Right of Way Asset Management Plan

11333 N. CEDARBURG ROAD 60W
MEQUON, WISCONSIN 53092

By
DEPARTMENT OF PUBLIC WORKS
CITY OF MEQUON

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EXECUTIVE SUMMARY

In 2017, the City of Mequon prioritized the development of asset management plans for Facilities, Fleet, and Right of Way Assets. An Asset management plan is a useful tool to maximize the efficiency of capital expenditures as well as operation and maintenance expenses. The purpose of this plan is to identify the City's assets located in the right of way. Assets in the right of way include: roadways, sidewalks, bike paths, traffic signals, street lights, bridges and large box culverts and guard rails.

In addition to the quantity and location of each asset, this report also includes a repair and replacement schedule. For many assets, there are several methodologies to use in developing a repair and replacement schedule. Various approaches and a recommended methodology are included with the summary for each asset. Included in this report are detailed analyses of the City's Right of Way Assets, which are summarized in the table below.

Asset	Annual Cost
Roadways	$1,750,000
Sidewalks	$10,000
Bike Paths	$100,000
Traffic Signals	$15,000
Signs	$15,750
Street Lights	$4,500
Bridges and Culverts	$50,000
Guardrails	$25,350
Total	$1,970,600

This report is being completed concurrently with a Facilities Asset Management Plan and a Fleet Asset Management Plan.

ROADWAYS

The City of Mequon maintains 212 miles of roadway. There are 69 miles of arterial roads and 143 miles of subdivision roads. The roadways are evaluated yearly using the PASER Asphalt Roads Manual created by the Transportation Information Center at the University of Wisconsin – Madison. The PASER rating system generates a Surface Condition Rating (SCR) for each road segment. PASER utilizes a 1-10 rating scale, where newly constructed roads are rated a 10, and as the condition of the roadway deteriorates, the associated rating is reduced. The SCR indicates the level of repair or reconstruction that is required for that specific roadway to extend the useful life. State Statute requires submittal of the ratings to the state each biennium.

See Figure 1 for a graphical relation of the SCR to the needed repairs. A table of treatments and costs specific to the City of Mequon is shown as Figure 2. The full PASER Manual is available at: http://www.apa-mi.org/docs/Asphalt-PASERManual.pdf.

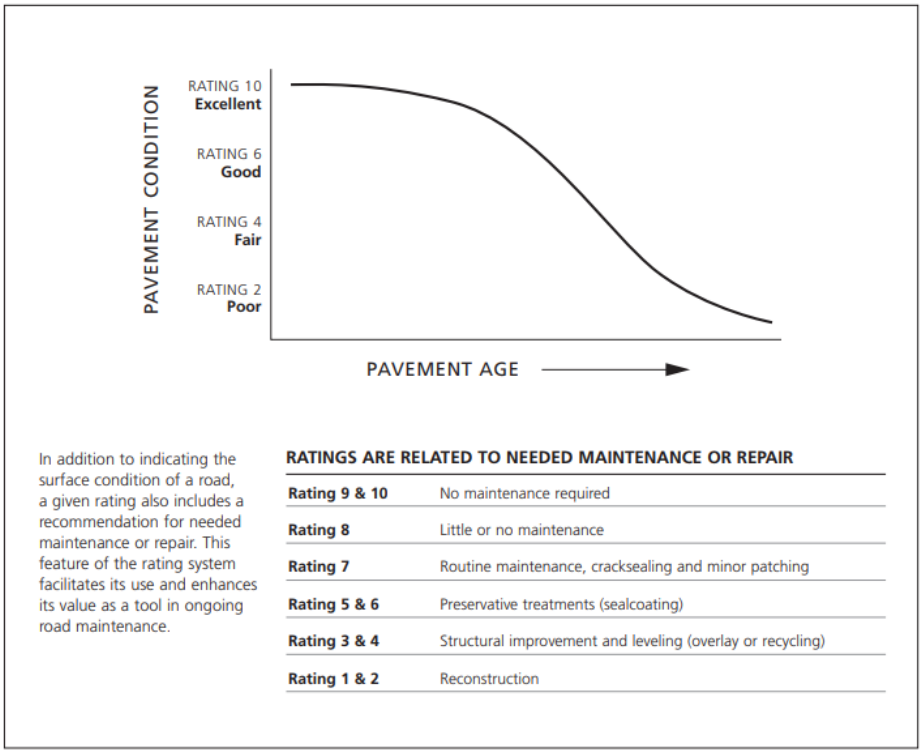

Figure 1: SCR Graph of Needed Repairs –Form the PASER Manual

PASER RATINGS	TREATMENTS	2018 COSTS
10 – Brand new road	Requires no treatment	$ 0
9 – Recently resurfaced road	Requires no treatment	$ 0
8 – Recently seal coated road	Requires no treatment	$ 0
7 – Road shows first signs of aging (cracks)	**Preventative** maintenance (crack filling)	$ 3,355/mile
6 – Road has cracking, raveling, or bleeding	**Preventative** maintenance (seal coating-Main Roads)	$ 28,400/mile
6 – Road has cracking, raveling, or bleeding	**Preventative** maintenance (GSB-88 Fog-Subdivision Streets)	$ 12,300/mile
5 – Road aged beyond seal coating	**Preventative** maintenance (asphalt overlay-Main Roads)	$ 115,100/mile
5 – Road aged beyond seal coating	**Preventative** maintenance (asphalt overlay-Subdivisions)	$ 122,350/mile
4 – Road definitely needs strengthening	**Restoration** (mill, repair, petro-mat & overlay, HIPR) Costs vary greatly depending on treatment	$ 125,000 to $175,000/mile
3 – Very poor road condition	**Restoration** (pulverize, grade, & new pavement-Main Roads)	$ 179,450/mile
3 – Very poor road condition	**Restoration** (pulverize, grade, & new pavement-Subdivisions)	$ 182,000/mile
2 – Road beyond repair	Requires total **reconstruction** of roadway	$ 400,000/mile
1 – Road nearly impassable.....	Requires total **reconstruction** of roadway & drainage system	$ 610,000/mile

Figure 2: SCR Graphic of Needed Repairs & Prices – Specific to Mequon

The 2017 SCR rating of the Streets in the City of Mequon are indicated in Figure 3 and Figure 4.

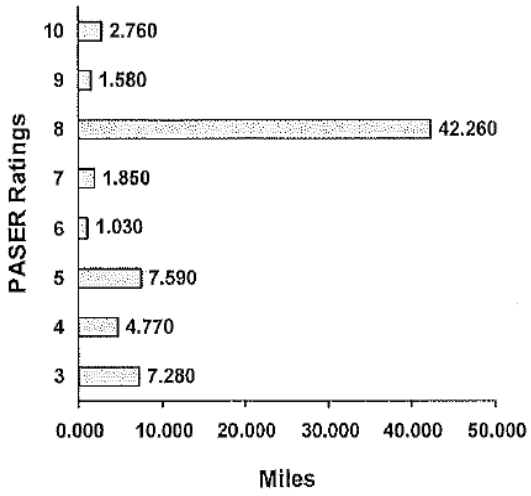

Figure 3: 2017 Main Road PASER Rating

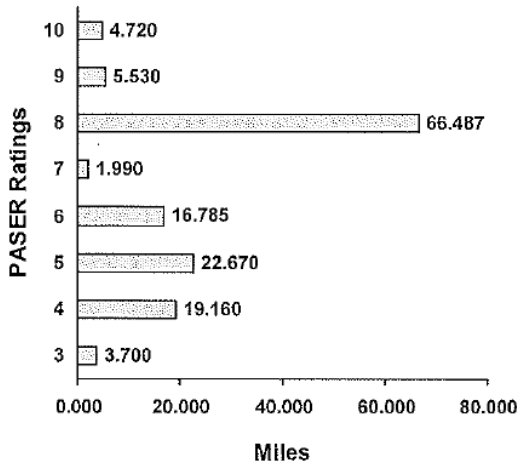

Figure 4: 2017 Subdivision Streets PASER Rating

Currently main roads have an average SCR of 6.70 and subdivision roads have an average SCR of 6.91. Average SCR can be used as a gauge for the overall health of the roadway system, but a balance of all the surface condition ratings across the system is desirable for long term planning and funding for the program. Preventative maintenance surface treatments such as crack sealing and seal coats reset the SCR of a roadway to SCR 8 the year after the treatment was applied. That is why in a well maintained system one sees a greater percentage of SCR 8 roadways. As is evident in the table in Figure 1, SCR 10, 9, and 8 all require no treatments, and thus represent the age of newer or better condition roads in the system.

MAINTENANCE STRATEGY

There are several methodologies that can be used to evaluate the repair and replacement of roadway assets. The following sections will go through each of the methodologies, identify the benefit and challenges of each approach, and provide a recommended methodology.

Roadways in Mequon are typically a rural cross section which includes ditches and culverts to convey stormwater. There are some streets that include curb and gutter and storm sewer conveyance. For the purposes of this report the roadway cross section is assumed to be uniform.

The average pavement life of a roadway is 21 years. The costs included in the analysis are 2018 rates.

RECONSTRUCTION ONLY

The reconstruction only methodology includes reconstructing roadways with no maintenance in between reconstruction practices. Based upon the average pavement life of 21 years, that would equate to reconstructing 212 miles of road every 21 years, or an average of approximately 10 miles each year.

Figure 5 shows pavement deterioration based upon this pavement management strategy.

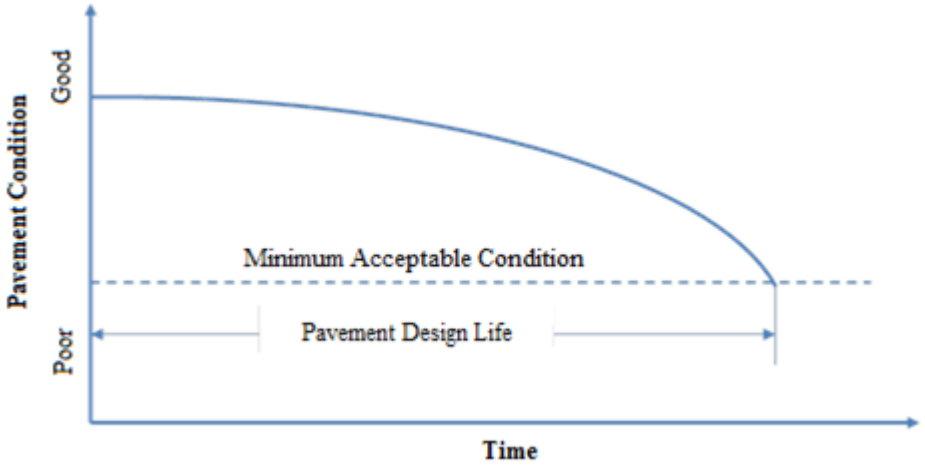

Figure 5: FHWA Basic concept of modern pavement design

The benefit of this approach is that budgeting is simple and would only vary based on inflation and/or a mileage change of the system. Given the

information below, it is a simple calculation to determine the funding required per year.

212 miles	– Miles of Roads in Mequon
21 years	– Average Lifespan of Roads
10.1 miles	– Miles Reconstructed per Year to Maintain System
$194,950	– Average Cost to Replace Road & Associated Work

$1,968,995 Cost per Year for this Approach

Within this pavement management strategy, the City would reconstruct a roadway and then wait until it reached an SCR 3 before reconstructing. No maintenance would be completed between reconstruction projects.

LIFE CYCLE WITH MAINTENANCE

The life cycle with maintenance methodology includes maintenance treatments to extend the life cycle of the roadways. This extends the life of the roadway to 41 years. Typical maintenance of a roadway includes crack filling, surface treatments like GSB 88 and overlays, and spot repairs.

The life cycle with maintenance strategy is generally based upon the following methodology:

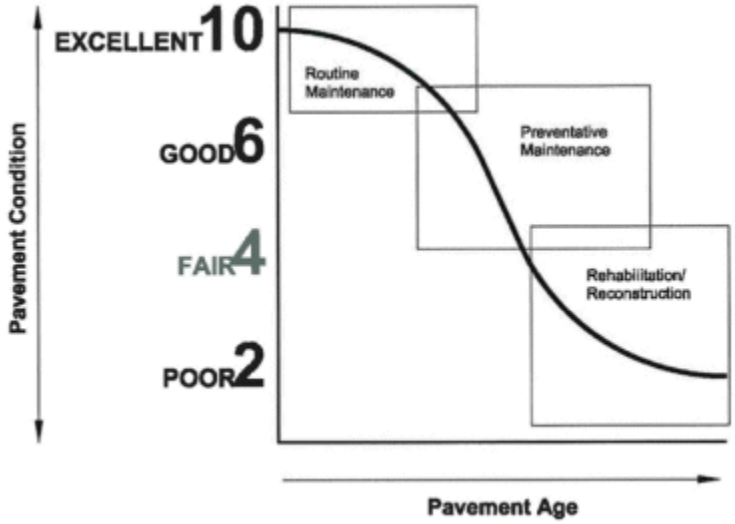

Figure 6: City of Novi, Michigan Asset Management Approach

By adding pavement maintenance between full reconstruction projects, the life of the pavement is extended almost double that of reconstruction only. The pavement life is represented in Figure 7 below.

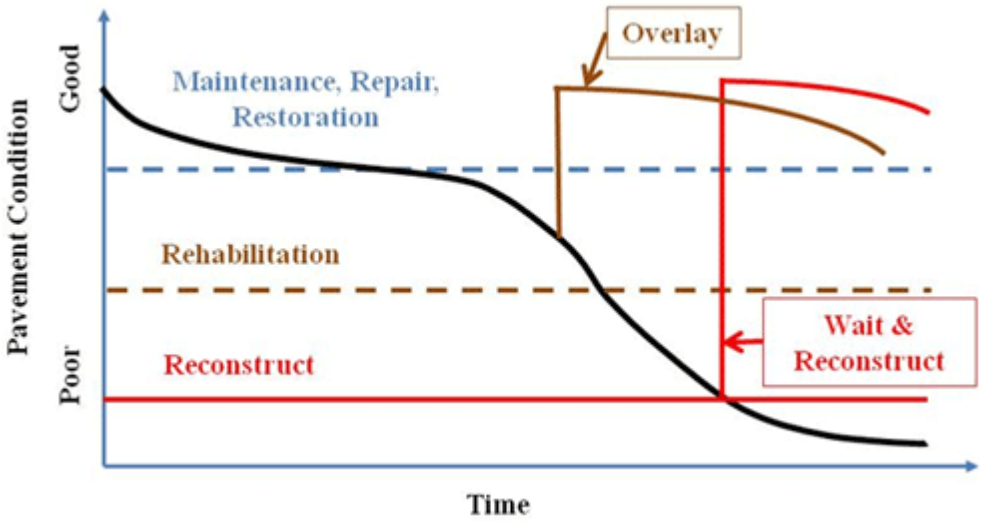

Figure 7: Treatment Zones of Pavement Condition - Federal Highway Administration

Figure 8 shows a roadway that includes maintenance and one that does not have regular maintenance using current City of Mequon treatments and prices. Both roadways are rated a 10 at the start of the deterioration. The variations in the magenta line indicate the maintenance of the road over time. The small improvements are crack filling and GSB-88 applications. The larger jump at year 21 indicates an overlay of the roadway. The cost to maintain 212 miles of roadways with this method is approximately **$1,822,000 per year**.

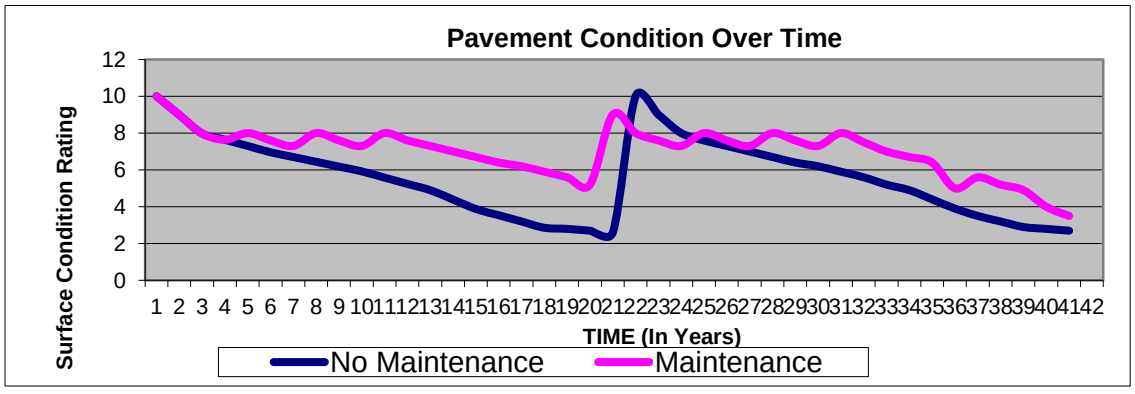

Figure 8: Pavement Condition over Time

MILEAGE BASED/LEVEL FUNDING

The mileage based/level funding methodology is a hybrid using a cost per year based on the reconstruction only and the life cycle with maintenance strategy to improve the system. The combined methodology breaks down the roads into main roads versus subdivision roads, differentiates separate lifespans based upon traffic loading and costs between main roads & subdivision roads and determines the appropriate number of miles and expenditures.

This method uses the benefits of the extension of the life cycle, with level funding based upon the mileage approach. A representation of the program can be found in Figure 9.

Main Roads	Subdivision Streets	Combined Totals	
70	142	212	Miles of Roads
25	35		Year Lifespan with Maintenance
2.8	4.1	6.9	Miles/Year Required to Maintain System
$194,174.00	$195,695.00	$389,869.00	Average Cost to Pulverize & Pave 4" and Associated Work (+7.5% for Drainage)
$543,687.20	$802,349.50	$1,346,036.70	Cost per Year - Reconstruct/Recondition
$163,106.16	$240,704.85	$403,811.01	Maintenance at 30% of Reconstruct/Recondition (Includes Crack Seal, GSB-88, and Overlays)
		$1,749,847.71	**Cost per Year**

Figure 9: City of Mequon Mileage Based/Level Funding

The required funding for this methodology is approximately **$1,750,000 per year.**

ONE-TIME FIX

The One-time Fix methodology utilizes the PASER pavement ratings and backlog of suggested treatments to effectively bring all roads in the City to a surface condition rating 8 (SCR 8). Backlog includes crack-sealing, GSB-88 treatments, and reconstruction. Currently the backlog for main roads in PASER is $3,653,172 and for subdivision streets is $6,163,189 for a total backlog of $9,817,071affecting approximately 90 miles of roadway. The City could spend almost $10,000,000 now to use this method and then wait an average of 21 years and repeat the process. The $10,000,000 current backlog is based on the current condition of the system which has been maintained in recent years. If this method is done with no maintenance, in average of 21 years, the backlog would be $41,380,870 affecting approximately 210 miles of roadway.

To compare this method to the previous methods, the amount required to allocate per year to perform this method the next time would be approximately **$2,000,000 per year**.

RECOMMENDED METHODOLOGY

While the City can consider any number of pavement management strategies, the recommended methodology is the mileage based/level funding. This method is the lowest cost per year and maintains the system at the most consistent level of service for City residents.

The hybrid system combines the fiscal benefit of level funding with the extension of the pavement life. It allows staff to utilize road ratings to anticipate future costs and to address current issues within the overall road system. It also provides residents with improved road conditions between reconstruction projects. This method is also the method that has been used in the past for the City of Mequon.

SIDEWALKS

The City of Mequon maintains 16.35 miles of sidewalks. The sidewalks are located along Port Washington, Mequon, Cedarburg Roads, and within the Mequon Business Park, the Highlander Estates Subdivision, and the Enclave at Mequon Preserve Subdivision. There are also sidewalks at several Mequon parks. The sidewalks at the parks were not included in this review. Parks assets are included under a separate asset report.

The sidewalks in the Highlander Estates Subdivision and the Enclave at Mequon Preserve Subdivision are generally in new or like-new condition. The Development Agreements require the Home Owner's Associations to maintain these sidewalks, including snow removal. When future replacement is required, it will be the City's responsibility to complete the work.

Sidewalks on Port Washington Road, Mequon Road and those in the Business Park have a wider range of conditions. Table 1 shows the year the sidewalk was installed, the location and the length.

Table 1 Sidewalk Asset Location

Year Installed	Location	Length (miles)
1991	Mequon Road	8.12
1991	Port Washington Road	4.82
2003	Business Park	1.11
2011	Cedarburg Road	0.48
2016-2017	Highlander Estates	1.30
2016-2018	Enclave at Mequon Preserve	0.53

Sidewalks have a life cycle of 20 to 40 years, however, the primary need for replacement are tripping hazards. Tripping hazards are caused by tree roots, settling, and the freeze-thaw cycle. Addressing sidewalk trip hazards is required to maintain ADA standards. Sidewalk repairs typically include shaving,

mud jacking, or single slab replacement. Mud jacking is generally more expensive than sidewalk shaving. Replacement is typically the most expensive alternative.

The City of Mequon has utilized each repair type, however, mud jacking hasn't been utilized since 1987. Contracts for sidewalk shaving and replacement were issued more recently. The history of the sidewalk replacement contracts is in Table 1 below.

Table 2 Historic Sidewalk Repair and Replacement Contracts

Year	Type	Location	Rate	Total Cost
1987	Mud Jacking	Library	$92.86 per slab	$650
2001	Replacement	Various	$4.48 per SF	$14,000
2012	Shaving	Mequon Road	14.90 per inch-foot	$7,500
2015	Shaving	Mequon Road	14.90 per inch-foot	$7,500
2017	Replacement	Various	$9.75 5-inch, $10.75 7-inch	$10,000

The 2012 sidewalk contract was intended to cover the length of Mequon Road, however, budgetary limitations resulted in the completion of only a portion of the roadway. The remainder of Mequon Road and a portion of Port Washington Road were completed in the 2015.

MAINTENANCE STRATEGY

There are several methodologies that can be used to evaluate the repair and replacement of sidewalks. These methodologies are similar to the road repair and replacement methodologies.

SYSTEM WIDE

A system wide approach to sidewalk evaluation would include the evaluation of the entirety of the City of Mequon sidewalk system for repair and replacement in one construction season, only once in the life cycle.

This approach would allow for some cost reduction in mobilization of contractors.

A system wide methodology would require significant effort by City staff to do the evaluation and contract management. This approach in theory could be done once every twenty years, however, tripping hazards can occur anytime during the life cycle. Additional evaluation and repairs may be needed to address tripping hazards.

MULTI-YEAR CYCLE

A multi-year funding approach to the evaluation and subsequent sidewalk repairs would be most similar to other asset management in the City. Utilizing a 2-year approach would still allow for cost reductions in mobilization and would reduce the impact to City staff for evaluation and management of the program.

Miles Per Year

Utilizing a miles per year funding approach would allow for entire roadway sections to be completed in one construction cycle. This method creates efficiency in traffic control and the mobilization of equipment.

Budget Per Year

The budget per year funding approach has historically been utilized for sidewalk shaving and repair. As previously indicated, the budget method could result in the need for subsequent contracts to complete a section of roadway. Additional mobilization and traffic control fees would be expected.

RECOMMENDED METHODOLOGY

Utilizing a combination of the miles per year and budget per year approaches results in a repair and replacement schedule that is efficient and effective. The shaving program is most effective as a miles-per-year approach, whereas replacement is most effective on a budget per year basis.

Sidewalk shaving would be focused on one roadway and one area resulting in combined traffic control and mobilization. Repairs are often in various

locations, requiring additional traffic control and mobilization. The budget per year approach typically focuses on the worst sections first to maximize the impact of replacement. A sample 20-year schedule is located in Table 3. This schedule allows for shaving to occur twice within the life cycle of the sidewalk. Mud jacking could be added to either the shaving or replacement contracts as warranted by sidewalk conditions.

Table 3 Sample 20-Year Sidewalk Schedule

Year	Type	Location
2019	Shaving	Port Washington Road
2021	Replacement	Various
2023	Shaving	Business Park/Cedarburg Road
2025	Shaving	Enclave/ Highlander Estates
2027	Replacement	Various
2029	Shaving	Mequon Road
2031	Shaving	Port Washington Road
2033	Replacement	Various
2035	Shaving	Business Park/Cedarburg Road
2037	Shaving	Enclave/ Highlander Estates
2039	Replacement	Various

Historic sidewalk repair and replacement contracts since 2001 have varied from $7,500 to $14,000 with an average of $9,750. Budgeting sidewalk repair and replacement at **$10,000 per year** would allow for flexibility in the amount of miles of roadway that could be completed with a 2-year sidewalk repair and replacement program.

BIKE PATHS

The City of Mequon includes 11.11 miles of off-road bike paths. Several of the existing bike paths are owned and maintained by home owners associations. The paths are often located in easements; however, they are considered a right of way asset since they follow a similar repair and replacement schedule as the roadway assets and are not otherwise included in any of the other asset management plans.

Table 4 shows the locations and lengths of bike paths in the City of Mequon. Approximately 7.64 miles of bike paths are maintained by the City of Mequon which includes the Ozaukee Interurban Trail, Laguna and Ranch Road, Swan Road, and the Donges Bay Road off road path.

Table 4 Bike Path Locations and Mileage

Bike Path	Mileage	Bike Path	Mileage
Ozaukee Interurban Trail	4.75	Grace Ave	0.25
Creekside Ct	0.08	Laguna/ Ranch NE	0.07
Oakview Ct	0.07	Laguna/ Ranch W	0.1
Willlowbrook Ct	0.07	Mequon Square Dr	0.08
Heron Pond Dr	0.02	Dogwood Ct	0.05
River Birch Dr	0.07	Donges Bay off Rd	1.63
Ridgeview Dr	0.09	Swan Rd off Rd	0.84
Highland Ridge Dr	0.23	Knightsbridge Dr	0.11
Hawks Landing	0.17	Stillwater Ct	0.05
Legacy Hills	0.2	Windpointe Ct	0.06
Birch Creek Rd	0.36	Woodcrest Dr	0.05
Sunnydale Ln	0.14	Ironwood Ln	0.05
Winding Hollow Ln	0.21	Pebble Ln	0.05
Winding Hollow – Sunnydale Connection	0.04	Mequon Nature Preserve	0.98
Stratford Place	0.04	Elderberry Ln	0.07
Range Line Rd off Rd	0.13		

The Mequon-Thiensville Bike and Pedestrian Way Commission established a 2030 Plan that identifies the top priorities for new bike and pedestrian ways within the City of Mequon and the Village of Thiensville. The prioritization list is included in Table 5.

Table 5 2010-2030 Bike and Pedestrian Way Prioritization List

Priority	Location	Projects
1	Donges Bay Road	5' marked lanes - Cedarburg Rd to Wauwatosa Rd
2	Donges Bay Rd	OIT - Flatten curve at substation
3	Donges Bay Road	Continue 5' marked shoulders beyond Grasslyn Rd to River Rd
4	Various	Bike Path Ahead Signs
5	Mequon/Thiensville	Develop a Bike Rack Plan
6	Mequon/Thiensville	Create a Grant Plan
7	Highland Rd	4' Bike lane - OIT to Wasaukee Rd
8	River Road	4' Paved Shoulder, Heiderl Rd - Freistadt Rd
9	Lake Shore Drive	Re-Striping-Glen Oaks to Mequon Rd
10	Lake Shore Drive	4' Bike Lanes (including Zedler Ln)
11	Donges Bay Rd	2-way, off-road trail-Lemke Park to Wasaukee Rd (south side)
12	County Line Road	4' lanes - Range Line Rd to River Rd
13	Range Line Road	4' Lane County Line Rd - Mequon Rd
14	Pioneer Road	4' Bike lane - Davis Rd to Wasaukee Rd
15	Port Washington Rd	Extend 4' Lanes and Sidewalks to hospital
16	Port Washington Rd	Off Road Bike path East of Pt Washington Rd Between Fairy Chasm and Zedler Ln
17	Thiensville	Connection 400-500 block Main St to OIT

These paths would be owned and maintained by the municipality upon completion.

MAINTENANCE STRATEGY

A replacement and repair process for Bike Paths has not been formally established, however, staff is developing a repair and maintenance program for bike paths. The first step to developing the replacement and repair program is to determine which paths are owned and maintained by the City. This involves reviewing the historical documentation of the various segments.

Once the City owned segments are determined the rating would follow the same Paser rating the road program uses. This will determine whether maintenance or replacement is warranted for each segment. The identification and rating of the bike paths is anticipated to be completed in 2019.

In 2015, the Mequon-Thiensville Pedestrian and Bikeway Commission rerouted a portion of the Ozaukee Interurban Trail at the WE Energies substation just south of railroad crossing on Cedarburg Road. The total cost of the project including design and review fees equated to $218,599.96.

In 2014, crack filling of the Ozaukee Interurban Trail (OIT) was included in the contract pricing for the road program. The total cost for the Mequon portion of the OIT was $4,070. In 2015 the Donges Bay Road path and the OIT were included in the GSB-88 sealing. The cost to seal both paths equated to $33,778.

RECOMMENDED METHODOLOGY

It is recommended that bike paths follow a similar maintenance repair and replacement program as City roadways.

Longitudinal cracks on the Ozaukee Interurban Trail were filled in 2018. Numerous transverse cracks were noted and should be filled in 2019 in conjunction with the road program crack filling.

The Joint Mequon-Thiensville Bike and Pedestrian Committee also has a 2030 plan that includes additional bike paths. Annual funding requests are $100,000. Maintenance could be accomplished within that funding.

TRAFFIC SIGNALS

The City of Mequon includes 24 signalized intersections. The Wisconsin Department of Transportation (WisDOT), Ozaukee County, and the City of Mequon have jurisdiction over the signals at each intersection. Table 6 indicates the locations and jurisdiction of the signals.

Table 6 Traffic Signal Locations

Traffic Signal Location	Jurisdiction
Highland Road at Wauwatosa Road	City of Mequon
Freistadt Road at Wauwatosa Road	City of Mequon
Highland Road at Cedarburg Road	City of Mequon
Mequon Road at Buntrock Avenue	City of Mequon
County Line Road at Wauwatosa Road	WisDOT
Donges Bay Road at Wauwatosa Road	WisDOT
Donges Bay Road at Cedarburg Road	WisDOT
Mequon Road at Wauwatosa Road	WisDOT
Port Washington Road at Mequon Road	WisDOT
I-43 off ramps at Mequon Road	WisDOT
Mequon Road at Cedarburg Road	WisDOT
Mequon Road at Range Line Road	WisDOT
Mequon Road at River Road	WisDOT
Mequon Road at Eastgate Drive	WisDOT
Mequon Road at Granville Road	WisDOT
Pioneer Road at Wauwatosa Road	WisDOT
Mequon Road at Wausaukee Road	WisDOT
Venture Court at Port Washington Road	Ozaukee County
Town Square Road at Port Washington Road	Ozaukee County
Pioneer Road at Port Washington Road	Ozaukee County
Donges Bay Road at Port Washington Road	Ozaukee County
Highland Road at Port Washington Road	Ozaukee County
Eastbrook Drive at Port Washington Road	Ozaukee County
Glen Oaks road at Port Washington Road	Ozaukee County

At the City's four signalized intersections there are a total of 50 fixtures and 34 poles. Table 7 shows the type of pole and the number of signal heads at each location. There are also loop detectors and advance loop detectors that trigger the signal at each intersection approach. Figure 10 shows an example loop detector.

Table 7 Traffic Signal Locations

Traffic Signal Location		Pole	Light Pole	Mast Arm with Light	Mast Arm	Signal Head
Highland Road at Wauwatosa Road	NE		1	1		3
Highland Road at Wauwatosa Road	NW	1		1		3
Highland Road at Wauwatosa Road	SW		1	1		3
Highland Road at Wauwatosa Road	SE	1		1		3
Freistadt Road at Wauwatosa Road	NE	1		1		3
Freistadt Road at Wauwatosa Road	NW	1		1		3
Freistadt Road at Wauwatosa Road	SW	1			1	3
Freistadt Road at Wauwatosa Road	SE	1		1		3
Highland Road at Cedarburg Road	NE	1			1	3
Highland Road at Cedarburg Road	NW	1		1		3
Highland Road at Cedarburg Road	SW	1			1	3
Highland Road at Cedarburg Road	SE	1		1		3
Mequon Road at Buntrock Avenue	NE	1		1		3
Mequon Road at Buntrock Avenue	NW	1			1	3
Mequon Road at Buntrock Avenue	Median		2			2
Mequon Road at Buntrock Avenue	SW	1			1	3
Mequon Road at Buntrock Avenue	SE	1			1	3

Figure 10: Loop Detector in Pavement

MAINTENANCE STRATEGY

Traffic signals are repaired and replaced as needed. Typically, a replacement is triggered by a traffic incident.

Life expectancy of signal components vary by component. Figure 11 indicates life expectancies as published in The National Cooperative Highway Research Program Report 173: Estimating Life Expectancies of Highway Assets, Volume 1: Guidebook, 2012. (Thompson, 2012)

Structural components			Controller system components			Signal display components		
Type	Count	Life	Type	Count	Life	Type	Count	Life
Tubular steel mast arm	14	20	Permanent loop detector	14	7.5	Incandescent lamps	15	1
Tubular aluminum mast arm	7	20	Non-invasive detector	12	10	Light-emitting diode lamps	18	6.5
Wood pole (and span wire)	9	15	Traffic controller	18	15	Signal heads	15	20
Concrete pole (and span wire)	2	12.5	Traffic controller cabinet	17	15	Pedestrian displays	1	15
Steel pole (and span wire)	9	20	Twisted copper interconnect cable	11	20			
Galvanized pole and span arm	1	>100	Fiber-optic cable	7	20			

Figure 11: Survey of life expectancy estimates for components (Thompson, 2012)

The cost for new signals is based on the location and traffic volume. Traffic Analysis and Design, Inc. (TADI) provided cost estimates for new and replacement signals. Table 8 indicates the replacement cost.

Table 8 Traffic Signal Replacement Costs

Type	Construction Cost	Survey and Design Cost	Total
New signal and pole	$180,00 to $225,000	$15,000	$195,000 to $240,000
Replacement	$50,000 to $225,000	$15,000	$65,000 to $240,000

RECOMMENDED METHODOLOGY

The replacement costs of traffic signals is a significant amount. The signals should be evaluated regularly for routine maintenance to extend the useful life of the signals. Incorporating **$15,000** annually into a non-lapsing account will establish a funding source when traffic signals require replacement.

SIGNS

The City of Mequon utilizes Geographic Information System (GIS) mapping to identify and track the signs within the City limits. There are 4,784 street signs in the City, of which 4,336 are owned by the City of Mequon. The remaining signs are privately owned, owned by the State of Wisconsin, or the Village of Thiensville. Figure 12 indicates that sign locations in the City of Mequon.

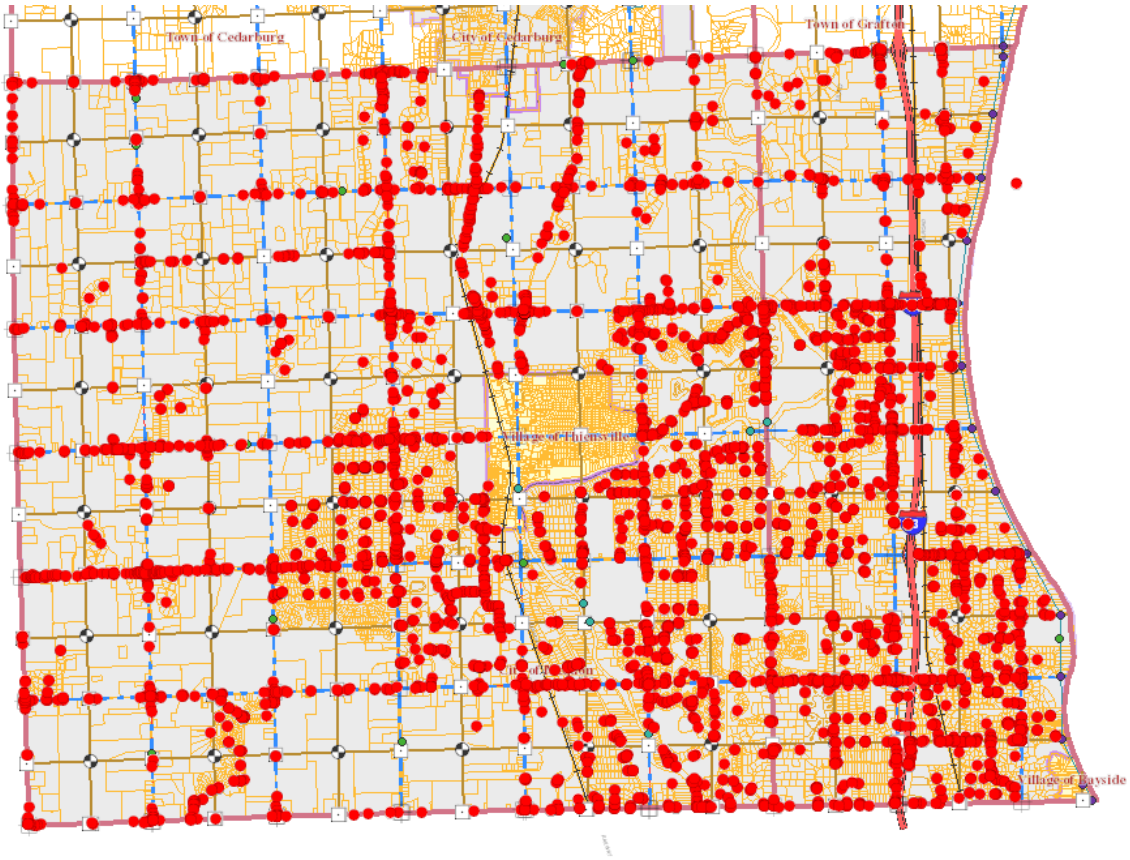

Figure 12: Sign Locations in the City of Mequon

Street signs are typically mounted on either a 4x4 wood post or a 2-3/8 inch galvanized steel pole. A few signs owned by the City are on other post types which are identified in the GIS sign inventory.

Retroreflectivity is a parameter that describes how reflective a sign is. The required retro-reflectivity is regulated by the Federal Highway Adminstraion and defined by the Manual on Uniform Traffic Control Devices (MUTCD). Figure

13 shows an example of different retro-reflectivity on a speed limit sign. The FHWA is not currently enforcing retro-reflectivity criteria, but may require and enforce minimum levels in the future.

Figure 13: Retro-reflectivity of a speed limit sign

MAINTENANCE STRATEGY

The GIS based sign tracking includes the evaluation of the pole condition, sign reflectivity, and overall condition. Signs are replaced as needed based on the sign inventory. Typically sign replacement is in conjunction with an accident.

Sign and sign pole replacement costs vary by sign type, pole type, and reflectivity. A typical stop sign replacement on a 4x4 post equates to $350.

RECOMMENDED METHODOLOGY

Sign and sign pole replacement is on an as-needed basis. Replacing 1% of the signs (45) at an estimated $350 per sign equates to an expenditure of **$15,750 per year**.

STREET LIGHTS

The City of Mequon includes 328 street lights mounted on wood, fiberglass or aluminum poles. Of those street lights, 154 of the lights and poles are maintained by the City. The remaining lights and poles are maintained by WE Energies or as part of a private system maintained by an HOA or Condominium Association. Appendix A includes a listing of the poles in the City of Mequon. Table 9 identifies the lights and poles maintained by the City of Mequon.

Table 9 Lights Owned and Maintained by the City of Mequon

Location	Approximate Quantity
Highland Road At Wauwatosa Road	8
Freistadt Road at Wauwatosa Road	4
Highland Road at Cedarburg Road	5
Mequon Road at Buntrock Avenue	4
Mequon Road	32
Port Washington Road	73
Mequon Business Park (East)	14
Cedarburg Road at the Town Center	14
TOTAL	**154**

The quantities for the lights and poles are based on sight inspections and historic lists. The verification of each light and pole were not included in the basis of this report.

MAINTENANCE STRATEGY

The average life expectancy of a lighting fixture is approximately 65 years. This life expectancy was researched in depth by the The National Cooperative Highway Research Program Report 173: Estimating Life Expectancies of Highway Assets, Volume 1: Guidebook, 2012. Figure 14 shows the graphical life expectancy of a lighting fixture. (Thompson, 2012)

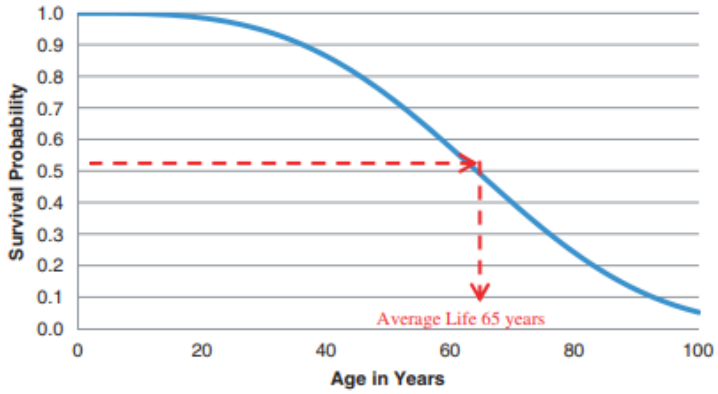

Figure 14: Life Expectancy of Roadway lighting Fixtures (Thompson, 2012)

The City of Mequon replaces lighting fixtures as needed. The typical replacement is the result of a vehicular incident. Recent light and pole replacements ranged from $700 to $1,800 depending on the style of the pole, the light fixture style, and the location.

RECOMMENDED METHODOLOGY

It is recommended that the lights and poles are replaced as needed. Utilizing a 60 year replacement cycle, that equates to 2.5 poles per year. At a replacement of $1,800 per pole, the budget would equate to **$4,500 per year**.

BRIDGES AND CULVERTS

The City of Mequon includes 7 bridges and over 1600 culverts. Bridges are required to be evaluated by a structural engineer every other year to determine their structural integrity. The last evaluation was completed in 2016.

The bridge evaluations identify the maintenance and replacement needed for the bridges in the City. Ozaukee County contracts the bridge inspections.

Table 8.1 Bridge Locations

Structure Number	Location
091114-B45-007	Freistadt Rd Over Pigeon Creek
091114-B-45-076	Bonniwell Rd Over Ulao Creek
091114-B45-077	STH 181 Wauwatosa Rd Over Pigeon Creek
091114-B45-085	Donges Bay Rd Over Little Menomonee River
091114-B45-088	Highland Rd Over Pigeon Creek
091114-B45-094	Granville Rd Over Little Menomonee Creek
092614-B45-090	Highland Rd Over Milwaukee River

Culverts range in size from 12-inch diameter to large box culverts. A full culvert and storm sewer map and evaluation is under development to better manage the evaluation and replacement of culverts in the City. Examples of culvert types are shown in Figure 15 and Figure 16.

Figure 15: Large Box Culvert prior to installation on Buntrock Avenue

Figure 16: Multiple Cross Road Culverts

MAINTENANCE STRATEGY

Bridge repair and replacement identified by the structural report can range from crack sealing to full bridge replacement. The costs vary depending on the types of repair. Replacement costs vary by the location of the bridge, the span length, the deck width, the number of piers and other bridge amenities.

In 2018, the City solicited bids for sealing the bridges at Granville Road, Highland Road and Donges Bay Road. Sealing an entire bridge is more expensive than sealing the individual cracks, however, the curing time is faster, the road is closed for a shorter duration, and the seal is a better quality when the entirety of the deck is done at one time. The cost estimate results are shown in Table 10.

Table 10 Bridge Sealing Costs

Location	Cost
Granville Road	$24,775
Highland Road	$63,800
Donges Bay Road	$15,420
All 3 bridges together	$82,912

Historic bridge replacements vary between $157,000 for the Highland Road Bridge over Pigeon Creek in 1992 to $470,000 for the Cedarburg Road Bridge over Trinity Creek in 2010.

The repair or replacement of a culvert is evaluated on a case by case basis. Many of the culverts in the City are corrugated metal pipe which degrades over time. These culverts are often replaced with High Density Polyethylene (HDPE) which has a longer life cycle. Other pipes may be lined or repaired using other methodologies.

Culvert replacement varies by the size of the culvert and the location. Smaller culverts are typically removed and replaced by the Department of Public Works. Larger culverts are replaced by contractors and may also require design services if the size, shape or length is changed. Recent box culvert replacement costs are indicated in Table 11.

Table 11 Box Culvert Replacement Costs

Location	Length	Material	Cost	Year
Baehr Road	48-FT	Concrete	$58,140	2000
Freistadt Road	48-FT	Concrete	$51,985	2001
Buntrock Avenue	42-FT	Aluminum	$64,319	2002

RECOMMENDED METHODOLOGY

It is recommended that bridges and culverts maintain the current repair and replacement methodology. Incorporating **$50,000** annually into a non-lapsing account will establish a funding source when bridges and culverts require replacement.

GUARD RAILS

Guard rails are typically located where there are steep drop offs from the pavement or reduced shoulder widths. They are designed to keep vehicular traffic from entering an area where they could not easily be extracted. Many guard rails are located in areas where there are bridges, large culverts, or environmentally sensitive areas. The City of Mequon includes 2.0 miles of guard rails. The location of the guard rails are indicated in Appendix B The average life cycle of a guard rail is 45 years (Thompson, 2012).

There are several types of guard rails. There are two types of guard rail in the City; metal and wood. Figure 17 shows the two types.

Figure 17: Metal and Wood Guard Rail

The end treatments of the metal guard rail also vary throughout the City. The ends are typically tapered, however other end treatments are used based on the roadway geometry and the regulations in place at the time of the installation. Figure 18 show the different types of end treatments.

Figure 18: Guard rail end treatments

MAINTENANCE STRATEGY

The City of Mequon replaces guard rails as needed. The typical replacement is the result of a vehicular incident. Replacement cost can vary by the amount of the existing rail that can be salvaged, the style and the location of the guard rail.

Table 9.1 Replacement Cost for Guard Rail

Item	Cost	Unit	Source
Metal Guard Rail	$80.80	L.F.	Previous City Contract
Energy Absorbing Terminal	$2,503	Each	State Average Cost
Salvaged End Treatment	$200	Each	State Average Cost

RECOMMENDED METHODOLOGY

The cost to replace all guard rails at the costs identified above equates to $853,248. There are 57 section of guard rail, assuming a new end section at each end would equate to $285,342 for a grand total of $1,138,590.

Considering the life cycle of guard rails is 45 years, in order to replace all of the guard rail the cost per year would equate to **$25,350 per year**.

CONCLUSION

Many of the assets located in the right of way have many methodologies that can be utilized to determine the repair and replacement planning and budgeting.

For roadways, sidewalks and bike paths utilizing a budget per year approach maximizes the ability to tailor the repair and replacement to the current conditions and allows staff to utilize available resources to determine the most efficient approach.

For traffic signals, lights and light poles, signs, bridges, culverts and guard rails utilizing the current operations and maintenance budgets to repair and replace as needed allows for the case-by-case management of these assets. The funding of the operations and maintenance should be based on life cycles.

At a minimum, establishing level funding sources that can address the varying annual costs of replacement and maintenance of the City's right of way assets will prevent the need for a large expenditure to address deferred maintenance. Proactive replacement of the street lights and traffic signals can also utilize newer technology which results in lower operating and maintenance costs.

Appendix A: Street Light Inventory

Street Light Inventory

Location	Quantity	Pole Material	Pole Color	Bulbs
County Line Rd. at Wasaukee Rd. (Northeast corner)	1	Wood	Natural	Single
County Line Rd. at Granville Rd. (Southwest corner)	1	Wood	Natural	Single
County Line Rd. at Tamerlane Dr. (Northwest corner)	1	Wood	Natural	Single
County Line Rd. at Swan Rd. (Southwest corner)	1	Wood	Natural	Single
County Line Rd. at Baehr Rd. (Northeast corner)	1	Wood	Natural	Single
County Line Rd. at Cedarburg Rd. (Northeast corner)	1	Wood	Natural	Single
County Line Rd. at Cedarburg Rd. (Southwest corner)	1	Wood	Natural	Single
County Line Rd. at Greenview Ln. (Northwest corner)	1	Wood	Natural	Single
County Line Rd. at Port Washington Rd. West of I-43 (Northeast corner)	1	Wood	Natural	Single
County Line Rd. at Port Washington Rd. East of I-43 (Northwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at Lemke Park entrance (first pole to the East)	1	Wood	Natural	Single
Donges Bay Rd. at Stanford Dr. (Southeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Swan Rd. (Southeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Wauwatosa Rd. (Southwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at Wauwatosa Rd. (Northeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Pioneer Dr. (Northwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at Baehr Rd. (Southeast corner)	1	Wood	Natural	Single
Donges Bay Rd. 100' +/- West of N. Baldev Ct. (North side)	1	Wood	Natural	Single
Donges Bay Rd. 1430' West of Cedarburg Rd. between Libby Montana's and Burning Bush Ln. (South side)	1	Wood	Natural	Single
Donges Bay Rd. 1240' West of Cedarburg Rd. between Libby Montana's and Burning Bush Ln. (South side)	1	Wood	Natural	Single
Donges Bay Rd. at Burning Bush Ln.	1	Wood	Natural	Single

(Northwest corner)				
Donges Bay Rd. 540' West of Cedarburg Rd. (South side)	1	Wood	Natural	Single
Donges Bay Rd. at River Rd. (Southwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at W. Gazebo Hill PKWY. (Northwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at E. Gazebo Hill PKWY. (Northwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at Le Monte/Le Petite BLVD. (North side)	1	Wood	Natural	Single
Donges Bay Rd. at N. Country Club Dr. (Northeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Range Line Rd. (Southwest corner)	1	Wood	Natural	Single
Donges Bay Rd. at Grasslyn Rd. (Southeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Sunnycrest Dr. (Southeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Greenview Dr. (Southeast corner)	1	Wood	Natural	Single
Donges Bay Rd. at Magnolia Dr. (Northwest corner)	1	Wood	Natural	Single
Mequon Rd. at Ashbury Woods Dr. (Northwest corner)	1	Wood	Natural	Single
Mequon Rd. at Sutton Ridge Dr. (Southeast corner)	1	Wood	Natural	Single
Mequon Rd. at Farmdale Rd. (South side)	1	Wood	Natural	Single
Mequon Rd. at Swan Rd. (Northeast corner)	1	Wood	Natural	Single
Mequon Rd. at Swan Rd. (Southwest corner)	1	Wood	Natural	Single
Mequon Rd. at Brighton Pl. (Southwest corner)	1	Wood	Natural	Single
Mequon Rd. at Meadowbrook Dr. (North side)	1	Wood	Natural	Single
Mequon Rd. at Vega Ave. (Northwest corner)	1	Wood	Natural	Single
Mequon Rd. at Solar Ave. (Northeast corner)	1	Wood	Natural	Single
Mequon Rd. at Industrial Dr. (Southeast corner)	1	Wood	Natural	Single
Mequon Rd. on East side of Railroad Tracks on North side of Mequon Rd. West of Cedarburg rd.	1	Wood	Natural	Single
Mequon Rd. from N. Buntrock Ave. to Cedarburg Rd. (Median)	6	Fiberglass	Dark Bronze	Double

Mequon Rd. at East end of bridge (Median)	1	Fiberglass	Dark Bronze	Double
Mequon Rd. at N. Parkview Dr. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at Country View Dr. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Crestline Rd. (Southeast corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Riverland Ct. (Southeast corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at Riverland Rd. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at Mulberry Dr. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at Sabra Ct. (Southeast corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at Bobolink Ln. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Robin Ln. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Lilac Ln. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Oriole Ln. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Oriole Ln. (Southeast corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at N. Valley Dr. (Northwest corner)	1	Fiberglass	Dark Bronze	Single
Mequon Rd. at West end of entrance to 909 W. Mequon Rd. (South side by easternmost RR Tracks)	1	Wood	Natural	Single
Freistadt Rd. at Ridge Rd. (Northeast corner)	1	Wood	Natural	Single
Freistadt Rd. at N. Lantern Ln. (Southwest corner)	1	Wood	Natural	Single
Freistadt Rd. at Wauwatosa Rd. (Southwest corner)	1	Wood	Natural	Single
Freistadt Rd. at Solar Ave. (Southeast corner)	1	Wood	Natural	Single
Freistadt Rd. at Vega Ave. (North side)	1	Wood	Natural	Single
Freistadt Rd. at N. Silver Ave. (Southeast corner)	1	Wood	Natural	Single
Freistadt Rd. at Ridgeway Ave. (Southeast corner)	1	Wood	Natural	Single
Freistadt Rd. at N. Farmdale Rd. (Southeast corner)	1	Wood	Natural	Single
Freistadt Rd. at Granville Rd. (North side of	1	Wood	Natural	Single

Freistadt Rd.)				
Freistadt Rd. at N. Church Pl. (Southeast corner)	1	Wood	Natural	Single
Freistadt Rd. at Granville Rd. (South side of Freistadt Rd.)	1	Wood	Natural	Single
Freistadt Rd. at Wasaukee Rd. (Southwest corner)	1	Wood	Natural	Single
Freistadt Rd. at Ville Grove Rd. (Southwest corner)	1	Wood	Natural	Single
N. Fieldwood Rd. at W. Ville Du Parc Dr. (Northwest corner)	1	Wood	Natural	Single
N. Fieldwood Rd. at Yvonne Dr. (Southwest corner)	1	Wood	Natural	Single
Highland Rd. at Granville Rd. (North side of Highland Rd.)	1	Wood	Natural	Single
Highland Rd. at Granville Rd. (South side of Highland Rd.)	1	Wood	Natural	Single
Highland Rd. at Hawks Glen Rd. (North side)	1	Wood	Natural	Single
Highland Rd. at Cedarburg Rd. (Northeast corner)	1	Wood	Natural	Single
Highland Rd. at Green Bay Rd. (Northeast corner)	1	Wood	Natural	Single
Highland Rd. at River Rd. (North side)	1	Wood	Natural	Single
Highland Rd. 350' East of River Rd. (North side)	1	Wood	Natural	Single
Highland Rd. at East Rotary Park entrance (North side)	1	Wood	Natural	Single
Highland Rd. at Yvonne Dr. (Southwest corner)	1	Wood	Natural	Single
Highland Rd. between Yvonne Dr. and W. Shoreland Dr. (North side)	1	Wood	Natural	Single
Highland Rd. at N. Fieldwood Rd. (North side)	1	Wood	Natural	Single
Highland Rd. at N. Shoreland PKWY. (Southwest corner)	1	Wood	Natural	Single
Highland Rd. at E. Shoreland Dr. (North side)	1	Wood	Natural	Single
Highland Rd. at N. Colony Dr. (Northeast corner)	1	Wood	Natural	Single
Highland Rd. at Oriole Ln. (Northwest corner)	1	Wood	Natural	Single
Highland Rd. at Maplecrest Ln. (North side)	1	Wood	Natural	Single
Highland Rd. at Port Washington Rd. (Southeast corner)	1	Wood	Natural	Single
Highland Rd. at N. Lakeshore Dr. (South side of Highland Rd.)	1	Wood	Natural	Single

Bonniwell Rd. at Granville Rd. (Southeast corner)	1	Wood	Natural	Single
Bonniwell Rd. at Wauwatosa Rd. (Southeast corner)	1	Wood	Natural	Single
Bonniwell Rd. at Cedarburg Rd. (Northeast corner)	1	Wood	Natural	Single
Bonniwell Rd. at Green Bay Rd. (Northeast corner)	1	Wood	Natural	Single
Bonniwell Rd. at Port Washington Rd. (Southwest corner)	1	Wood	Natural	Single
Bonniwell Rd. at Lakeshore Dr. (North side)	1	Wood	Natural	Single
Pioneer Rd. at Wasaukee Rd. (Southeast corner)	1	Wood	Natural	Single
Pioneer Rd. at Granville Rd. (Northwest corner)	1	Wood	Natural	Single
Pioneer Rd. at Green Bay Rd. (Southwest corner)	1	Wood	Natural	Single
Granville Rd. at Donges Bay Rd. (Southeast corner)	1	Wood	Natural	Single
Granville Rd. from Sunset Woods Ln. to Freistadt Rd.	1	Wood	Natural	Single
Granville Rd. 500' South of Freistadt Rd. (East side)	1	Wood	Natural	Single
Swan Rd. at Concord Dr. (Northwest corner)	1	Wood	Natural	Single
Swan Rd. at Daventry Rd. (Northeast corner)	1	Wood	Natural	Single
Wauwatosa Rd. at Vessels of Honour Church entrance (Northwest corner)	1	Wood	Natural	Single
10459 Wauwatosa Rd. (Southwest corner)	1	Wood	Natural	Single
Wauwatosa Rd. at Mequon Square Dr. (Northeast corner)	1	Wood	Natural	Single
Wauwatosa Rd. at Willowbrook Ct. (Southeast corner)	1	Wood	Natural	Single
Wauwatosa Rd. at Willowbrook Dr. (East side)	1	Wood	Natural	Single
Wauwatosa Rd. at Sunnyvale Rd. (Southwest corner)	1	Wood	Natural	Single
Wauwatosa Rd. at Lafayette Pl. (Northeast corner)	1	Wood	Natural	Single
Wauwatosa Rd. at Evergreen Rd. (East side)	1	Wood	Natural	Single
Wauwatosa Rd. at Hawthorne Rd. (Northwest corner)	1	Wood	Natural	Single
N. Buntrock Ave. 140' +/- North of W. Industrial Dr. (West side)	1	Wood	Natural	Single
N. Buntrock Ave. at Steffen Dr. (East side)	1	Wood	Natural	Single

N. Buntrock Ave. at Division St. (Northwest corner)	1	Wood	Natural	Single
Cedarburg Rd. at Hiawatha Dr. (East side)	1	Wood	Natural	Single
Cedarburg Rd. at River Barn Park entrance (Southeast corner)	1	Wood	Natural	Single
Cedarburg Rd. at Willow Rd. (Northwest corner)	1	Wood	Natural	Single
Cedarburg Rd. at Elmdale Rd. (Southwest corner)	1	Wood	Natural	Single
Cedarburg Rd. at Kathleen Ln. (Southwest corner)	1	Wood	Natural	Single
Cedarburg Rd. at Westfield Rd. (Northeast corner)	1	Wood	Natural	Single
Cedarburg Rd. at Bayberry PKWY. (Northwest corner)	1	Wood	Natural	Single
Cedarburg Rd. at Sherwood Dr. (East side)	1	Wood	Natural	Single
11124 N. Cedarburg Rd. (East side)	1	Wood	Natural	Single
Cedarburg Rd. at Pine Lane (East side)	1	Wood	Natural	Single
Cedarburg Rd. 627' North of Pine Lane (East side	1	Wood	Natural	Single
Cedarburg Rd. 306' South of Lucern Ct. (East side)	1	Wood	Natural	Single
Cedarburg Rd. 740' South of Lucern Ct. (East side)	1	Wood	Natural	Single
Cedarburg Rd. at Lucern Ct. (Southwest corner)	1	Wood	Natural	Single
Cedarburg Rd. 300' South of Mequon Rd. (West side)	1	Wood	Natural	Single
Cedarburg Rd. 210' South of Mequon Rd. (West side)	1	Wood	Natural	Single
River Rd. at Le Grande BLVD. (Southeast corner)	1	Wood	Natural	Single
River Rd. at W. Haven Ave. (Northeast corner)	1	Wood	Natural	Single
River Rd. at Laverna Ave. (Southwest corner)	1	Wood	Natural	Single
River Rd. at Grace Ave. (Northwest corner)	1	Wood	Natural	Single
Range Line Rd. at Country Club Dr. (Southeast corner)	1	Wood	Natural	Single
Range Line Rd. at Sunnydale Ln. (Southeast corner)	1	Wood	Natural	Single
Range Line Rd. at southernmost entrance to Lakeshore Middle School (East side)	1	Wood	Natural	Single
Range Line Rd. 700' South of Mequon Rd. (East side)	1	Wood	Natural	Single
Range Line Rd. 600' South of Mequon Rd. (East side)	1	Wood	Natural	Single

Port Washington Ln. at El Rancho Dr. (Southwest corner)	1	Wood	Natural	Single
Port Washington Ln. at Fiesta Ln. (Southwest corner)	1	Wood	Natural	Single
Port Washington Rd. at Katherine Dr. (West side)	1	Wood	Natural	Single
Port Washington Rd. at Katherine Dr. (Northwest corner)	1	Wood	Natural	Single
Port Washington Rd. from Port Washington Ln. to Donges Bay Rd. (Median)	16	Fiberglass	Dark Bronze	Double
Port Washington Rd. from Port Washington Ln. to Donges Bay Rd. (West side)	6	Fiberglass	Dark Bronze	Single
Port Washington Rd. from Port Washington Ln. to Donges Bay Rd. (East side)	3	Fiberglass	Dark Bronze	Single
Port Washington Rd. from Donges Bay Rd. to Mequon Rd. (Median)	29	Fiberglass	Dark Bronze	Double
Port Washington Rd. from Donges Bay Rd. to Mequon Rd. (West side)	3	Fiberglass	Dark Bronze	Single
Port Washington Rd. from Donges Bay Rd. to Mequon Rd. (East side)	3	Fiberglass	Dark Bronze	Single
Port Washington Rd. at 50' North of W. Venture Ct. (West side)	1	Wood	Natural	Single
Port Washington Rd. at W. Homestead Trail (Southwest corner)	1	Wood	Natural	Single
Port Washington Rd. at W. Eastbrook Dr. (Southwest corner)	1	Wood	Natural	Single
Port Washington Rd. at W. Eastbrook Dr. (Southwest corner)	1	Wood	Natural	Single
Port Washington Rd. at N. Eastbrook Dr. (Southwest corner)	1	Wood	Natural	Single
Port Washington Rd. at W. Glen Oaks Ln. (Southwest corner)	1	Wood	Natural	Single
Port Washington Rd. 400' North of Glen Oaks Ln. (West side)	1	Wood	Natural	Single
Port Washington Rd. at River Oaks Pl. (East side)	1	Wood	Natural	Single
Port Washington Rd. at Liebau Rd. (Southeast corner)	1	Wood	Natural	Single
Port Washington Rd. at Dorothy Pl. (East side)	1	Wood	Natural	Single
Port Washington Rd. at River Forrest Dr. (Southwest corner)	1	Wood	Natural	Single
W. Fleur De Lis Dr. at Jacqueline Ct. (Southeast corner)	1	Aluminum	Black	Single

W. Fleur De Lis Dr. at La Belle Ct.	1	Aluminum	Black	Single
W. Fleur De Lis Dr. at Jonquil Ct. (Southeast corner)	1	Aluminum	Black	Single
La Belle Ct.	1	Aluminum	Black	Single
Chateau Ct.	1	Aluminum	Black	Single
Jacqueline Ct.	1	Aluminum	Black	Single
Jonquil Ct.	1	Aluminum	Black	Single
Colette Ct.	1	Aluminum	Black	Single
W. Fleur De Lis Dr. at Joliet Ct.	1	Aluminum	Black	Single
W. Fleur De Lis Dr. at Celeste Ct.	1	Aluminum	Black	Single
W. Fleur De Lis Dr. at Parc Ct.	1	Aluminum	Black	Single
W. Fleur De Lis Dr.	1	Aluminum	Black	Single
N. Eastgate Dr. at W. Hillcrest Dr. (East side)	1	Wood	Natural	Single
N. Eastgate Dr. at W. Elmhurst Dr. (Southwest corner)	1	Wood	Natural	Single
N. Eastgate Dr. at W. Sunnyside Dr. (Northwest corner)	1	Wood	Natural	Single
N. Commerce St. (Median)	2	Fiberglass	Dark Bronze	Double
N. Commerce St. (West side)	5	Fiberglass	Dark Bronze	Single
N. Commerce St. (East side)	5	Fiberglass	Dark Bronze	Single
W. Executive Dr.	30	Fiberglass	Dark Bronze	Single
Executive Ct.	1	Fiberglass	Dark Bronze	Double
Executive Ct. (West side)	1	Fiberglass	Dark Bronze	Single
Executive Ct. (East side)	1	Fiberglass	Dark Bronze	Single
Enterprise Dr. (Median South of Executive Dr.)	6	Fiberglass	Dark Bronze	Double
Enterprise Dr. (West side)	2	Fiberglass	Dark Bronze	Single
Enterprise Dr. (East side)	1	Fiberglass	Dark Bronze	Single
Industrial Dr. (Median)	3	Fiberglass	Dark Bronze	Double
Industrial Dr. (West side)	6	Fiberglass	Dark Bronze	Single
Industrial Dr. (East side)	5	Fiberglass	Dark Bronze	Single
Baehr Rd. North of Donges Bay Rd. (Median)	2	Fiberglass	Dark Bronze	Double

Baehr Rd. North of Donges Bay Rd. (West side)	5	Fiberglass	Dark Bronze	Single
Baehr Rd. North of Donges Bay Rd. (East side)	7	Fiberglass	Dark Bronze	Single
Eastwood Ct.	4	Fiberglass	Dark Bronze	Single
Steffen Dr. at Balsam Tree Ct. (Northeast corner)	1	Wood	Natural	Single
Steffen Dr. at North Elder Tree Ct. (South side)	1	Wood	Natural	Single
Steffen Dr. 800' West of Buntrock Ave (South side)	1	Wood	Natural	Single
Steffen Dr. at 100' +/- West of N. Redwood Tree Ct. (North side)	1	Wood	Natural	Single
Total	**328**			

Appendix B: Guard Rail Inventory

Guard Rail Inventory

Locations	*Direction*	*Length*
County Line Rd. W of Tamerlane Dr.	E to W	175
County Line Rd. W of Tamerlane Dr.	W to E	238.64
End of Glen Oaks Ln.	W of i-43	28.21
End of Glen Oaks Ln.	E of i-43	23.85
End of Dandelion Ln.	E of i-43	28.26
End of W. Liebau Rd.	W of i-43	24.28
End of Donges Bay Rd.	W of the river	27.52
End of Donges Bay Rd.	E of the river	53.27
End of Shoreland Dr. off W Thrush Ln.	E/W	18.66
East end of County Line Rd.	E to W	359.15
East end of County Line Rd.	W to E	229.18
Winding Hollow Ln. @ Port Washington Rd.	W to E	242.33
N Riverland Rd., N of 3540 Bonniwell Rd.	N to S	201.18
N Riverland Rd., N of 3540 Bonniwell Rd.	S to N	386.53
9231 W Bonniwell Rd.	E to W	663.22
9231 W Bonniwell Rd.	W to E	454.22
Wauwatosa Rd. N of Bonniwell Rd.	N to S	182.36
Wauwatosa Rd. N of Bonniwell Rd.	S to N	189.41
Bonniwell Rd. W of Legacy Hills Dr.	E to W	326.23
Bonniwell Rd. W of Legacy Hills Dr.	W to E	326.05
W Freistadt Rd. @ Villa Grove Rd.	E to W	138.97
W Freistadt Rd. @ Villa Grove Rd.	W to E	110.73
6520 W Freistadt Rd.	E to W	140.1
6520 W Freistadt Rd.	W to E	134.59
Cedarburg Rd. N of Trinity Lutheran Church	N to S	236.57
Cedarburg Rd. N of Trinity Lutheran Church	S to N	178.04
N River Rd. @Tarry Town Ln.	S to N	155.51
N River Rd. @ W Stonefield Rd.	N to S	87.17
N River Rd. N off W River Ct.	N to S	83.61
N River Rd. N off W River Ct.	S to N	79.53
7749 W Hawthorne Rd.	E to W	273.1
7749 W Hawthorne Rd.	W to E	171.42
E of Highland/St Paul & Pacific Railroad	E to W	143.47
E of Highland/St Paul & Pacific Railroad	W to E	126.07
N of Wauwatosa/Highland intersection	N to S	182.73
N of Wauwatosa/Highland intersection	S to N	179.16
Wauwatosa Rd. @Creekside Valley Farm	N to S	202.99
Wauwatosa Rd. @Creekside Valley Farm	S to N	205.57
11375 N. Concord Creek Dr.	N to S	288.31
11375 N. Concord Creek Dr.	S to N	251.85

County Line Rd. @ N River	E to W	63.13
County Line Rd. @ N River	W to E	58.62
County Line Rd. @ Mequon Nature Preserve building	W to E	102.78
10738 N. Granville Rd.	N to S	117.71
10738 N. Granville Rd.	S to N	117.27
11011 N. Granville Rd.	N to S	206.68
11011 N. Granville Rd.	S to N	264.04
11031 N. Granville to Granville/Mequon intersection	N to S	710.29
9475-9531 W. Donges Bay Rd.	E to W	253.64
Mequon Rd./Granville Rd. intersection	N to S then E to W	394.93
Mequon Rd./Granville Rd. intersection	S to N	63.9
Mequon Rd./Granville Rd. intersection	W to E	180.29
Foxtail Ln.	N to S	90.52
Foxtail Ln.	S to N	91.85
Hawks Landing Rd.	N to S	124.2
Hawks Landing Rd.	S to N	130.66
Behind City Hall	N/S	14.19
Total		**10531.74**

BIBLIOGRAPHY

Thompson, e. a. (2012). *NCHRP Report 173 – Estimating Life Expectancies of Highway Assets, Volume 1: Guidebook.* Washington, D.C.: Transportation Research Board.