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Sturgeon Bay Drawbridges- Remote Operations Report

Prepared for: United States Coast Guard

Prepared By: Northeast Region Wisconsin Department of Transportation
944 Vanderperren Way
Green Bay, WI 54304

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Jason Lahm, P.E. – Bridge Maintenance Engineer, Northeast Region-Wisconsin DOT (Date- m/d/yy)

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Will Dorsey – Director, Northeast Region-Wisconsin DOT (Date- m/d/yy)

Executive Summary

The Wisconsin Department of Transportation (WisDOT) mission is to provide leadership in the development and operation of a safe and efficient transportation system. Remote operations technology of drawbridges provides safe and reliable bridge operations for watercraft, vehicular, and pedestrian traffic while realizing significant dollar savings.

WisDOT has been utilizing remote operations on three state owned movable bridges (Michigan Street Bridge, Maple-Oregon bridge, and Bayview bridge) located in the city of Sturgeon Bay in Door County, Wisconsin. Michigan Street Bridge in 2011 and Bayview bridge in 2014 have been remotely operated from the Maple-Oregon bridge.

The test period for these drawbridges has proven remote operations to be a safe, reliable and cost effective for vehicular traffic, navigational vessels, pedestrians and WisDOT. During the test period, no known safety or navigational concerns have occurred related to remote operations. The three drawbridges have functioned efficiently, the navigational channel has remained a reliable waterway, and WisDOT has realized savings of nearly $600,000 yearly with the use of remote operations. It is for these reasons WisDOT requests United States Coast Guard-Ninth District via Federal Code of Regulations to implement Final Rule Making in support of continuing to remotely operate the three movable structures in Sturgeon Bay beginning in the 2018 navigational season from the Maple-Oregon bridge.

To further support WisDOT's request, this report includes background information for three drawbridges and details of remote operations efficiencies, equipment in use, safety mechanisms and safeguards in place. Also included is data on vehicular traffic, pedestrian counts, navigational vessel information and public comments received during the interim rule making period.

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Purpose of Remote Operations

The Wisconsin Department of Transportation (WisDOT) mission is safe, reliable and cost effective transportation system. Remote operations of drawbridges utilize technology to provide safe and reliable drawbridge operations for watercraft, vehicular, and pedestrian traffic while realizing significant cost savings. The purpose of this report is to provide an operational summary of the planning history, equipment, safeguards, and procedures for the Sturgeon Bay area drawbridge remote operations system. WisDOT is interested in controlling or reducing costs and increasing efficiency whenever possible. The remote operation of the Michigan Street Bridge and the Bayview movable bridges has resulted in significant cost savings.

Location and Remote Operations of Sturgeon Bay Drawbridges

Three drawbridges (Michigan Street Bridge, Maple-Oregon bridge and Bayview bridge) are in the city of Sturgeon Bay in Door County, Wisconsin. The drawbridges are located over the Sturgeon Bay Ship Canal which connects Lake Michigan to Sturgeon Bay and Green Bay. Commercial and pleasure vessels use the canal to navigate between the two bodies of water.

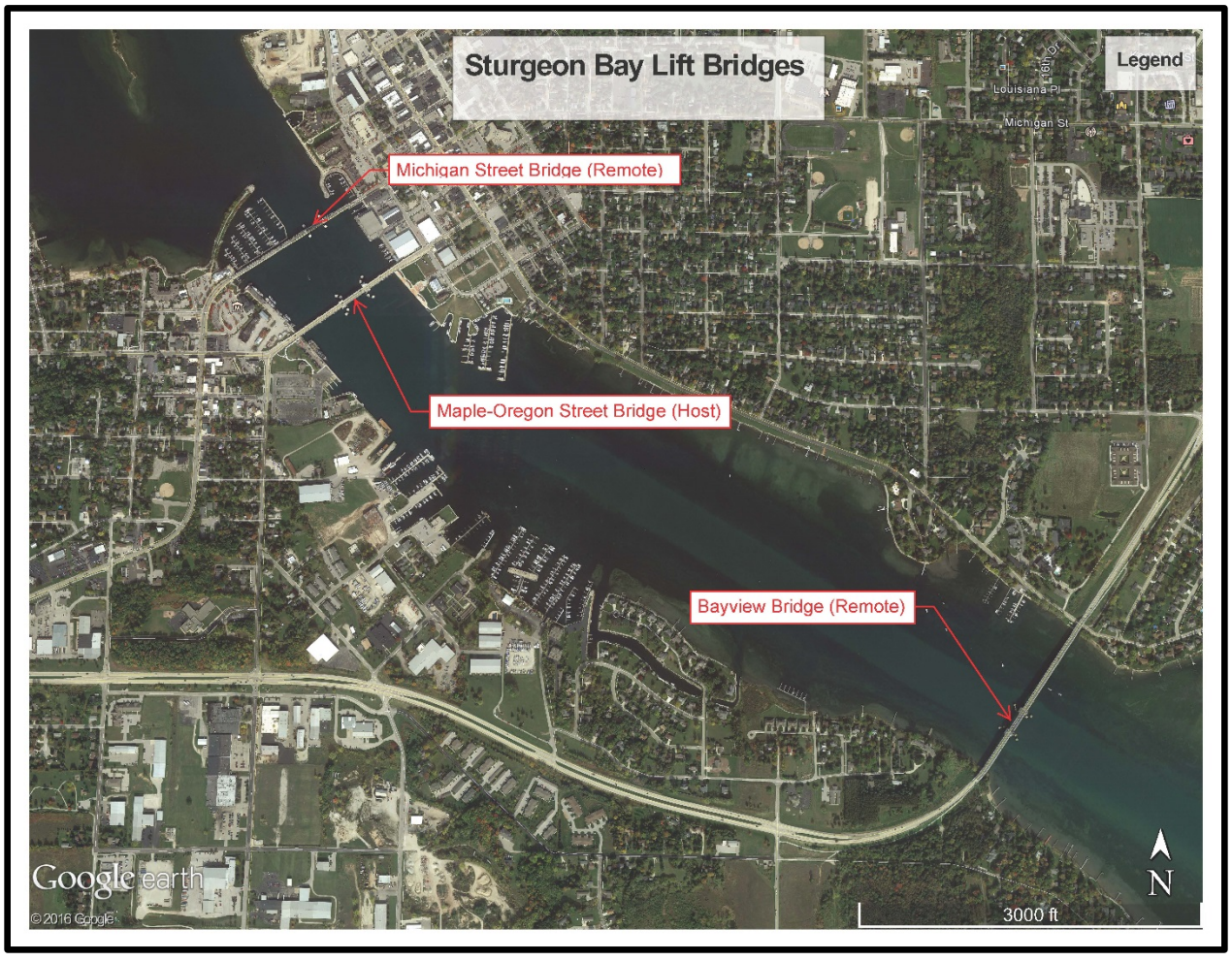

Exhibit 1: Aerial Map of Sturgeon Bay Drawbridges

The Michigan Street Bridge is in downtown Sturgeon Bay. It is a double leaf, rolling lift, bascule through truss structure with overhead counter weights and Scherzer center locks[1]. The drawbridge connects the residential district west of the waterway to the city's commercial district on the east side and is crossed by approximately 11,000 vehicles per day. It has a vertical clearance of 14 feet above normal water and must open for commercial vessels on demand and taller pleasure craft on the hour and the half hour. The drawbridge was originally constructed in 1931 and had major rehabilitation work completed in both 2001 and 2009.

The Maple-Oregon bridge, located approximately 750 feet south of Michigan Street Bridge, is a double-leaf rolling lift deck girder bascule drawbridge with mechanical center locks. It connects the west residential district to the city's commercial district on the east side of the waterway and has approximately 10,000 vehicles crossing it per day. It has 24 feet vertical clearance above normal water and opens for commercial vessels on demand and pleasure craft on the ¼ and ¾ hour. Due to its proximity to the Michigan Street Bridge, both drawbridges are required to be open at the same time when a large commercial vessel passes. However, the Maple-Oregon bridge has 10 feet of additional vertical clearance above that of the Michigan Street Bridge, resulting in 80-85% of all boat traffic can pass under the closed drawbridge. The Maple-Oregon bridge is the host drawbridge for remote operations, thus, the Michigan Street Bridge and the Bayview bridge are both operated remotely by the bridge tender housed on the Maple-Oregon bridge. The drawbridge was built in 2008.

The Bayview bridge, located approximately 7,075 feet south of the Maple-Oregon bridge, is a double-leaf rolling-lift deck-girder bascule drawbridge with Scherzer center locks[1] and has approximately 17,000 vehicles crossing it per day on WIS 42/57 bypassing the city. It has 49 feet of vertical clearance above water and opens only for taller pleasure craft and larger commercial vessels. A twin bridge to the Bayview bridge is a future long range possibility. The drawbridge was built in 1978 with a major rehabilitation work taking place in 2012.

In the table below is a summary of the drawbridge openings, the number of vessels that passed through and the average opening time for each of the three drawbridges for the years 2011-2016. A more detailed log of data is available in Volume I: Appendix A.

[1] A Scherzer center lock is a type of device for connecting the two leaves, or halves, of a movable bridge with each other. It is also known as a structural lock. The interlocking parts of the lock are rigid with the structure of the bridge leaves and are brought together and inter-locked as the front ends of the bridge leaves move down into a closed position.

	Michigan Street Bridge			Maple-Oregon Bridge			Bayview Bridge		
	Openings	Vessels	Opening Ave. Time (Min)	Openings	Vessels	Opening Ave. Time (Min)	Openings	Vessels	Opening Ave. Time (Min)
2011 Commercial	893*	1112*	6.3	440	461	7.2	139	142	8.3
2011 Pleasure	1136*	2679*	4.6	1179	1711	4.3	448	495	3.8
2012 Commercial	1362	1671	5.2	399	418	6.3	136	138	7.7
2012 Pleasure	1576	3528	4.3	1244	1807	4.2	453	527	4.1
2013 Commercial	1130	1385	5.1	291	319	7.0	101	106	9.9
2013 Pleasure	1456	3036	4.2	1089	1480	4.0	405	457	5.0
2014 Commercial	1416	1766	5.2	394	470	7.3	169	179	9.9
2014 Pleasure	1348	2897	4.1	957	1335	3.9	410	466	4.8
2015 Commercial	1598	2057	4.9	392	463	7.2	163	171	8.8
2015 Pleasure	1641	3922	3.9	1050	1449	3.9	407	476	4.7
2016 Commercial	1259	1615	5.4	300	351	6.7	166	181	9.6
2016 Pleasure	1819	4727	3.8	1050	1522	4.0	374	436	4.3
2017 thru Nov Commercial	1237	1576	5	413	506	6	111	120	9.1
2017 thru Nov Pleasure	1781	4710	3.9	1026	1490	4.1	377	431	4.7

*Bridge Painting took place on Michigan Street Bridge during the month of May 2011 so no openings took place.

Table 1: Sturgeon Bay Remote Operation Opening Summary

The Wisconsin Department of Transportation Northeast Regional Office in Green Bay is responsible for the operation of and the specialized maintenance required for the drawbridges in Sturgeon Bay. Door County Highway Department employees perform the operation of the drawbridges wherein WisDOT reimburses Door County for these drawbridge operation costs.

Background Info

History

The purpose of constructing the Maple-Oregon bridge in the similar vicinity of the Michigan Street Bridge was to provide dual crossings, and to improve the approach roadways on both sides of Sturgeon Bay to meet vehicular traffic needs. The Environmental Assessment (EA) and Finding of No Significant Impact (FONSI)[2] was approved February 7, 2006 and construction of the Maple-Oregon bridge began in October 2006. Vehicular traffic began utilizing the drawbridge in September 2008. As a part of the FONSI it was determined that the existing Michigan Street Bridge would be rehabilitated to remain in place.

[2] A copy of the Environmental Assessment and Final Finding of No Significant Impact is in Appendices Volume III.

Remote operation discussions of the drawbridges began during the Environmental Assessment phase of the Maple-Oregon bridge study. In February 2001 WisDOT requested guidance from the United States Coast Guard (USCG) Ninth District to verify if they would require two drawtenders, one for each drawbridge[3]. In April 2001 response letter the USCG stated that *"regulations governing the operation of drawbridges shall not discriminate between commercial and recreational vessel traffic"* and *"if regulations are requested for the new bridge(s), a period of two years shall first pass before a request is submitted to the Coast Guard"*[4].

Moving forward with further discussions, in November 2002, USCG responded to additional inquiries from WisDOT. WisDOT requested operator requirements for the different alternatives that were being studied in the Environmental Assessment than were previously commented on by the USCG. In November 2002, the USGC stated that both drawbridges may be operated by one bridgetender[5]. As a result, design considerations were incorporated to meet the needs of remotely operating the drawbridges from an equipment and infrastructure standpoint.

WisDOT commissioned a ***Feasibility Study for Remote Control of Movable Lift Bridges in Sturgeon Bay*** in 2007. The study report is available in Volume I: Appendix C. The purpose of the study was to research, investigate, and report on the feasibility and practicality of implementing remote control operations for the existing and future movable bridges in Sturgeon Bay. While conducting the feasibility study, final design and construction was in progress for the Michigan Street and Maple-Oregon bridges.

The Michigan Street Bridge has been remotely operated since 2011 and the Bayview bridge has been remotely operated since 2014; both operated from the host drawbridge, the Maple-Oregon bridge.

Investment of Infrastructure

As part of WisDOT's FONSI, Feasibility Study, and designs the investment of the infrastructure and longevity of the structures were considered. On standard, WisDOT designs structures for a service life of approximately 75 years. Part of the consideration for design and construction was the tender houses located on each drawbridge. When designing and constructing the new tender house for the Maple-Oregon bridge, considerations such as having sufficient room for operating systems for remote operations functions. In order to operate the other two drawbridges from the Maple-Oregon bridge, additional room was needed in the tender house main area, mechanical and electrical rooms. Windows were installed to provide a line of sight in all directions as feasible to the Maple-Oregon bridge and the other two drawbridges. As part of the rehabilitation of the existing tender house of the Michigan Street Bridge, modifications and updates were made to the mechanical and electrical components. WisDOT is interested in protecting its investment and getting the most out of the infrastructure as is practical. Approximately $28.9 million was

[3] See letter dated February 15, 2001 on pages B-34 and B-35 of the Environmental Assessment located in both Volume I: Appendix B and Volume III: Appendices.

[4] See letter dated April 16, 2001 on pages B-32 and B-33 of the Environmental Assessment located in both Volume I: Appendix B and Volume III: Appendices.

[5] See letter dated November 20, 2002 in Volume I: Appendix B

spent on the construction of the Maple-Oregon bridge. Approximately $600,000 in 2001 and $18.5 million in 2009 were spent on the rehabilitation projects for the Michigan Street Bridge. Approximately $5 million was spent in 2012 on the rehabilitation and alterations of the Bayview bridge. Rehabilitation projects included items to meet requirements to remotely operate the drawbridge, to improve efficiency and safety of operating the drawbridge, and to restore structural infrastructure and maintenance components.

Maintenance of Infrastructure

The three drawbridges are inspected annually in accordance with WisDOT policy. As part of this policy, WisDOT personnel and private electrical professionals perform inspection and routine maintenance in the spring of each year. These inspections are documented in Wisconsin's Highway Structures Information System (HSI). Maintenance logs and an example of an inspection report for each bridge are in Volume I: Appendix D.

Waterway and Navigation Information

The Sturgeon Bay navigational channel is utilized by both pleasure (recreational) and commercial vessels. On record, the three drawbridges opened a total of 4,968 times during the 2016. As the drawbridges are opening, one of the drawtender's duties is to record the type of vessel that the draw is opening for and the duration time. The logs are included in Volume I: Appendix A. The Sturgeon Bay area has many services available for vessel use such as marine shops, marinas, marine radar companies, supply businesses and resorts. A map of some of the existing businesses that provide services for mariners is included in Volume I: Appendix E. Freighter-sized vessels use the navigational channel to take advantage of the many accommodations for commercial vessels. Drawtenders typically see freighter-sized vessels throughout the year and have an approximate ship schedule of their arrival and departure through the area.

Currently the drawbridge openings are scheduled to open per Chapter 33 of the Code of Federal Regulations Section 117.1101 which is included in Volume I: Appendix G. All three drawbridges open upon signal for commercial vessels if proper notice is given and during scheduled times. The Maple-Oregon bridge is additionally scheduled to open from March 15 through December 31 and will open on the quarter hour and three-quarter hour, 24 hours a day. The Michigan Street Bridge is scheduled to open on the hour and half-hour, 24 hours a day, if needed during March 15- December 31. The purpose for the lapse in time scheduled for opening the Maple-Oregon bridge and the Michigan Street Bridge to is to ensure an extra measure of safety to operate the bridges. This allows the drawtender to focus on operating one drawbridge at a time. Both the Maple-Oregon and Michigan Street bridges can be open at the same time, but the operation of doing so is separate. Additionally, upon the onset of the draw opening schedule it was requested by the City of Sturgeon Bay and Door County officials to have a staggered schedule due to convenience of vehicular traffic and the safety of emergency response vehicles for response times and routes. The Bayview bridge is approximately 7,800 feet south of the Michigan Street Bridge which allows vessels adequate space in between structures to maneuver if both structures are not open at the same time. However, the Michigan Street Bridge and the Maple-Oregon bridge are approximately 750 feet apart. There are a few commercial vessels that require both structures to be open at the same time due to their length and limited mobility in the

channel. For these instances both draws will be open at the same time to ease the vessel's maneuvers and to protect the infrastructure from collision for both the drawbridges and the vessels. The quarter hour schedule for the Michigan Street Bridge and the Maple-Oregon bridge allows enough time for the drawtenders to attend to each drawbridge and for vessels going each direction in the navigational channel approximately the same amount of time for the drawbridges to open to ease the congestion in the channel.

Visual and Audio Equipment on Drawbridges

PLC Automation

A programmable logic controller (PLC), or programmable controller is an industrial digital computer which is specifically designed to operate reliably in harsh usage environments and conditions for any activity that requires high reliability control and ease of programming and process fault diagnosis.

PLC driven control systems for all three drawbridges are housed on the Maple-Oregon bridge and are designed specifically for the function of these three drawbridges. There are also PLC systems located in each individual drawbridge. Below in exhibit 2 is a picture of the main control console for the PLC on the Maple-Oregon bridge. The Remote Operating procedures for all three drawbridges can be seen in Volume I: Appendix F. Additionally, the various screens related to the main control console are in the Bay View Street Bridge Operation and Maintenance Manual, which starts on page 2,532 of Volume II Appendices. The various screens are: Traffic Control Screen, Span Operation, Alarm History, Drive, Brake Test, Camera, Inclinometer, Trends, Bypass, Maintenance, Ethernet Switches, and Parameter Entry.

Exhibit 2: Main control console for the Maple-Oregon bridge located in the Maple-Oregon operation house.

The PLC system is not a new concept in terms of movable structures. However, the element that is different is that for the three Sturgeon Bay drawbridge applications the three control consoles are housed on the Maple-Oregon bridge. This allows the Michigan Street Bridge and Bayview bridge to be remotely operated. Below in exhibit 3 is a picture of the Maple-Oregon operation house with all three PLC consoles. One drawtender can efficiently and safely control, monitor, and operate all three drawbridges with this configuration.

Exhibit 3: Picture of the Maple-Oregon bridge operation house

The control system has multiple indicator lights that are located on the console which indicate current operations of the drawbridge and are referred to as "pilot lights". Pilot lights allow the drawtender to be notified of functions on the drawbridge. This is very important when visual obstructions occur. An example of a pilot light indication is *Near Oncoming Gate UP*. This pilot light is on when the control power is on and the gate is fully raised. It will flash while the gate is rising. Additional information on pilot lights can be found in Volume II, Appendix C which is the *Bayview Street Bridge Operation and Maintenance Manual*.

Visual (Lights/Signals)-Speaker Systems, Cameras, and Radar

Each drawbridge is equipped to follow Chapter 33 of the Code of Federal Regulations Section 117.15 in terms of signals. See Volume I: Appendix G for an excerpt from 33 C.F.R. § 117.15. With the presence of remote operations some of the equipment has been enhanced and modified to further assist the drawtender to operate from the host drawbridge.

Sound Signals-Microphones and Speaker Systems

Each of the three drawbridges has a microphone and PA[6] system that allows the drawtender located at the host drawbridge, Maple-Oregon bridge, to hear and respond when a signal is emitted from a vessel, motor vehicle, or pedestrian. The system allows the drawtender to respond directly to a vessel operator if necessary. The system also allows the drawtender to talk directly with pedestrian or vehicular traffic if needed.

The Bayview bridge has microphones and speakers attached near the vehicular gates on each side of the operation house, and located on the pier under the center of the bridge. A picture of a microphone and speaker is shown below. The air horn speaker is used to emit the required horn signal from the drawtender of when the draw can be opened or cannot be opened immediately.

Exhibit 4: Microphone system that allows the drawtender to communicate with the vessel operator

[6] A public-address system (PA system) is an electronic sound amplification and distribution system with a microphone, amplifier and loudspeakers.

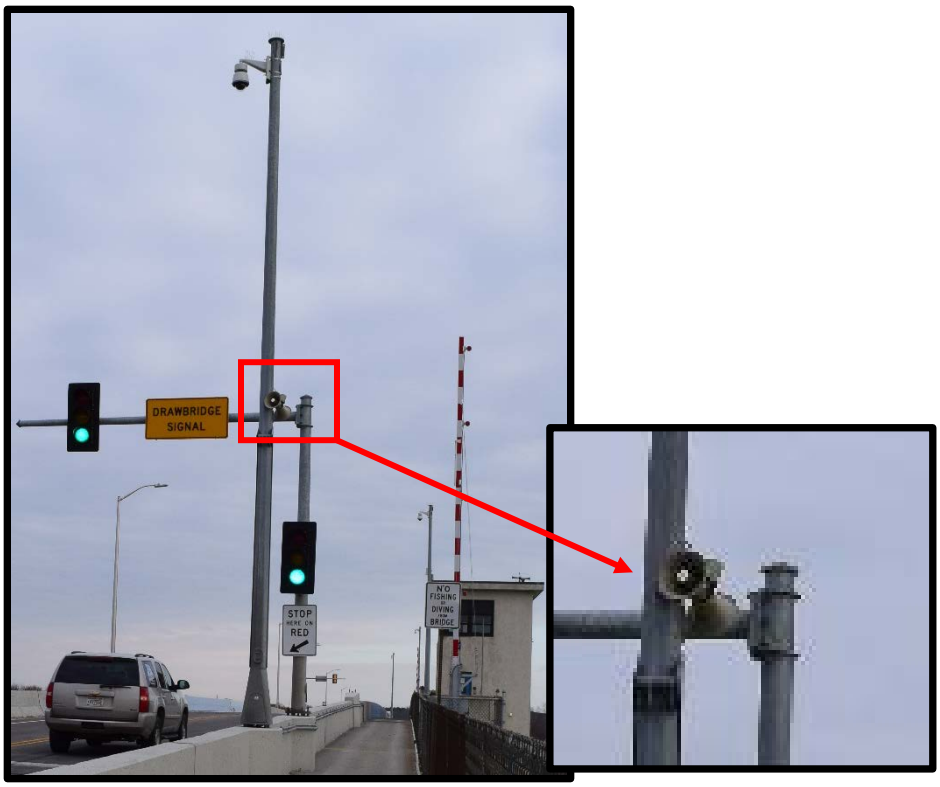

Exhibit 5: The Bayview bridge speaker and microphone system.

The Maple-Oregon bridge microphone and speakers are located underneath the drawbridge and on top of the drawbridge. They are fastened to the pier underneath the drawbridge. On top of the drawbridge they are near the vehicular gates.

Exhibit 6: Maple-Oregon bridge microphone and speaker system located under the drawbridge on the drawbridge pier.

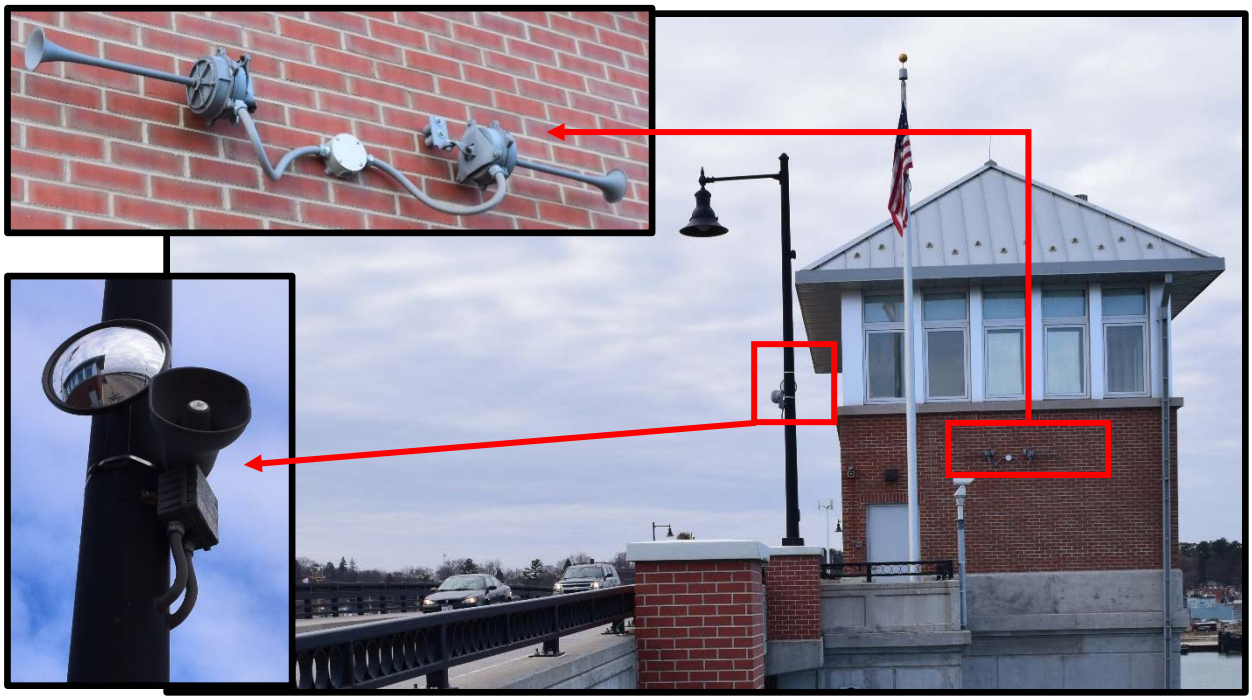

Exhibit 7: Maple-Oregon bridge microphone, speaker, and horn system located on top of the drawbridge.

The Michigan Street Bridge speaker and microphone system is similar to the Maple-Oregon drawbridge system. There are speakers and microphones located underneath the drawbridge on the drawbridge pier, as well as on top of the drawbridge attached to the truss members.

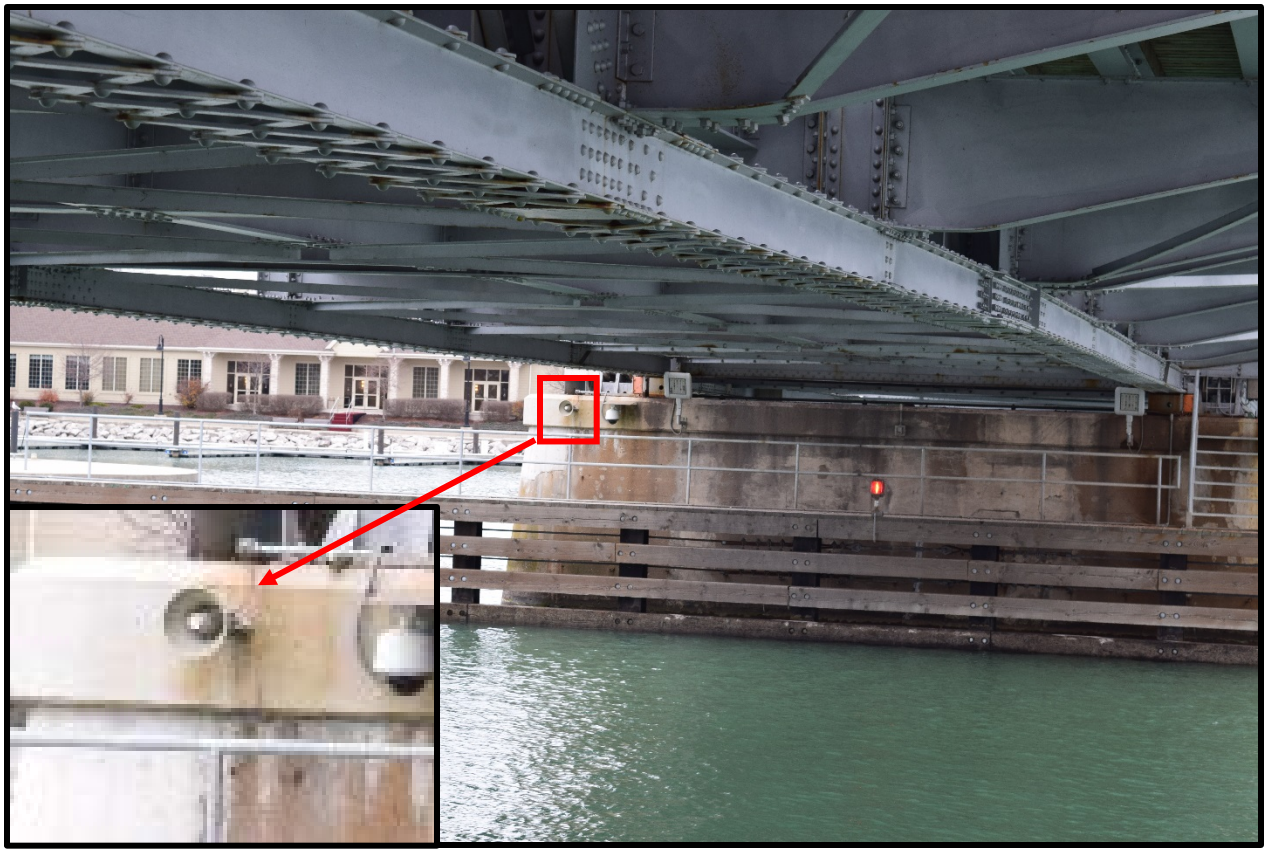

Exhibit 8: Michigan Street Bridge microphone and speaker system located under the drawbridge on the drawbridge pier.

Exhibit 9: Michigan Street Bridge microphone and speaker system located on top of the drawbridge.

There is an air horn system located at each drawbridge that can be controlled from the Maple-Oregon bridge. The system allows for navigation communication; an example being emitting the required horn signal when the draw cannot be opened or cannot be opened immediately. Communication capabilities are very important in the remote operations system as it allows the drawtender to communicate with all entities when not physically located on the drawbridge that needs to be opened.

Lights

The drawbridges have many street, sidewalk, and underdeck lights which help create visibility for drawtenders to operate the drawbridges safely. Lighting of the waterway near the movable spans allows better visibility of vessels clearing the drawbridge during nighttime operations. Street lighting illuminates the area, providing light for the cameras and safety for pedestrians and vehicles. All three drawbridges have lighted sidewalks for pedestrian safety. Advanced warning signals and lights let drivers and pedestrians know when the draw is going to open.

Visual Navigation Signals

Visual signals are an important aspect of all three drawbridges in the Sturgeon Bay area when it comes to communicating with pleasure craft. Many commercial craft operators are very familiar with the sound signals and options of communication with the drawtenders. However, as apparent in the Opening Summary Logs shown in Volume I: Appendix A there are equal if not more pleasure craft that require openings of the draws. Each drawbridge is equipped with a navigation signal system similar to a traffic signal. This signal system meets the requirements of 33 C.F.R. § 117.15 (c). An example of the signals is shown below in exhibit 10.

The signals shown below also indicate the navigational channel for vessels. Additional lights are located on each drawbridge near the piers or abutments as necessary. Additional specification information can be found in each of the drawbridges' Operation Manual in Volume II: Appendices A-C.

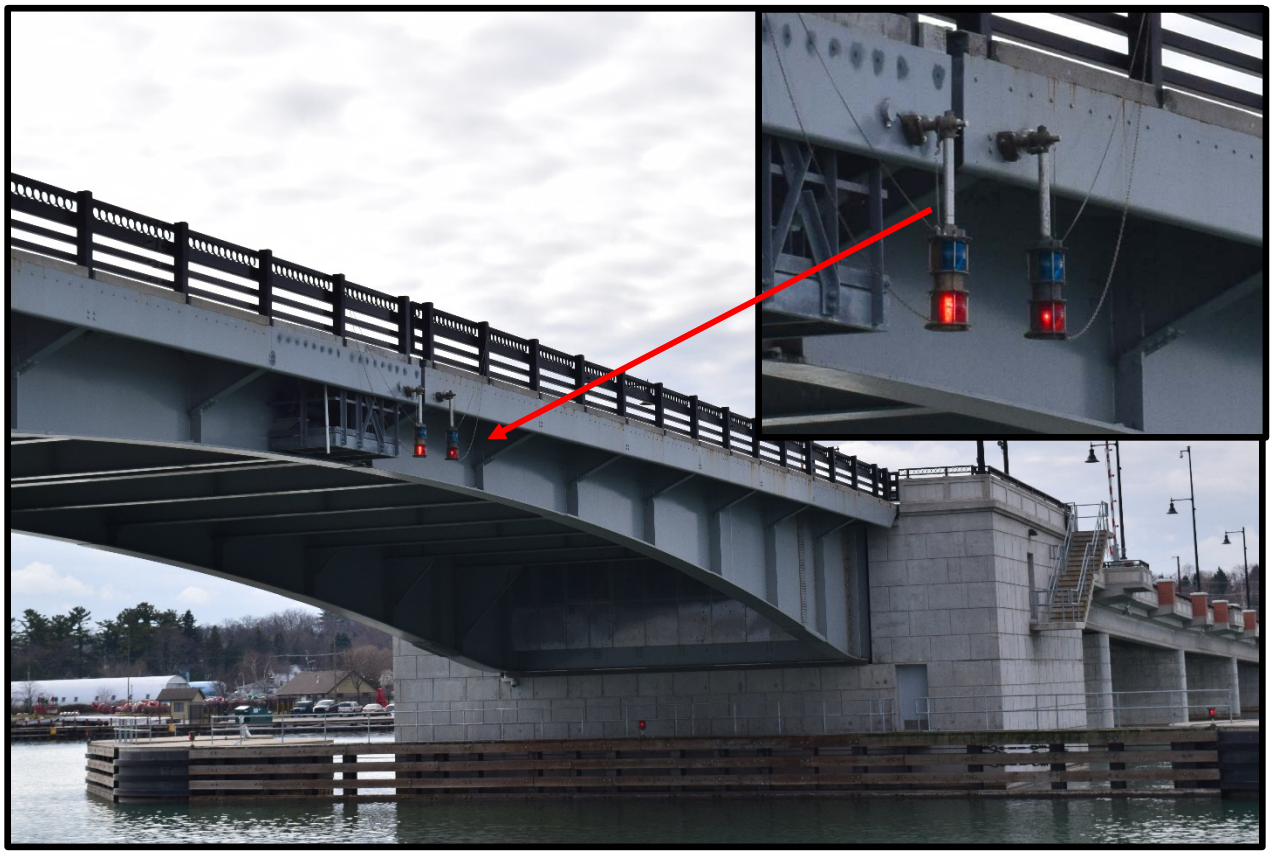

Exhibit 10: Visual Signals located on Maple-Oregon bridge

Radiotelephone System

Signs located at all three drawbridge locations provide vessels with the telephone number for the drawtender, as well as monitored marine radio channel. This is in compliance with 33 C.F.R. § 117.24 which states that:

(b) The sign shall give notice of the radiotelephone and its calling and working channels

Below are pictures of the three signs available for all three drawbridges in the Sturgeon Bay area. The signs also notify the vessels of the drawbridge operation schedule as approved in Chapter 33 of the Code of Federal Regulations Section 117.1101 (Volume I: Appendix G).

Exhibit 11: Radiotelephone system signs for all three drawbridges. Left picture displays signs posted for Bayview bridge. Middle picture displays signs posted for Maple-Oregon Street bridge. Right picture displays signs posted for Michigan Street Bridge.

Cameras

Safe and effective remote operation of a movable bridge requires the operator to have a clear view of the structure, its roadway and sidewalk approaches, and the waterway approaches. Video cameras provide this function.

As the drawtender operates the PLC, the cameras move to show the appropriate views for the current function that is taking place. These various camera views can be seen in Volume I: Appendices H-I. This capability allows the drawtender to systematically walk through various operations at the same time while monitoring different aspects of the drawbridge such as the navigational channel, vehicular and pedestrian traffic. Additional information on the importance of placement of cameras is further explained in the Feasibility Study for Remote Control of Movable Bridges in Sturgeon Bay in Volume I: Appendix C.

The cameras have various views which allow the drawtender to see the operation house, the road in both directions, near the gates, down the sidewalks, upstream of waterway, downstream of waterway and an overview of the waterway. These cameras have the capability to pan/tilt, zoom, and rotate also known as PTZ controls. Recorded video on the cameras is kept as a record for 30 days. A location layout of the cameras for all three drawbridges are located in Volume I: Appendix H. The Michigan Street Bridge has 12 cameras[7]. The Maple-Oregon bridge has eight

[7] The type of cameras are Pelco Spectra III, IV.

cameras[8]. The Bayview bridge has 12 cameras[9]. Exhibit 12 Below is a picture of a camera on the Bayview bridge.

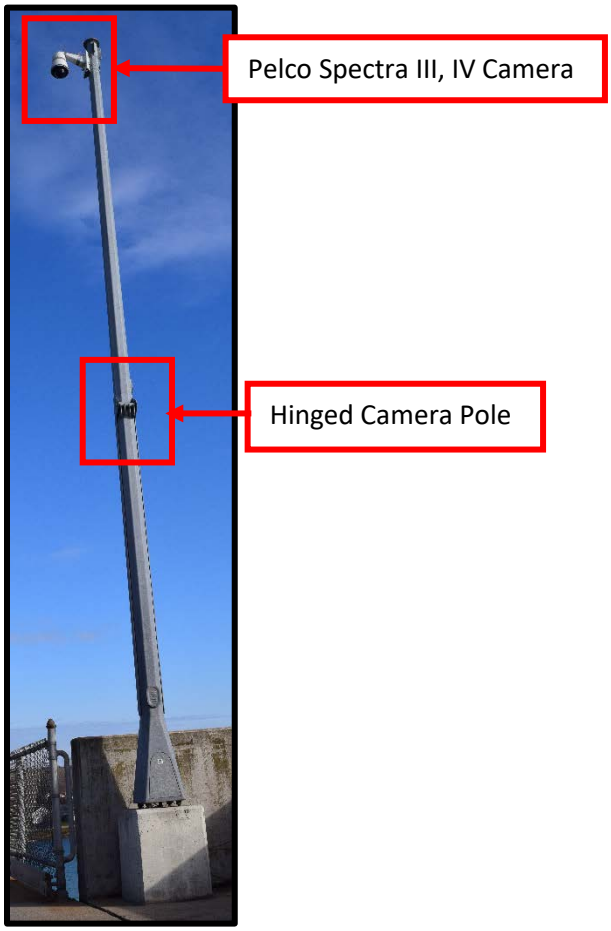

Exhibit 12: Example picture of hinged camera pole and camera.

Two sets of cameras on the Bayview bridge are focused on the tail locks. These cameras are very beneficial as they provide a vantage point that would be otherwise unavailable to the drawtender.

Based upon the feasibility study, cameras were placed on the Maple-Oregon and Bayview bridges on aluminum poles. However, as the feasibility study suggested, vibration of cameras was an issue. Poles have been upgraded to steel hinged camera poles since initial construction to minimize these issues. A picture of a new steel hinged camera pole is above in exhibit 12. An efficiency and safety function that these upgraded poles provide is the ability to lower the top half to access the camera. This allows maintenance of the camera to take place during live vehicular traffic. These new poles have also been moved to different locations on the drawbridge where less vibrations occur such as over the piers behind the sidewalk instead of on the parapet walls next to traffic.

[8, 9] The type of cameras are Pelco Spectra III, IV.

Additionally, there is a thermal infrared camera located on the Maple-Oregon bridge. The camera provides a Michigan Street Bridge profile view. The thermal camera has zoom capabilities as well as tilt and pan functions. An example view from the thermal infrared cameras can be seen in Volume I: Appendix I.

Thermal infrared cameras are an asset because they allow the drawtender to see objects that would be otherwise obstructed to the naked eye due to low light or shadows. This is the most prevalent on the Michigan Street Bridge because its truss system can have many 'blind spots'.

Radar System

Michigan Street and Bayview drawbridges have a radar detection system mounted on the drawbridge. The radar can be viewed and controlled both locally and remotely at Maple-Oregon bridge. The radar system is very effective at detecting on-coming vessels both out of visual sight and during obstructed visibility such as poor weather. This is am extremely important safety feature during weather such as fog where thermal imaging and cameras are not as effective. The radar system sounds an alarm when a vessel crosses a "guard line" that is preset into the radar system. A "guard line" is a virtual line that is set in the radar system at a predetermined distance from each drawbridge. The distance is determined by the average distance from the drawbridge the drawtender would need to be prepared to start the draw lifting procedures. It is just an average so the drawtender also must consider the speed of the vessel shown on the radar to be sure the draw is opened so the vessel can safely pass through the drawbridge.

Safety Mechanisms & Safeguards

Back-Up Systems (Both Electronic and Manual)

All drawbridges have dual PLC's (one main and one back-up) that allows for redundancy in the case of one PLC system failure. Also in the case of both PLC systems failing, basic drawbridge functions can be operated manually through a relay system.

There are also backup systems known as bypass switches on all three of the PLC consoles on the drawbridges. These bypass switches are both electronic and manual depending upon the current operation mode of the drawbridge. The bypass operation is defined and described in detail in each drawbridge's operation and maintenance manual which are located in Volume II, Appendices A-C. As shown below in exhibit 13 the five main bypass switches are located on a separate area of the control console with a lid and keys to the switches to ensure that precautions are met before implementing such operations as outlined in the Operation and Maintenance Manuals.

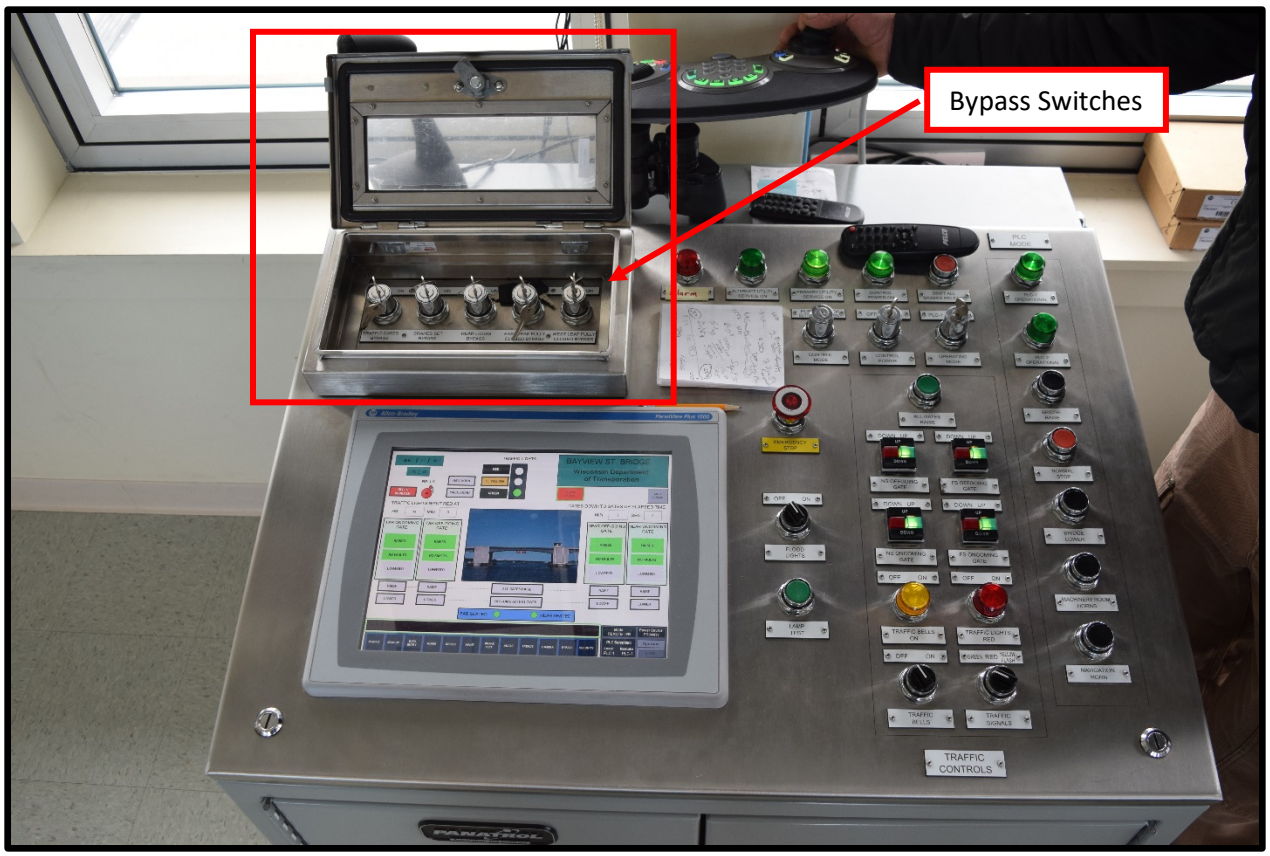

Exhibit 13: PLC Bypass Switches Located on Control Console for Bayview bridge in Maple-Oregon bridge Operation House

Drawtender (Bridgetender) Info

For purposes of this section, drawtender is referred to as bridgetender. Bridgetenders are employed by Door County Highway Department. Together WisDOT and Door County developed qualifications and requirements for the position. An example of a qualification is that the bridgetender have the ability to keep clear and accurate records concerning vessel movements, maintenance activities, equipment malfunctions, or accident information occurring on the drawbridge. An example of a bridgetender requirement is that the bridgetender must have a good understanding of regulations governing drawbridge opening protocol including the U.S. Coast Guard regulations governing waterways and drawbridges. A complete list of qualifications and requirements can be seen in Volume I: Appendix J. In conjunction with the qualifications and requirements, each spring bridgetenders receive, review, and sign off on Bridgetender Responsibilities documents. An example of this is shown in Volume I: Appendix K.

A total of four bridgetenders are employed for the navigational season and one tender is employed during the off season. One permanent employed bridgetender is a lead worker and has additional duties when not tending the drawbridge. Some of these additional duties are maintenance of the drawbridges, safety inspections, and informing WisDOT of any operational issues. During holiday, special event traffic, or inclement weather events the bridgetender has

the authority to call in additional bridgetenders to operate each drawbridge independently to ensure safety of all vehicular, pedestrian, and vessel traffic.

The estimated total labor cost of the bridgetenders to remotely operate the drawbridges for the 2016 season was $342,000. In the event that the drawbridges are not remotely operated it would be necessary to employ 12 bridgetenders instead of 4 which would require approximately $684,000 additional funds on a yearly basis bringing the total to over $1 million to operate the three structures.

Before each navigational season begins in March bridgetenders attend an annual staff meeting which is administered by WisDOT to discuss issues logged, discuss any changes to protocol and operating procedures or to voice any safety concerns. At this meeting the bridgetenders review and sign documentation that they understand and can perform operating procedures and responsibilities. As a part of bridgetender orientation the bridgetenders review all procedures developed in the Remote Operating Procedures developed for each drawbridge through extensive on-the-job training. All three operating procedures can be viewed in Volume I: Appendix F.

Training and communication between bridgetenders is crucial to proper operation and maintenance of all three drawbridges. Bridgetenders follow all guidelines and procedures appropriately to ensure safety and to efficiently operate the drawbridges.

As a part of open communication and safety compliance the bridgetenders have an understanding of proper judgement calls. An example is that if additional help is needed for a particular scenario that multiple bridgetenders may be on hand to assist. When assistance is needed, it is understood that additional bridgetenders respond within 30 minutes as necessary. Another judgment call that the bridgetenders are equipped to handle is to open the draw on non-scheduled times for vessels when 10 or more are waiting or when judgment to do so is necessary. This follows the requirement of Chapter 33 of the Code of Federal Regulations Section 117.1101[10]. Bridgetenders often communicate with local law enforcement and emergency response entities when extended drawbridge openings are necessary. Dispatch will communicate with bridgetenders so tenders can notify them of the draw being opened on non-scheduled times to ensure that they can cross and be efficient as possible in their emergency response time. This scenario might allow the tender to suggest using another drawbridge or route for dispatch to utilize.

Contingency Plans in Case of Equipment Failure or Loss of Connection

Protocol that has been developed in conjunction with the Remote Operations is the Bridge Remote Operation Protocol as seen in Volume I: Appendix L. The Bridge Remote Operation Protocol is a list of potential scenarios the drawtender may encounter, along with appropriate primary and secondary actions to address those problems. It also lists the appropriate contact names and phone numbers of both WisDOT and Door County employees responsible for

[10] Chapter 33 of the Code of Federal Regulations Section 117.1101 (1): From March 15 through December 31, need open on signal for recreation vessels only on the hour and half-hour, 24 hours a day, if needed. However, if more than 10 vessels have accumulated at the bridge, or vessels are seeking shelter from severe weather, the bridge shall open on signal.

addressing potential problems. Many of the problems that are outlined relate to the Remote Operations functions of the drawbridge with respect to visual and audio equipment issues.

To ensure continuity of operations, inoperable audio and video equipment that is used on the drawbridge can be replaced within the next business day. It is up to the drawtender to inform the head drawtender to add additional tenders or to change the view of other cameras to cover any blind spots in the event that one of the cameras goes out.

The drawbridges have two independent sources of power for each structure which come from Sturgeon Bay Utilities. In the case of power outage from one of the sources of power; the power source will switch automatically to the other source.

The Sturgeon Bay drawbridges are connected by a fiber optic cable that runs from the Michigan Street Bridge to the Maple-Oregon bridge. A separate fiber optic cable runs from the Maple-Oregon bridge to the Bayview bridge. A conceptual layout of the approximate location of the fiber optic cable can be seen in Volume I: Appendix C.

Equipment Adjustments or Modifications

Initially Remote Operations was studied and documented with the Feasibility Study for Remote Control of Movable Bridges in Sturgeon Bay. This document is available in Volume I: Appendix C. This study was used as the building block for implementation of remote operations for the three structures. However, as with any study, lessons were learned once the drawbridges were operating remotely and modifications have been made from these lessons.

Cameras

Most modifications on the drawbridges to present date have dealt primarily with the cameras. One of the modifications made was to add more cameras to the Bayview bridge. More cameras were needed to thoroughly cover the missing views and blind spots such as waterway depth perception and mechanical rear locks. These blind spots exist regardless if remote operations are utilized so the modifications are beneficial in either operating scenario.

Another modification was to some of the original preset views of the cameras on all three drawbridges. The preset views needed to be modified to function with the PLC system and provide the views for the current operation in motion.

Additionally, as mentioned above in the Cameras section of this report, modifications to the type of camera pole and placement of poles were made. These modifications were made to help reduce the vibrations of cameras and to allow maintenance of the cameras without impeding live vehicular traffic nearby.

In the future, upgrades to the existing cameras and system will enhance the quality of picture and resolution such as HD[11] cameras and HD monitors. This will be done as components become obsolete.

[11] The definition of HD is high definition.

Security and Fire Alarm System

Bayview and Maple-Oregon bridges have security and fire alarm systems. Bayview's system in integrated into the PLC. When an alarm is activated at Bayview, the drawtender at Maple-Oregon will be able to see which alarm was activated. The drawtender can then determine the appropriate action. The drawtender also has the ability to turn off an alarm that has been activated on Bayview from Maple-Oregon.

Lights

LED lighting was installed for reliability and longevity. LED lighting is much more efficient and cost effective than the previous high pressure sodium lighting.

Doors

All three operation houses located on the drawbridges have had remote access controls installed to operational doors. The benefit of this is that the drawtender can remotely unlock the operational house from the host drawbridge. This is a safety feature that in the event access needs to be obtained immediately to the operational house the drawtender has the ability to do such.

Documented Incidents

Drawtenders document incidents that effect WisDOT's infrastructure system which includes all three movable drawbridges. None of the incidents documented were as a result of utilizing remote operations of the movable drawbridges. Any repairs to the structures were repaired in accordance with Federal Regulations standards of notification to the USCG if the draw opening schedule was altered from the Code of Federal Regulations schedule (as seen in Volume I: Appendix G). The incident history can be viewed in Volume I: Appendix N. As a summary, there were four incidents documented from 2008-2016 on the Maple-Oregon bridge, there have been seven incidents documented on the Michigan Street Bridge from 2008-2017, and there has been one incident documented on the Bayview bridge from 2008-2016.

History: Summary of Correspondence Regarding Remote Operations Permissions

The following is a summary of the correspondence regarding remote operations permissions between the U.S. Coast Guard and the Northeast Region of the Wisconsin Department of Transportations (WisDOT). All correspondence can be seen in Volume I: Appendix M.

Remote operation discussions of the drawbridges began during the Environmental Assessment phase of the study. In February 2001 WisDOT requested guidance from the United States Coast Guard (USCG) Ninth district regarding if they would require two drawtenders, one for each bridge[12]. In a response letter from April 2001 the USCG stated that regulations governing the operation of drawbridges shall not discriminate between commercial and recreational vessel

[12] See letter dated February 15, 2001 on pages B-24 and B-25 of the Environmental Assessment which are located in Volume I: Appendix B or Volume III Appendices.

traffic and if regulations are requested for the new bridge(s), a period of two years shall first pass before a request is submitted to the Coast Guard[13]. Moving forward with further discussions, in November 2002, USCG responded to additional inquiries from WisDOT. WisDOT requested operator requirements for the different alternatives than they were previously commented on by the USCG. In November 2002, the USGC stated that both bridges may be operated by one bridgetender[14].

In 2006, the Northeast Region of WisDOT hired a consultant to conduct a Remote Operations Feasibility Study for Sturgeon Bay.

In April 2007, correspondence passed between Dale Weber, Northeast Region Bridge Engineer of WisDOT, and Robert Bloom of the Coast Guard (CG) regarding remote operations (ops) in Sturgeon Bay. In his April 10 letter, Weber shared study results that remote ops are feasible and navigation services won't deteriorate. He proposed remote ops in Sturgeon Bay and requested comments. In Bloom's April 23 response, he noted that the Coast Guard would not object to remote operations as long as the drawbridges responded to vessels in accordance with federal regulations.

Public outreach occurred with the remote ops feasibility study. In May 2007, the study team met with the Sturgeon Bay drawtenders to explain the study. In June 2007, local officials' and public involvement meetings were held. In all three meetings, a PowerPoint presentation was used to explain the concept of remote control, the equipment needed, cost comparisons and safety issues.

The Remote Operations Feasibility Study for Sturgeon Bay was completed in July 2007.

The three drawbridges were set up for remote operations in the following years. In 2008 construction of the Maple-Oregon bridge was completed, setting the drawbridge up as Host Bridge for remote operations. In 2010, the Michigan Street Bridge was rehabilitated and set up for remote ops. It has been operating remotely since 2011. In 2013 the Bayview bridge was rehabilitated and set up for remote ops. It has been operating remotely since 2014.

In the March 2015 Lake Carrier's Association (LCA) wrote a letter to the Coast Guard citing concerns about remote operation of Green Bay drawbridges, including delays. They recommended that the Coast Guard study remote ops of drawbridges over commercial waterways nationwide to develop minimum standards and region-specific policies. The Coast Guard is currently conducting the study.

In mid-September 2016, Lee Soule (CG) called the operations house at the Bayview bridge. The drawbridge is operated remotely so no one answered and the answering machine directed him to call the drawtender at the Maple-Oregon bridge. The redirected telephone call set off a series of meetings and correspondence between the NE Region and the Coast Guard.

[13] See letter dated April 16, 2001 on pages B-32 and B-33 of the Environmental Assessment which are in Volume I: Appendix B or Volume III Appendices.

[14] See letters dated September 27, 2002 and November 20, 2002 in Volume I: Appendix B, pages or Volume III Appendices.

Initially, although Dale Weber provided updates of the reliable service of remote ops in Sturgeon Bay, the USCG was unable to support WisDOT's request to continue the remote operations of the Michigan Street and Bayview bridges. In fact, in his October 20 letter, Scott Striffler (USCG) rescinded the April 23, 2007 Coast Guard response that it didn't object to remote ops in Sturgeon Bay.

After multiple discussions, the Coast Guard reversed their decision. In a December 1, 2016 letter, the Coast Guard undid the October 20, 2016 letter and restored remote operations. WisDOT had one drawtender at Maple-Oregon for all three drawbridges until the start of the winter schedule. The Coast Guard had the Code of Federal Regulations interim rulemaking in place by the time 2017 season starts to cover all three drawbridges it can been seen in Volume I: Appendix Q. The 2017 season will be considered a formal test platform for remote operations and the Coast Guard will publish a notice of public comment in the federal register and take input.

If the 2017 test period outcome is positive, the Coast Guard will publish it in federal regulations and remote operations in Sturgeon Bay will be officially approved starting with the 2018 navigation season.

2017 Activities during Interim Rule Making

Public Involvement

Public Involvement has been conducted by Wisconsin Department of Transportation for purposes of informing the public and collecting comments related to the Interim Rulemaking for remote operations of the Sturgeon Bay drawbridges.

Date (m/d/yyyy)	Meeting Sponsor	Type of Meeting	Location	Approximate Number of Attendees
4/11/2017	WisDOT	Local Officials Meeting	City of Sturgeon Bay-City Hall	7
5/11/2017	WisDOT	City of Sturgeon Bay-Community Protection Services Meeting	City of Sturgeon Bay-City Hall	Approximately 12
8/1/17	WisDOT	Stakeholder Meeting	City of Sturgeon Bay-City Hall	8
8/1/17	WisDOT	Public Involvement Meeting	City of Sturgeon Bay-City Hall	12

Table 2: Public Meetings

Other methods such as those identified in the Public Involvement Plan can be seen in Volume I: Appendix O, but are summarized below.

- USCG sent an email to Lake Carriers Association (LCA) on December 13, 2016, it is attached in Volume I: Appendix O.
- USCG sent a notice to mariners in December 2016 that the interim rule would be published, this is also included in Volume I: Appendix O.
- A news release was issued by WisDOT on February 21, 2017 of the interim rule and information on the eRulemaking Portal. The notice is included in Volume I: Appendix O.
- A stakeholder group including organizations and special interest groups associated with marine activities has been developed and can be seen in Volume I: Appendix O.

Data Collection

Pedestrian Counts

The collection of pedestrians on all three drawbridges is scheduled to be taken during two months. They will be taken during the month of May and July on a Tuesday and a Saturday. Sixteen hour counts will be utilized from 6 am to 10 pm to capture the pedestrian traffic for the entire span of the day. These counts will be included in the final report in Volume I: Appendix P, a summary of the counts has been included below in Table 3.

Pedestrian Counts in 2017 for Sturgeon Bay Bridges Summary

	Tuesday, May 9	Saturday, May 13	Tuesday, July 11	Saturday, July 15
Michigan Street	108	328	614	704
Maple-Oregon	62	192	189	254
Bayview	16	26	38	37
Totals:	186	546	841	995

Note: Counts were taken for 16 hours from 6:00 am - 10:00 pm

Table 3: Pedestrian Count Summary

Vehicular Traffic Counts

Automated traffic recorders (ATR)s are currently installed on all three drawbridges to record vehicular traffic volumes daily. During the peak month of July, approximately 10,000 vehicles cross the Michigan Street bridge daily, approximately 9,000 vehicles cross the Maple-Oregon Street bridge daily and approximately 19,000 vehicles cross the Bayview bridge daily. Vehicular traffic volumes for 2016 were not included with this report because Bayview bridge was closed for construction which would not represent the "normal" traffic across the Michigan Street bridge and Maple-Oregon Street bridge. The 7-day average for the months from February to October are included below in Table 4. The peak and lowest months' traffic counts for each bridge in 2017 are included in Volume I: Appendix P.

7-Day Average for each month in 2017

	Feb	March	April	May	June	July	Aug	Sept	Oct
Michigan Street	7,708	7,747	8,878	9,249	9,901	10,209	9,776	9,462	9,264
Maple-Oregon	6,072	6,041	6,689	7,719	8,251	8,871	8,503	7,812	7,223
Bayview	9,066	9,039	10,376	13,456	15,739	18,789	17,334	15,690	15,044
Totals:	22,846	22,827	25,943	30,424	33,891	37,869	35,613	32,964	31,531

Table 4: 7-Day average for each month in 2017

Frequency of Equipment Failure and Temporary Suspension of Remote Operations

There was no equipment failure or temporary suspension of remote operation of the bridges in 2017.

Frequency of Restricted Visibility

There was no restricted visibility that affected the remote operation for the bridges in 2017.

Instances When Ten or More Vessels Were Present

In 2017, there were 20 instances on Michigan Street bridge and 2 instances on Maple Oregon Street bridge when ten or more vessels were present.

Lessons Learned

This study provided a valuable learning experience for WisDOT. The following is a list of lessoned learned:

- Designate one of the drawtrenders as the “Head Drawtender”. The Head Drawtender is the first point of contact who is accountable for maintenance needs, bridge issues and staffing needs on the bridges.
- After initial installation, review camera set up and be flexible to adding additional cameras (including possibly adding infrared cameras) based on input from the drawtenders.
- Have phone calls to remote bridges transferred to the host bridge.
- Involve local law enforcement early in the planning process to address their needs.
- Plan for network expansion on bridge and off bridge.
- Plan for future expansion of the system by installing extra conduit and pull boxes.
- Investigate WiFi options if no hard wire connections are feasible. Today’s WiFi technology is very reliable.
- Utilize electronic entry system to allow bridge tender to unlock doors at the remote bridges from the host bridge.

- Utilize large monitors with multiple views versus many small monitors.
- Put cameras in areas on bridge with known issues (rear locks, center locks and other known problems areas specific to a particular bridge).
- Have camera server rack in a serviceable area or movable so it can be serviced easily.
- Budget for future replacement of camera systems. Camera system life expectancy is 5-8 years.
- Have sufficient speakers on bridge to allow for clear communication with boaters and pedestrians.
- Position additional cameras to show any blind spots.
- Utilize hinged camera poles in area where traffic can't be disrupted. This allows camera maintenance from the sidewalk without closing a traffic lane and using a lift.
- Place camera poles in locations with minimal movement on bridge (over a pier). Light poles and traffic signals typically have too much sway causing the image to vibrate too much. Sign structures and monotube traffic signals typically work well but need to be evaluated before final design.
- If possible, add extra submarine cables for future expansion.
- Use Human Machine Interface (HMI) that replicates the bridge movement on screen.
- Use a camera system that can be serviced locally.
- Try to interconnect with police and government networking prior to design.
- Use high-quality, high-definition monitors that can be on 24-hours/day.

Appendices

Volume I Appendices:

Volume II Appendices:

Volume III Appendices: