long-term goals. Other alternatives are less effective in the long-run. Finally, at an average cost of $1.8 million per year, lateral replacement will cost less than the annual $3 million allotted by the Village. This is not the most preferred average annual cost, but unlike other options, satisfies both short-term and long-term criteria.

Pipe bursting as a lateral replacement solution will be the least invasive, as it does not require major disruption to homeowners' front lawns. It is also the most the most cost-effective method, as estimates of open ditch lateral replacement can be as high as $7,000 per lateral. Lateral replacement also allows the Village flexibility in the number of laterals replaced per year. The cost table in the appendix shows the recommended lateral replacement schedule but the Village would not necessarily need to replace 960 laterals in the first year, just to meet the short-term criterion.

Using public funds for private repairs would need to be approved by the Village Board. However, this course of action is not unprecedented, as cities like Ann Arbor have funded private solutions, such as foundation drain disconnects. Some programs advocate for foundation drain disconnection in conjunction with lateral replacement or repair. However, numerous studies have suggested that floor drain disconnection is not an effective solution to reducing inflow and infiltration. Adding that component would also significantly increase costs and necessitate the increase of taxes or utility fees.

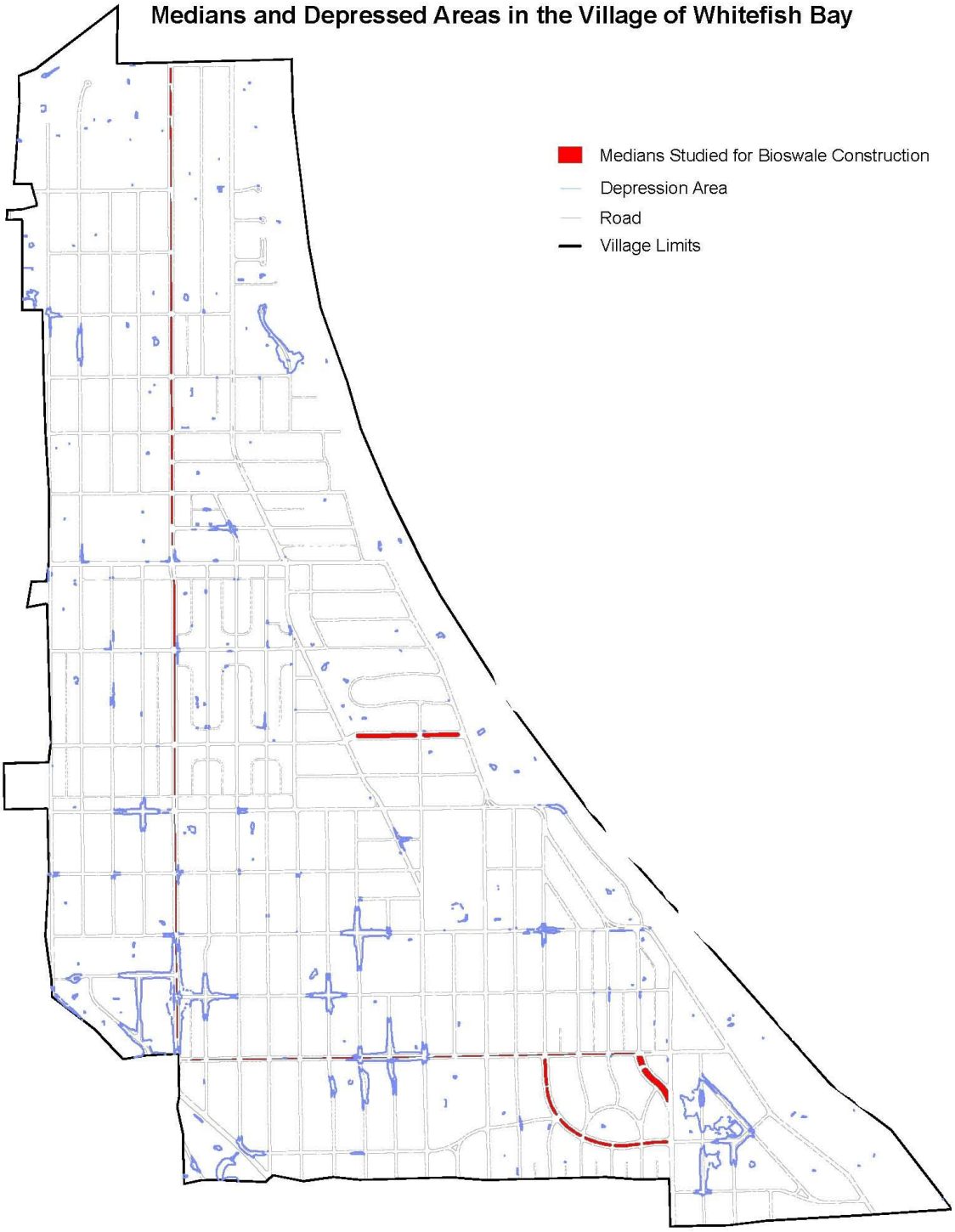
Appendix:

Lateral Replacement Cost Projection:

Years	Laterals Replaced	Cost	Cost Per Lateral	Gallons Reduced Per Lateral	Yearly Gallons Reduced	Total Gallons Reduced
1	960	$3,673,440.00	$3,826.50	892	856,320	856,320
2	427	$1,633,915.50			380,884	1,237,204
3	427	$1,633,915.50			380,884	1,618,088
4	427	$1,633,915.50			380,884	1,998,972
5	427	$1,633,915.50			380,884	2,379,856
6	427	$1,633,915.50			380,884	2,760,740
7	427	$1,633,915.50			380,884	3,141,624
8	427	$1,633,915.50			380,884	3,522,508
9	427	$1,633,915.50			380,884	3,903,392
10	424	$1,622,436.00			378,208	4,281,600
Total	4,800	$18,367,200.00			4,281,600	
Avg Cost/ Yr		$1,836,720.00				

Stormwater Management Figures

Stormwater Figures							
Storm Date	**Inches**	**Hours**	**In/Hr**	**Sq/in in WFB**	**Cu in rain**	**Cu. In. per gallon**	**Total Gallons**
6/1/1997	5.9	48	0.122916667	8,591,007,744	50,686,945,690	231	219,424,007
8/1/1998	3.8	48	0.079166667	8,591,007,744	32,645,829,427	231	141,323,937
6/1/2008	6.2	48	0.129166667	8,591,007,744	53,264,248,013	231	230,581,160
7/15/2008	5.6	12	0.466666667	8,591,007,744	48,109,643,366	231	208,266,854
7/22/2008	7.5	4	1.875	8,591,007,744	64,432,558,080	231	278,928,823
SEWRPC 100 year	5.88	24	0.245	8,591,007,744	50,515,125,535	231	218,680,197
SEWRPC 10 year	3.62	24	0.150833333	8,591,007,744	31,099,448,033	231	134,629,645
SEWRPC 100 year	6.13	48	0.127708333	8,591,007,744	52,662,877,471	231	227,977,825
SEWRPC 10 year	4.2	48	0.0875	8,591,007,744	36,082,232,525	231	156,200,141
Bonestroo 100 year	2.64	1	2.64	8,591,007,744	22,680,260,444	231	98,182,946
Bonestroo 10 year	1.9	1	1.9	8,591,007,744	16,322,914,714	231	70,661,968
Reductions Needed	**SEWRPC 24**		**SEWRPC 48**		**Bonestroo 1**		
	84,050,552		71,777,684		27,520,977		
Residential Area Figures							
Area (sq. in.)	Residential (sq. ft.)	Total SFH	Avg. SFH	Total Home Area	Total Roof Area (sq in)	Total Roof Volume Cu. In.	Total Roof Gallons
8,591,007,744	59,659,776	4,800	2,500	12,000,000	1,728,000,000	10,592,640,000	45,855,584
	Cost	Storage (gal/cu ft)	Needed (sq. Ft.)	Size per house			
Rain Gardens	$10	6	15,285,195	3184.415584			
Rain Garden Poential (sq ft)	Total Residential Area	Total House Area	Available Space	Required Rain Garden (sq ft)	Percent of yard required	Rain Garden Cost	Percent Effective
	59,659,776	12,000,000	47,659,776	7,642,597	16%	$76,425,974	64%
						$7,642,597.40	
						$15,922.08	
Area	2.14						
Residental Properties	4800						
Structure built before 1960	1,966	67.70%					
Owneroccupied units	4617						
Area residential	94%						
Rain Gardens	$5-10						
	1-3 gal						
	$7.50						
	2 gal						



Source: MCAMLIS

Sources:

[a]Bonestroo, Rosene, Anderlik, & Associates, Inc. (2002). *Village of Whitefish Bay Sanitary Sewer Facility Plan*.

[b]Metropolitan Council. (2009). *Inflow and Infiltration Toolbox*. Publication #32-09-046.

[c]MMSD. *Fresh Coast Green Solutions: Weaving Milwaukee's Green & Grey Infrastructure Into A Sustainable Future*. Milwaukee: Milwaukee Metropolitan Sewerage District. Print.

[d] Milwaukee Metropolitan Sewerage District. (2003). *Evaluation of Stormwater Reduction Practices.* Milwaukee.

[e]MMSD. *Fresh Coast Green Solutions: Weaving Milwaukee's Green & Grey Infrastructure Into A Sustainable Future*. Milwaukee: Milwaukee Metropolitan Sewerage District. Print.

[f]Simicevic, J., & Sterling, R. L. (2001). *Guidelines for Pipe Bursting*. TTC Technical Report #2001.02